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Fifth International Concept Mapping Conference

Concept Maps:

Theory, Methodology, Technology

Proceedings of the Fifth International Conference on Concept Mapping

Alberto J. Cañas
Joseph D. Novak
Jacqueline Vanhear
editors

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Volume 1

Full papers, part one

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Concept Maps: Theory, Methodology, Technology
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Volume 1

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Preface

Welcome to CMC 2012, the Fifth International Conference on Concept Mapping, and to Malta.

A group that joins for the fifth time from all over the world to share research and experience, alternating between Europe and the Americas, shows maturity and a sense of community. We welcome into our community participants from new countries that had not previously taken part in the conference.

Once again we have a strong program that covers a variety of topics resulting from the Program Committee's tough time selecting the papers that would be presented orally and as posters from a large number of high quality submissions. We thank the members of the Committee for their effort and hard work. And of course, the conference would not take place if it were not for all the authors that are willing to share their work with the concept mapping community.

Outstanding invited speakers complement the high quality of papers: Joseph D. Novak, who will join us via videoconference, Ian Kinchin, Jaime Sánchez and Robert Hoffman. Panels that we expect will generate a lot of discussion among the participants complete the Program.

The Local Organisation Committee has made a wonderful job not only with the organization of the Conference, but also making sure we feel at home in Valletta and that we have a great time through the superb social programme.

Finally, we thank the sponsors whose support was crucial in making the Conference a reality.

Alberto J. Cañas
Chair, Program Committee CMC 2012

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Contents

Concept Maps: Theory, Methodology, Technology
Proc. of the Fifth Int. Conference on Concept Mapping
A. J. Cañas, J. D. Novak, J. Vanhear, Eds.
Valletta, Malta 2012

A RESEARCH METHODOLOGICAL STUDY OF CONCEPT MAPPING TO FOSTER SHARED UNDERSTANDING TO PROMOTE SUSTAINABLE DEVELOPMENT IN THE UNU-IAS RCE ESPOO, FINLAND

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http://blogs.helsinki.fi/biology-and-sustainability-education/

Abstract. When interview transcripts or other texts are transformed into concept maps, the results will vary. In this study we'll make a small experiment using a novice concept mapper and an expert concept mapper to map the same interview transcripts. The intent of the novice concept mapper is to use concept mapping as a research method in his doctoral dissertation on and for the UNU-IAS RCE Espoo. A RCE (Regional Center of Expertise) is a network of existing formal, non-formal and informal education organizations, to deliver Education for Sustainable Development (ESD) to local and regional communities. RCEs aspire to achieve the goals of the UN Decade of Education for Sustainable Development (UN DESD 2005-2014). A purposeful sample of stakeholders, partners and supporters of the UNU-IAS RCE Espoo were interviewed (N=27). The interviews were analyzed using concept mapping data analysis. This paper focuses on the concept mapping data analysis of the Director General of The Finnish National Board of Education and represents his understanding of concept of sustainable development and ESD. This is an example how concept mapping is used as a research method to promote shared understanding and learning for sustainable development. We are experimenting how concept maps of a novice concept mapper differs from concept maps of an expert concept mapper, when the same transcript of an interview is used as a source text. Åhlberg's (1991, 1993) theory of concept mapping as a general research method for revealing structure of a prose text is used. Results will be discussed from the viewpoint of ESD.

1 Introduction

According to the United Nations University, Institute of Advance studies (UNU-IAS, 2012), Regional Centres of Expertise (RCEs) "bring together institutions at the regional/local level to jointly promote ESD. They build innovative platforms to share information and experiences and to promote dialogue among regional/local stakeholders through partnerships for sustainable development. They create a local/regional knowledge base to support ESD actors, and promote four major goals of ESD in a resource-effective manner…" RCE Espoo is one of the 101 accepted RCEs around the world. Our paper deals with UNU-IAS RCE Espoo, in particularly, how concept mapping can be used as a research method to promote shared understanding and learning for sustainable development. Earlier, concept mapping for sustainable development has been researched by Åhlberg (1993, 2004a and 2005). Concept mapping as a research method has been thoroughly discussed in Wheeldon & Åhlberg (2012). We have not found earlier research in which novices and experts in concept mapping would have constructed concept maps from the same text. We used keywords 'concept map novice expert'. Expertise is focused on special area or field of human culture. To become an expert in any area requires about ten years of purposeful inquiry and practice. An expert has "has stored experience of the actual outcomes of tens of thousands of situations" (Charness, N. & al. (Eds.) (2006) and Dreyfus, H.; Dreyfus, S. (2005)). Åhlberg's research from 1989 has been focused on research use of concept mapping. He has used, researched and developed different versions of Novakian concept mapping for different purposes over decades, tens of thousands of times. He has published both nationally and internationally on the subject. Mr. Jani Siirilä, as his doctoral student has started use of concept mapping in the year 2012. In this sense he is a novice on concept mapping.

1.1 Research Questions

1. What is the structure and content of two basic concepts of SD and ESD as revealed by an interview of the Director General of The Finnish National Board of Education?
2. How do concept maps of a novice concept mapper differ from an expert concept mapper in this comparison?

2 Method: Using concept mapping in data analysis to promote shared understanding for ESD

2.1 Sampling, data and concept mapping as a research method

A purposeful sample of stakeholders, partners and supporters of UNU-IAS RCE Espoo were interviewed (N=26). The interviews were analyzed using concept mapping data analysis (Åhlberg 1991, 1993, 2004, 2005 and Wheeldon & Åhlberg 2012). This paper focuses on the concept mapping data analysis of the Director General of The Finnish National Board of Education. We present excerpts from transcription of the interview.

The novice concept mapper (Jani Siirilä, a doctoral student) and an expert concept mapper (Prof. Mauri Åhlberg) transformed the same texts into concept maps. We will compare the original translated, and slightly edited transcripts, and the three concept maps. Transforming free oral language to written language demands a little bit editing. When people are thinking and speaking at the same time, they are seeking for words how to best express their thoughts. We have presented our interpretation what the interviewee tried to express in the transcript. We are using the interviewee's own words as accurately as possible. The method we used was presented originally by Åhlberg (1991 and 1993), developed on the work of Novak (1981) and Novak & Gowin (1984).

2.2 Relevance, validity and reliability of the research and its conclusions

The data is very valuable and relevant, because it is from the person who was one of the originators of UNU-IAS RCE Espoo and nowadays the Director General of the National Board of Education. Validity and reliability of concept mapping has many aspects (Åhlberg 1991, 1993, Wheeldon & Åhlberg, 2012). One aspect of validation is auditing: comparing the original text and the concept map, checking the concept map concept by concept, proposition by proposition. The expert's concept maps have more validity, when audited proposition bay proposition, concept by concept. The other form of concept mapping validation is social validation: showing the concept maps to the interviewee and asking him to check whether they correspond his thinking. By doing this way concept maps can be amended until the interviewee is satisfied with the resulting concept map. The social validation will be done later on. Methodologically, the results can be generalized to other similar situations, in which oral or written text is to be transformed into one or more concept maps. Again, concept mapping showed its power in revealing propositional and concept structure of the interviewee.

2.3 Data

The first excerpt from the interview the Director General of the National Board of Education, an answer to the question focused on how the interviewee understands concept of sustainable development and from the three aspects of sustainable development (ecologic, economic and social) its ecological dimension: "I understand sustainable development as a value. A value for me is a guiding principle for action, a way of thinking. We ought to think always what are the consequences of what we do, and what would be a sustainable way of acting. It means that we do not destroy nature, people or society. We ought to make decisions based on ethical thinking. The Earth has limits. Natural resources are limited. Ecosystems are vulnerable. If natural resources are used too much, they will diminish and end. Fishing is an example. The seas have been fished too much and fish catches are diminishing. In mining, amount of many useful minerals has been declined. I am an expert in history, and I have many examples how cultures have been destroyed, when they have not lived sustainably. In these cases, the whole landscapes have been transformed. Ancient Greece is a typical example. Its forests were felled, and the whole country became transformed. In US Midwest, land was farmed unsustainably, as a result the top soil was literally blown away by winds, this led to surge of refugees. I mean, I'm proceeding on the supposition that we do not waste natural resources, rather that we should live in a way that our footprint of coal and those that are identical are as small as possible. I mean, that natural resources ought to be used sustainably. Small is beautiful in this sense."

The second excerpt from the interview the Director General of the National Board of Education, an answer to the question focused on how the interviewee understands concept of Education for Sustainable Development (ESD): "(1) In ESD thinking, thinking skills, sense of community etc. will be promoted. (2) Pupils will learn to create, learning by doing, integrating ideas broadly. (3) ESD is focused on creation of a worldview, integration of personality, and creating sufficient capabilities, in order that pupils will become able to flourish in this world. (4) ESD is not rote learning, and is not learning those kinds of contents that do not have any practical value, learning those kinds of contents that do not have any practical value. (5) This is the way, how sustainable development becomes a value, that influences the whole societal change via behavior of individuals." Numbering statements from (1) – (5) is done in order to show, how a concept map can be created that follows the original text as closely as possible.

3 Results

3.1 Understanding the concept of sustainable development

Based on the interview transcript excerpt #1, concept maps created by a novice and an expert concept mapper are represented in Figures 1 and 2. The two concept maps differ in, how detailed the understanding of sustainable development is presented in concept maps. The novice aims for comprehensive view in his concept map analysis. Number of concepts and propositions is very different in these two concept maps. The novice concept mapper summarizes the central aspects for ecological sustainable development into two main points: "sustainable use of natural resources" and "small footprint of coal". Expert concept mapper follows the text more detailed proposition by proposition, concept by concept. The expert in this case, aims for accurate presentation of interviewee's concepts and propositions.

3.2 Understanding the concept of education for sustainable development

Based on the interview transcript excerpt #2, concept maps created by a novice and an expert concept mapper are presented in Figures 3 and 4. The two concept maps differ in relation to how accurately they follow the original text. The novice aims for comprehensive view in his concept map analysis. The expert's concept maps follows accurately the original text proposition by proposition, concept by concept. The novice uses 13 concepts and the expert 16 concepts. All concepts used by the novice and the expert can be found in the original transcript. The experts created the second, more articulated version of the interview transcript excerpt #2, that is presented in Figure 5.

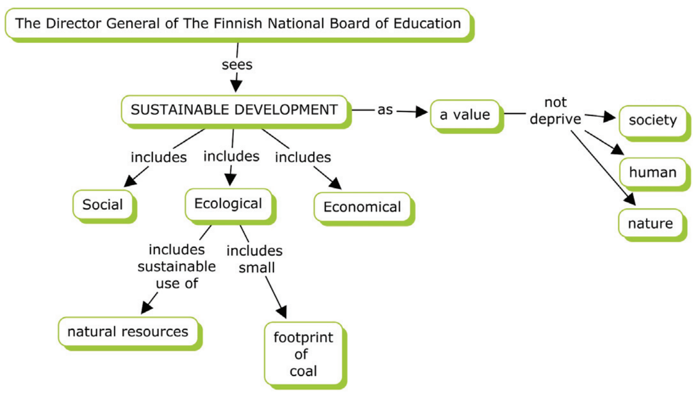

Figure 1. A concept map of the concept of ESD, created by a novice concept mapper from the interview transcript.

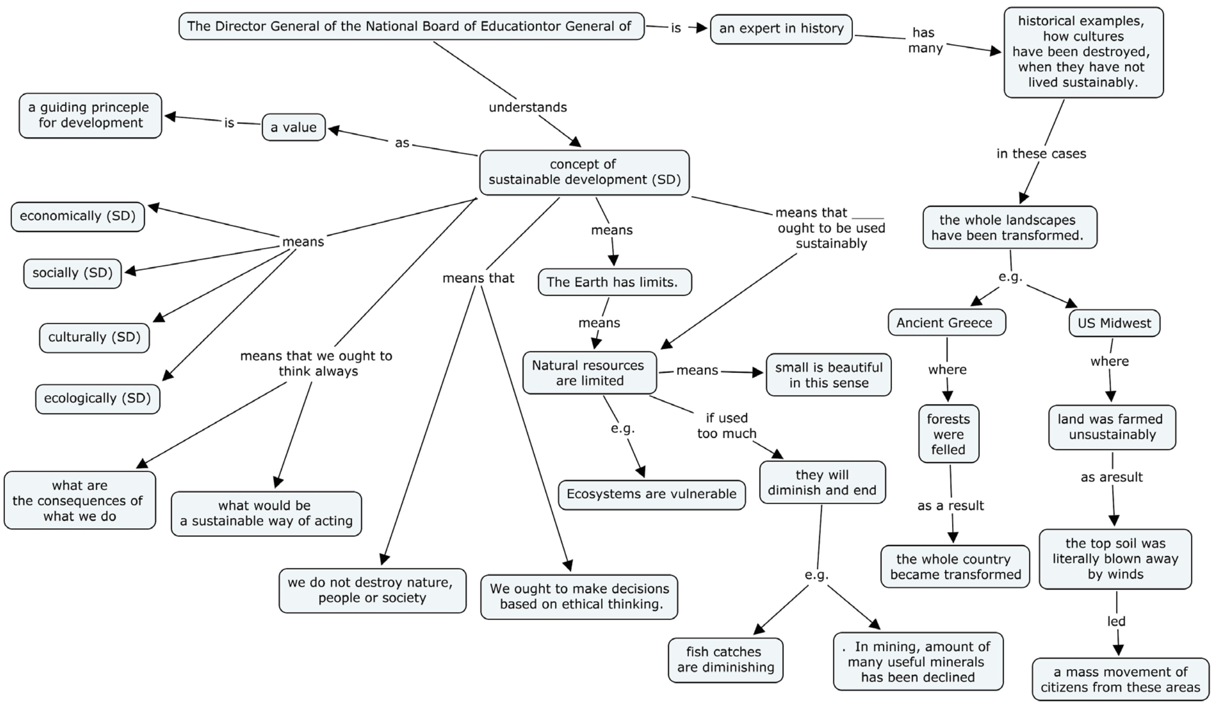

Figure 2. A concept map of the concept of ESD, created by an expert concept mapper from the interview transcript.

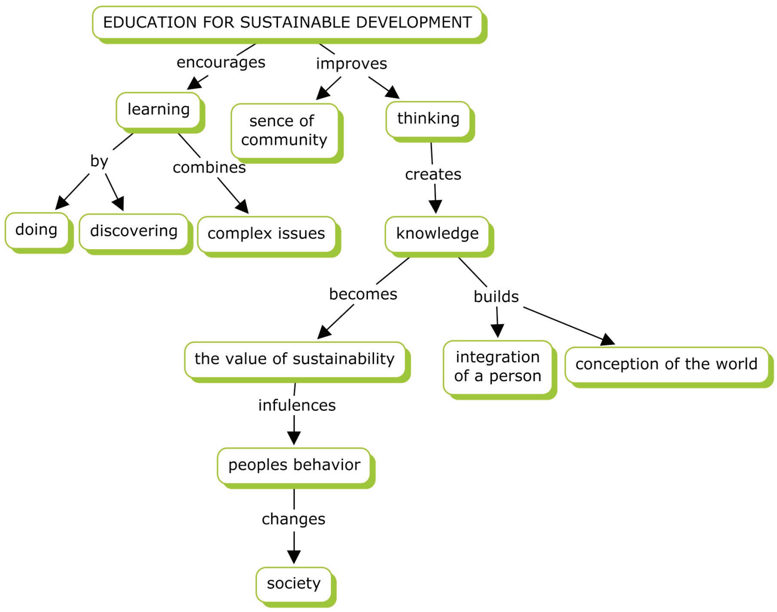

Figure 3. A concept map of the concept of ESD, created by a novice concept mapper from the interview transcript.

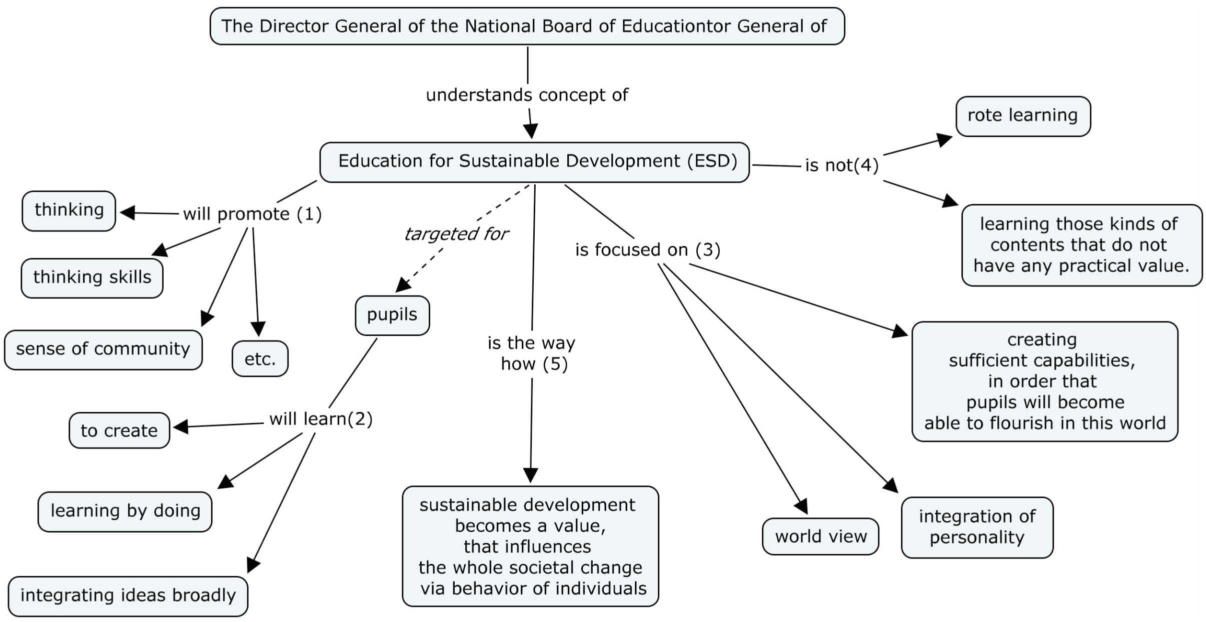

Figure 4. A concept map of the concept of ESD, created by an expert concept mapper from the interview transcript. The first version.

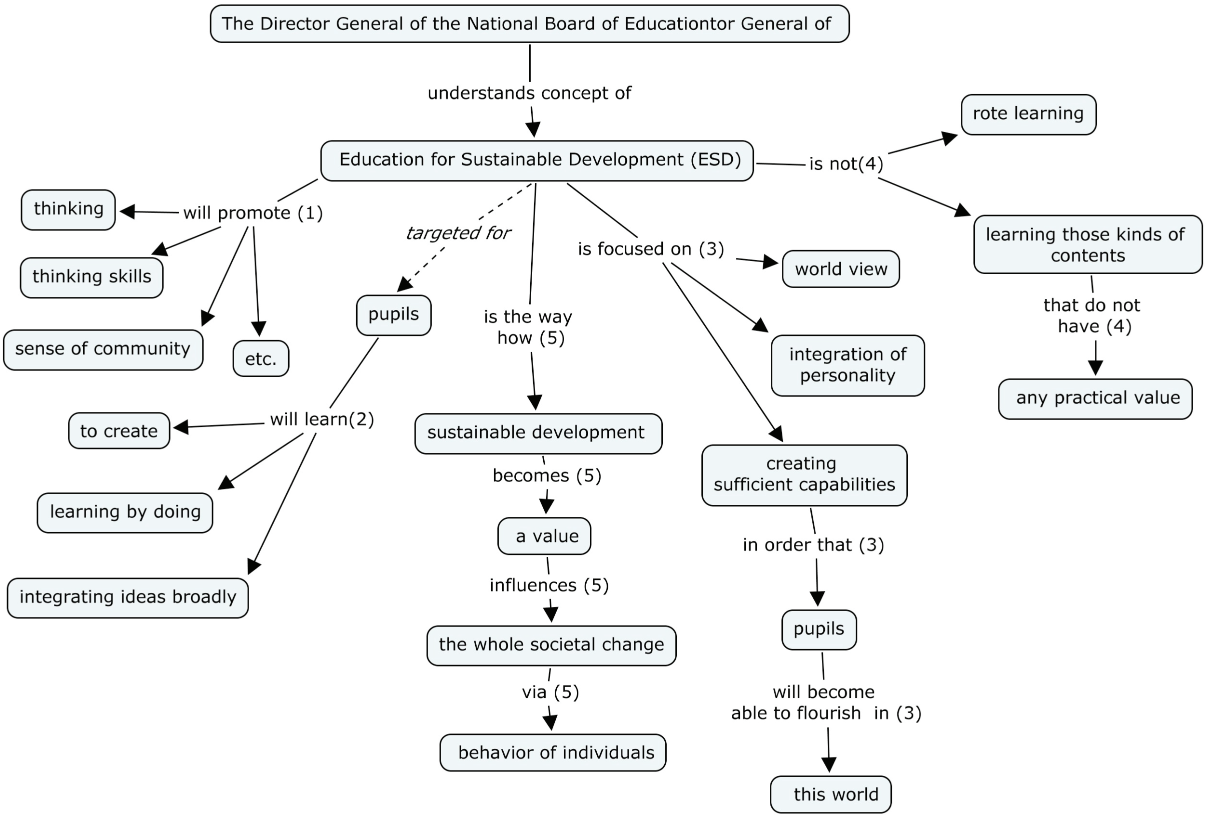

Figure 5. A concept map of the concept of ESD, created by an expert concept mapper from the interview transcript. The second version.

4 Results and discussion

Qualitatively concept maps differ in many ways. The impression is that the two concept maps of the novice are clearly smaller than the concept maps created by the expert. The detailed qualitative analysis reveals that in our case study, the novice uses concept mapping method as described in Novak & Gowin (1984). The linking words are very short, but still they can be found in the original text. The novice aims for comprehensive view via more holistic approach in his concept map analysis. The concept maps created by the expert use flexible improved concept mapping method developed by Åhlberg (1991 – 2004b). The linking phrases can be as long as needed. The label for concept can be as long as needed. Equivalent to concepts in a concept map, also other undivided mental contents can be used inside concept boxes, such as ‘the top soil was literally blown away by winds’ and ‘fish catches are diminishing’. The main point is to search for as good correspondence between the thinking, thoughts, ideas, content of oral or written words, as possible.

Because the original interview was in Finnish and both of us translated it independently, we came a little bit different translations. The expert has studied psychology in Helsinki University, and he translated “persoonan eheytyminen” into a psychological term “integration of personality”. The novice has studied sociology, and he translated the same Finnish words into “integration of a person”. After checking from the transcript, what the interviewee means, the expert changed his mind: ‘Integrating of person’ is a better translation to English. The expert remembered also how Jarvis (2006, 32 -49) in his adult learning theory book highlighted the idea: “It is the whole person who learns”. The other interesting dialogue between the novice and the expert was created by the Finnish expression “käsitys maailmasta”. The novice translated it into ‘conception of the world”. The expert first thought that expression of ‘world view’ might be the best translation, because there is psychological article of importance of worldviews (Koltko-Rivera 2004). For sure there is also Piaget’s (1960) book that is translated into English titled ‘The Child's Conception of the World’. After truth seeking dialogue, the expert admitted that from the two possible translations, they discussed, the novice’s conception of the world’ was the best choice. It came into the expert’s mind that the famous Finnish philosopher Eino Kaila (1929) published a book ‘Nykyinen maailmankäsitys’, which translates into ‘The Modern Conception of the World’. It is a better choice than “world picture” that as often used in 20th century.

Quality of the concept map	**Topic 1:** The sum of concepts (k)	**Topic 2:** The sum of propositions (p)	**Topic 3:** DIFFERENCE (k) – (p)
Novice (N1), the 1st	11	9	2
Expert (E1), the 1st	29	29	0
DIFFERENCE (E1 –N1)	18	20	

Table 1: Quantitative differences between the novice's and the expert's first concept maps

Interpretation of the Table 1: The expert uses much more concepts and propositions than the novice. The expert tries to catch as accurately as possible the wording, conceptual and propositional structure of the interviewee's as possible.

Quality of the concept map	**Topic 1:** The sum of concepts (k)	**Topic 2:** The sum of propositions (p)	**Topic 3:** DIFFERENCE (k) – (p)
Novice (N2), the 2nd	13	12	1
Expert (E2), the 2nd	16	14	2
DIFFERENCE (E2 – N2)	3	2	

Table 2: Quantitative differences between the novice's and the expert's second concept maps

Interpretation of the Table 2: The expert uses more concepts and propositions than the novice. The expert tries to catch as accurately as possible the wording, conceptual and propositional structure of the interviewee's as possible. This time expert uses many "concepts" that can be interpreted as undivided wholes.

Quality of the concept map	**Topic 1:** The sum of concepts (k)	**Topic 2:** The sum of propositions (p)	**Topic 3:** DIFFERENCE (k) – (p)
Novice (N2), the 2nd	13	12	1
Expert (E2), the 2nd	21	20	1
DIFFERENCE (E2 – N2)	8	8	

Table 3: Quantitative differences between the novice's second concept map and the expert's the second version of second concept map.

Interpretation of the Table 3: The expert uses much more concepts and propositions than the novice. The expert tries to catch as accurately as possible the wording, conceptual and propositional structure of the interviewee's as possible. This time expert divides the "concepts" that were interpreted as undivided wholes in his first version of the interview transcript excerpt #2. In his second version of the second concept maps, he tries to use as basic concepts as possible. The result is very big difference between the novice's and the expert's concept maps.

5 Conclusions

Research on research methodology is useful in the sense, that it can be generalized into all similar analyzes of texts, theoretically/conceptually/analytically as all case studies do (Halkier 2011). Cases are always cases of something. In this paper, cases in interview transcripts, and prose texts in general. Applying (Åhlberg & Ahoranta, 2008) we conclude: Our research data are not random samples, but purposeful samples, which are information rich (applying Patton1990, 181–185 and Patton 2002, 242). The researched texts are sample of interviewee's thinking and responses (Cook, Leviton & Shadish 1985, 763 – 764; Yin 2009; de Vaus 2002, 148). Purposeful samples of real interviewee excepts allow us to conclude that under the similar conditions, similar phenomena are likely to happen. For sure, each stakeholder is unique in his/her thinking in details, but very probably there are common concepts and common propositions, shared culture. It is the goal of future research to find out what is shared and what is different in each stakeholders thinking, what propositions and work theories are sound, will stand continual theoretical and empirical testing, and which are not, whether there are innovations, that would deserve spreading more broadly etc.

The Director General of the National Board of Education is a learned man. Based on his interview transcripts, and concept maps, created from them, he has sound propositional and conceptual structure of ESD. His ideas provide good starting points for practical actions and continual dialogue for truth and ESD. For sure, he is not an expert in ESD, but he seems to understand many key issues of SD and ESD. It is a good starting point. In future this experiment ought to be replicated using different source texts. Interesting is also to make research on learning from novice to expert in improved concept mapping, in which accurate correspondence between source text/thoughts are sought.

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ANALISIS DEL CONTENIDO Y LA ESTRUCTURA DE LAS REPRESENTACIONES A PARTIR DE MAPAS CONCEPTUALES

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Abstract. Proponemos los mapas conceptuales como herramienta para la recolección de representaciones sociales y/o científicas y como fuente de información apta para la determinación tanto de la estructura, como del contenido de una representación común -a un grupo de estudiantes universitarios en nuestro caso de estudio-. Basándonos en diferentes métodos de exploración de las representaciones sociales, particularmente en la "teoría del núcleo central", hemos adaptado tres análisis para la determinación de la representación común a partir de los mapas conceptuales. Estos análisis, constituyen una triangulación metodológica que permite la identificación del núcleo y periferia de la representación común.

1 Introducción

Durante las últimas tres décadas, la identificación de las representaciones de los alumnos ha sido un tema central en la investigación en didáctica. Según Mignon y Closset (2004), el pasaje del discurso de la vida cotidiana al científico no es fácil para los estudiantes y con frecuencia el conocimiento común del alumno prevalece sobre el saber científico. De hecho, las investigaciones referentes a las representaciones de los estudiantes han puesto en evidencia las raíces profundas de estas ideas y las diferencias significativas respecto a los conocimientos científicos (Duit y Treagust, 2003).

Las investigaciones realizadas con el fin de explicar la resistencia a la apropiación del conocimiento científico, con frecuencia la analizan fragmentando la información. En efecto, la mayoría de las investigaciones en didáctica de ciencias insisten en identificar las representaciones de conceptos aisladamente; los estudios no tienen suficientemente en cuenta las representaciones como un sistema, es decir, como un conjunto de elementos (conceptos) en interacción (relaciones). En el caso de Ecología por ejemplo, a menudo, los investigadores se preguntan por la idea que tienen los estudiantes de un concepto: ecosistema, cadena trófica, fotosíntesis, etc., sin considerar todos elementos de la representación y aspectos tales como la función que el concepto desempeña o la estructura a la que pertenece. Esto puede verse en la mayoría de los estudios de "concepciones erróneas" (ver Stamp, N., 2007).

Explorar las representaciones de conceptos como sistema nos parece esencial. En esta perspectiva, hemos examinado las teorías que estudian la organización interna de las representaciones sociales y elegimos la del "núcleo central", ideada por Abric (1976). Según esta teoría, identificar la estructura de una representación es principalmente reconocer su núcleo central, lo que significa "considerar las representaciones sociales como sistemas cognitivos jerárquicos basándose en dos dimensiones: una central y otra periférica. Delimitar lo que constituye el 'corazón' de la representación es esencial para identificar a describir o comprender su dinámica" (Roussiau y Bonardi, 2001, p.119).

Se sabe que el estudio de la estructura de las representaciones en Sociología, incluye una gran variedad de herramientas para la recolección de datos: verbales, escritas y gráficas. Según nuestra exploración bibliográfica, el mapa conceptual como instrumento de recolección de representaciones sociales aún no ha sido utilizado, por tanto tiene características que pueden ser de gran utilidad. En efecto, los mapas conceptuales favorecen la expresión de las personas y reducen los límites de producción discursiva -tales como la cantidad de información a analizar y su organización-. Permiten un análisis de contenido cuantitativo y cualitativo de la representación. Ponen en evidencia los vínculos significativos entre los conceptos y permiten visualizar el campo semántico de la representación. La información se presenta en forma de unidades de significado: las proposiciones.

Sabemos también que el análisis de las representaciones en Sociología requiere la aplicación de varios métodos (triangulación metodológica), porque es sólo a través de la combinación de diferentes procedimientos que la exactitud y la estabilidad de las observaciones pueden verificarse (Apostolidis, 2003). A este respecto hemos observado que los datos provenientes de los mapas conceptuales pueden ser equivalentes a los obtenidos por otras herramientas y con ellos también es posible lograr una triangulación.

En este artículo, proponemos los mapas conceptuales como una herramienta para la recolección de representaciones sociales y/o científicas y como fuente de informaciones aptas para el análisis de representaciones y para la organización de una triangulación metodológica.

2 La representación: contenido y estructura

El concepto de "representación" fue elegido en ciencias sociales para referirse a "una gran clase de formas mentales (ciencia, religión, mitos, espacio, tiempo), de opiniones y de conocimientos, de manera indiscriminada" (Moscovici, 1989, p.65). El término permite abordar esta variada clase de formas mentales de manera individual o colectiva. Una representación individual es aquella propia del individuo. Las representaciones colectivas son aquellas que presentan las ideas, creencias y valores de un grupo social.

De la redefinición del concepto de representación colectiva, introducida por Moscovici, se deriva el concepto de "representación social", definido como "una forma de conocimiento, socialmente elaborado y compartido con una finalidad práctica, que contribuye a la construcción de una realidad común para un grupo social" (Jodelet, 1989, p.36). La representación social "puede ser considerada como un conjunto de elementos cognitivos vinculados por relaciones, donde los elementos y las relaciones son validados por un grupo específico" (Flament y Rouquette, 2003, p.13).

Según Abric (2003), en la actualidad, la investigación en representaciones sociales dispone de un conjunto de herramientas metodológicas que garantizan el carácter científico de los resultados y permiten una aproximación multi-metodológica que refuerza su fiabilidad. Esas herramientas y métodos son el resultado de tres tipos de enfoques: uno antropológico, basado en el estudio y observaciones en el terreno, la recolección de datos y el análisis de los testimonios (Jodelet, 1989), otro basado en el análisis de datos y encuestas (Doise, et al., 1992) y un último estructural, basado en la "teoría del núcleo central" de Abric (1976).

La teoría del núcleo central considera una representación social como un conjunto de información organizado y estructurado que constituye un sistema socio-cognitivo particular compuesto por dos subsistemas en interacción: un sistema central y otro periférico (Abric, 2001). El sistema central o núcleo, es el elemento fundamental de la representación ya que determina tanto su estructura como su significado. El sistema periférico esta compuesto por elementos ordenados jerárquicamente alrededor del núcleo. Según la teoría, es importante identificar el núcleo de una representación para describir y comprender la dinámica que lo caracteriza.

Nuestra investigación se inscribe en el enfoque estructural, basado en la "teoría del núcleo central". Somos conscientes de que las representaciones de los estudiantes incluyen creencias y valores que influyen en la apropiación del conocimiento, pero no las discutiremos en este artículo. Hemos elegido centrar nuestra atención en la representación de los conceptos científicos en Ecología, que es compartida por un grupo de estudiantes. A ella haremos referencia con los términos de "representación común" en lugar de representación social.

3 Preguntas y dispositivo de investigación

En este artículo pretendemos responder a las preguntas siguientes: ¿Cómo utilizar los datos de los mapas conceptuales para identificar el núcleo y la periferia de una representación común? ¿Qué tipo de datos puede ser utilizado como base? ¿Qué análisis pueden ser aplicados?

En cuanto al proceso metodológico, incluye la selección de la población, del tema de trabajo de las representaciones (los conceptos clave) y el procedimiento de recolección de datos.

3.1 La población

Está constituida por diecisiete (17) de los diez y nueve (19) estudiantes de segundo año de bachiller, inscritos al curso de Ecología (UCL, 2010), realizado durante el año académico 2009-2010, en la facultad de Biología de la Universidad Católica de Lovaina (Bélgica).

3.2 Identificación de los conceptos clave

Según Novak (2006), para construir un mapa conceptual, primero hay que delimitar el tema. En nuestro caso se restringe al contenido del programa del curso de Ecología, concretamente a los conceptos considerados como "clave".

Para identificarlos, se procedió a un análisis del libro de referencia del curso (Ecología, Ricklefs y Miller, 2005) y de los documentos guías preparados para los estudiantes. Del resultado de los análisis y la opinión del profesor se obtuvo una lista que incluye veinte conceptos: *adaptación, biodiversidad, cambio, comunidad, competencia, dinámica, ecología, ecosistema, medio ambiente, especies, evolución, factores abióticos, factores bióticos, flujo de energía, individuo, interacción, mutualismo, población, predación y selección natural.* Este repertorio de "conceptos clave" es propuesto a los estudiantes como la base para la construcción de sus mapas conceptuales.

La presentación de los veinte conceptos a los estudiantes es una opción que obedece a la voluntad de concentrar su atención en la Ecología como una ciencia y no en las acciones o de protección y/o preservación del medio ambiente.

3.3 Recolección de Datos

Los mapas conceptuales, que contienen las representaciones acerca de los conceptos de Ecología, fueron realizados de la siguiente manera: los estudiantes participaron a una sesión introductoria de 45 minutos, durante la cual se presentó el método de realización de mapas conceptuales, el programa CmapsTools y algunos ejemplos de mapas relacionados con la Biología. Luego realizaron un mapa a manera de ejercicio (30 minutos) y a continuación, ellos trabajaron durante una hora y media en la creación de su mapa.

Los estudiantes fueron invitados a construir el mapa como respuesta a la pregunta: "¿Cómo cree usted que se relacionan los conceptos de Ecología?". En esta perspectiva, se dieron las siguientes directivas:

1. Lea la lista de conceptos. Seleccione los que considere apropiados (mínimo 16) y añada otros si lo requiere (teniendo en cuenta el límite de 24 conceptos).
2. Escriba un concepto en cada rectángulo. Cada concepto debe aparecer una sola vez en el mapa.
3. Redacte los enlaces entre los conceptos.
4. Registre: la construcción del mapa con la opción "grabadora" y registre el mapa.

4 Triangulación metodológica

Con el fin de identificar el núcleo y la periferia de la representación común de los estudiantes, proponemos tres análisis: orden de selección de los conceptos, de robustez y de asociación. El primero tiene en cuenta la etapa de construcción del mapa y los demás el mapa como producto (Salamanca-Ávila y Vander Borght, 2010). A continuación, de cada uno de ellos, explicaremos el principio, el procedimiento, el resultado, la interpretación y las limitaciones.

4.1 Orden de selección de los conceptos

Este análisis ha sido inspirado por el de "asociación libre" (Abric, 2003) que estipula que a partir "de una palabra de estímulo, se le pregunta al sujeto a propósito de todas las palabras o frases que le vienen a la mente" (p.63). De esta manera, explica Abric (Ibíd.), la espontaneidad de la respuesta facilita el acceso a los elementos que constituyen el universo semántico del concepto, objeto o término estudiado.

En el caso de la construcción de un mapa conceptual, la pregunta de enfoque incluye o indica la palabra de estímulo. En nuestro estudio la pregunta: ¿Cómo cree usted que se relacionan los conceptos de Ecología?, anuncia el concepto inductor "ecología", que será, normalmente, el concepto raíz de los mapas elaborados por los estudiantes.

En el proceso de construcción de un mapa conceptual hay dos escenarios posibles: el individuo es libre de redactar los conceptos, o parte de una lista de conceptos entre los que se debe efectuar una elección. Consideramos que la primera opción corresponde literalmente a una asociación libre, mientras que la segunda es una adaptación a la que llamaremos "selección de conceptos" (es el caso en nuestro estudio).

4.1.1 Procedimiento

- El video del proceso de construcción de mapas, nos permitió codificar la secuencia de selección de los conceptos, para cada estudiante.
- Para registrar los datos, otorgamos un valor numérico a todos conceptos de la lista, a excepción del concepto inductor "ecología". Así, asignamos el número 1 al primer concepto seleccionado, dos al segundo y así sucesivamente. Los conceptos de la lista que no hayan sido seleccionados fueron considerados como última opción, a ellos corresponde entonces la última cifra.
- Una matriz "grupal" fue elaborada con datos individuales. Esta matriz se sometió al análisis de clasificación jerárquica utilizando el programa estadístico "R Comander". Como parámetros de análisis, se optó por el método de agregación de Ward, la Distancia Euclídea al cuadrado.

4.1.2 Resultado e interpretación

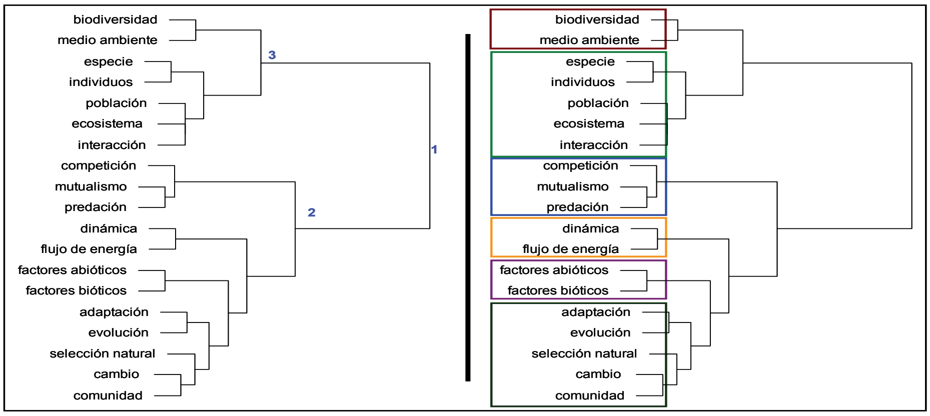

Figura 1. Clasificación jerárquica del orden de selección de los conceptos. (Método de agregación de Ward, distancia Euclídea al cuadrado). A la izquierda, los grupos que conforman la estructura del árbol. A la derecha la distribución de las clases y de temas

De acuerdo con el dendrograma resultado del análisis de clasificación jerárquica, desde el punto de vista estructural, el campo representacional (identificado con el número 1), presenta una dicotomía entre el posible núcleo: grupo 3 y la posible periferia: grupo 2.

Desde el punto de vista del contenido, es posible deducir que los estudiantes asocian rápidamente el concepto de "ecología" a los conceptos: *interacción, ecosistemas, poblaciones, especies e individuos*. El concepto de "ecología" también está vinculado -menos directamente- a la *biodiversidad y el medio ambiente*. Todo parece indicar que el núcleo de la representación es: *"La Ecología es el estudio de las interacciones en el ecosistema entre las poblaciones, los individuos y las especies"*. Definición que se complementa con los conceptos de *medio ambiente y biodiversidad*.

En cuanto a los conceptos del segundo grupo, la posible periferia, encontramos que los subgrupos tienen un tema específico. De esta manera, un grupo se compone de ejemplos de las interacciones entre los seres vivos (*competencia, predación y mutualismo)*. Otro relacionado con la energía (*dinámica y flujo de energía*). Uno más constituido por factores del medio (*factores biótico y abiótico*). Y un último relacionado con la teoría de la evolución (*adaptación, evolución, selección natural, cambio, comunidad*).

4.1.3 Limites del análisis

El análisis del orden de la selección de los conceptos es interesante ya que permite explorar la estructura de la representación a partir del proceso de construcción del mapa. Sin embargo, no debe olvidarse que el orden de selección de los conceptos -o de redacción de los conceptos-, puede utilizarse solamente como un "índice de accesibilidad", ya que es posible que las palabras asociadas fácilmente no sean las más importantes para el individuo, sino las más compartidas socialmente (Silvana de Rosa, 2003). Para tener certeza hay que validar la información con otros análisis.

4.2 Análisis de robustez

En el análisis de "evocaciones jerárquicas", Abric (2003) relaciona dos indicadores cuantitativos para cada elemento: "la frecuencia de aparición de un concepto y la importancia dada a este ítem por los sujetos" (p.63).

La frecuencia de aparición es un indicador de la centralidad a condición de complementarse con información acerca de la importancia acordada por el sujeto.

Bajo el nombre de "análisis de robustez", nosotros hemos adaptado el análisis de evocaciones jerárquicas a los mapas conceptuales. En este caso, la frecuencia de aparición del concepto en un grupo, se refiere al número de estudiantes que citaron el concepto. La importancia acordada, la hacemos corresponder a un "índice de la subordinación del concepto" (I.s.c.), calculado por la fórmula:

$$I.s.c. = \frac{\text{nivel de jerarquía del concepto}}{\text{nivel de jerarquia del mapa}}$$

El nivel de la jerarquía del mapa corresponde al número conceptos, contados a partir del concepto raíz (presente en el nivel 1), que forman la cadena más larga. El nivel de jerarquía de un concepto "x", corresponde al lugar que ocupa el concepto en una cadena, contando siempre a partir del concepto raíz.

4.2.1 Procedimiento

- En primer lugar es necesario calcular las dos variables y registrarlas en una matriz grupal para obtener las medias.
- Con los datos de las medias se realiza una gráfica bidimensional de coordenadas cartesianas, en la que los datos de la frecuencia de aparición del concepto corresponden a la eje de la abscisa (X) y los de la media del índice de la subordinación del concepto, al de las ordenadas (Y).
- Finalmente, se delimitan los cuadrantes determinados trazando las líneas rectas que correspondientes a los valores medios de la frecuencia de aparición del concepto y de la importancia jerárquica (Figura 2).

4.2.2 Resultado e interpretación

Para interpretar el gráfico, debe seguirse las instrucciones de Abric (2003): El cuadrante 1 corresponde al núcleo central, los cuadrantes 2 y 4 contienen los elementos periféricos, clasificados como primera periferia y segunda periferia respectivamente. El cuadrante 3 contiene elementos de contraste, es decir aquellos poco presentes y de poca importancia en el campo de las representaciones. Estos elementos de contraste pueden ser considerados como suplementos de la primera periferia, o puede revelar la existencia de un subgrupo minoritario que tiene una representación diferente.

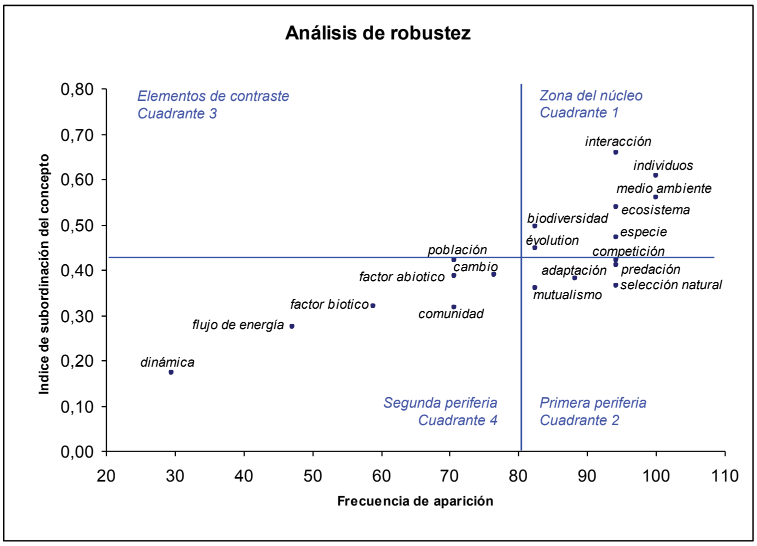

Figura 2. Resultado del análisis de robustez del concepto

Desde el punto de vista estructural, los conceptos del cuadrante 1, la zona núcleo, son los más mencionados por los estudiantes y ocupan los primeros niveles jerárquicos en los mapas conceptuales. El cuadrante 2, primera periferia, contiene los conceptos más comunes citados por los estudiantes, pero a niveles inferiores que los anteriores. El cuadrante 4, segunda periferia, incluye los conceptos citados raramente por los estudiantes y ordenados en niveles de una jerarquía lejanas del concepto raíz -presente en el primer nivel-.

Desde el punto de vista del contenido, el resultado del análisis parece indicar que para los estudiantes, el núcleo de la representación del concepto "ecología" es definido como: *"La Ecología es el estudio de las interacciones en el ecosistema entre los individuos y su medio ambiente. Las interacciones entre las especies puede dar lugar a la evolución y a la biodiversidad".*

4.2.3 Limites del análisis

El análisis presenta el inconveniente de la selección de los ejes horizontal y vertical que definen cuatro zonas (Bouhon, 2009). Por otra parte, como señalan Lebart et al. (2006), los dendrogramas limitan las posibilidades de interpretación dada la falta de representación simultánea de filas y columnas. Lo mejor es validar la información a través de otros análisis.

4.3 Análisis de asociación

Este análisis es una combinación de la "prueba de Olmstead y Tukey" y el análisis de "evocaciones jerárquicas" de Abric (2003). La primera se inscribe entre las pruebas estadísticas no paramétricas y tiene por objetivo determinar la presencia de una correlación entre dos variables (Sokal y Rohlf, 1995), en nuestro estudio la frecuencia de las variables cuantitativas de la asociación de cada concepto y su número total de relaciones. Del análisis de "evocaciones jerárquicas" retenemos la clasificación en cuadrantes para la determinación del núcleo y las periferias.

En una matriz grupal, el "número total de relaciones" se define como la suma de las relaciones establecidas por el concepto. Por ejemplo, en la tabla 1, se registró que el concepto *adaptación* fue relacionado por dos estudiantes con el de *biodiversidad*, un estudiante lo relacionó con el concepto *cambio*, un estudiante lo relacionó con el concepto *medio ambiente*, tres estudiantes lo relacionaron con el concepto *especie*, tres estudiantes lo relacionaron con el concepto *evolución,* un estudiante lo relacionó con el concepto *individuo y* cinco estudiantes lo relacionaron con el concepto *selección natural*. En total los 17 estudiantes, relacionaron el concepto *adaptación* 16 veces con otros conceptos. La "frecuencia de asociación" de un concepto "x", el número de conceptos diferentes a los que el concepto "x" esta conectado. Siguiendo el mismo ejemplo, los 17 estudiantes relacionaron el concepto *adaptación* con siete (7) conceptos diferentes: *biodiversidad, cambio, medio ambiente, especie, evolución, individuos y selección natural*.

Prueba de O-T	adaptación	biodiversidad	cambio	comunidad	competición	dinámica	ecosistema	medio ambiente	especie	evolución	factor abiótico	factor biótico	flujo de energía	individuos	interacción	mutualismo	población	predación	selección natural	**Total de relationes**	**Frecuencia de la relación**
adaptación	0	2	1	0	0	0	0	1	3	3	0	0	0	1	0	0	0	0	5	16	7

Tabla 1. Ejemplo de registro de datos en la matriz grupal

4.3.1 Procedimiento

Siguiendo el protocolo aplicado a los mapas conceptuales por González-Yoval et al. (2004):

- En primer lugar se realizan las matrices de asociación individuales. Cada matriz, contiene las relaciones que un estudiante ha establecido para cada concepto. De esta manera, a cada par de conceptos asociados se le atribuye el valor 1.
- A partir de las matrices individuales, se elabora la matriz grupal (suma de las matrices individuales).
- Una vez registrados los resultados grupales, se calcula la frecuencia de las relaciones y su número total. Luego se realiza un gráfico bidimensional en un plano cartesiano en el que los datos de las relaciones de frecuencia corresponden a la del eje de la abscisa (X) y el número total de relaciones, el eje de ordenadas (Y).
- En paralelo al eje x, se traza una línea que proyecta el valor de la frecuencia media de asociación de conceptos. Paralelamente a la eje y, se traza la línea que proyecta la media del valor total de las relaciones. El resultado es un gráfico en el que los conceptos se organizan en cuadrantes delimitados por la media (Figura 3).

4.3.2 Resultado e interpretación

Cuatro grupos llamados "dominante, constante, ocasional y raro" por González-Yoval et al. (2004), son delimitados. Ellos definen los cuadrantes de la siguiente manera: los conceptos dominantes son los que tienen una frecuencia de asociación más alta y un mayor número de relaciones. Los constantes son aquellos con una alta frecuencia de asociación y un número pequeño de relaciones. Los raros son los que tienen la frecuencia más baja de la asociación y el menor número de relaciones y los ocasionales son los que tienen una baja frecuencia de asociación y de un elevado número de relaciones.

Adaptando el resultado al lenguaje de representaciones sociales, establecemos una correspondencia: los conceptos presentes en el cuadrante dominante corresponden posiblemente al núcleo. Aquellos de los cuadrantes "constantes y raros" constituyen las posibles periferias 1 y 2. Finalmente, los conceptos del cuadrante "raro" corresponden a conceptos aislados o excepcionales.

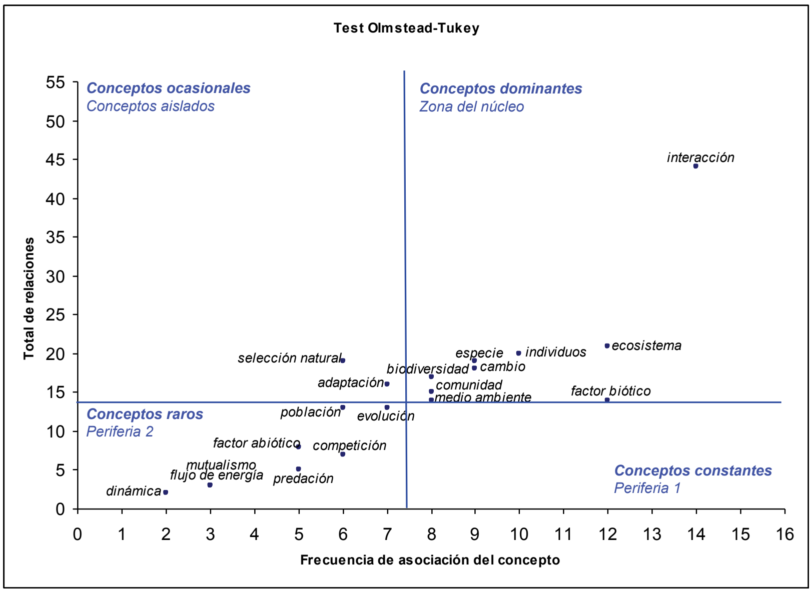

Figura 3. Resultado del análisis de asociación

Basándose en este análisis, la estructura de la representación se compone de conceptos situados en el núcleo y la periferia 2, con dos excepciones presentes en el cuadrante de los conceptos casuales.

En términos de contenido, el posible núcleo de la representación del concepto "ecología" se explica principalmente por el término de *interacción*. Nosotros lo interpretamos como: *"La Ecología es el estudio de la interacción entre los ecosistemas, especies e individuos. Las especies presentan cambios que son el origen de la biodiversidad en el medio ambiente".*

En la periferia 2, se encuentran ejemplos de las relaciones entre los seres vivos: *competición, predación, mutualismo.* Conceptos relacionados con el cambio de energía: *flujo de energía y dinámica*. También están presentes los conceptos *población y evolución*. En el cuadrante conceptos casuales se encuentran los de la *selección natural y de adaptación*, a los que consideramos como parte del núcleo.

4.3.3 Limites del análisis

Del mismo modo que el anterior, este análisis puede proporcionar una primera visión de la representación. Al igual que los otros, su validez depende de la comparación con los resultados de otros análisis.

5 Conclusiones

Los análisis que hemos aplicado para la identificación del núcleo de la representación del concepto "ecología", demuestran que las diferentes etapas de realización de los mapas conceptúales (construcción, producto) proporcionan datos aptos para la para logar la identificación del núcleo y la periferia de una representación común.

En cuanto a la triangulación, los resultados comunes a los tres análisis parecen confirmar que para los estudiantes la "ecología" hace referencia a dos dimensiones, las *interacciones* y los *ecosistemas.* La Ecología parce ser definida como: "*el estudio de las interacciones en los ecosistemas".*

Nuestro trabajo, realizado en un contexto particular limita la población, proporcionando al estudio una validez interna. Sin embargo, creemos que es posible aplicarlo a poblaciones mucho más grandes y en otros contextos. Los mapas conceptuales "bien utilizados" pueden resolver algunos inconvenientes de análisis de representaciones sociales, ¿por qué no incluirlos entonces en una triangulación de datos y/o metodológica? En didáctica pueden ser de gran utilidad en la determinación de "representaciones preexistentes" y en el seguimiento de su evolución a través de un curso.

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ANALYSING KNOWLEDGE GENERATION AND ACQUISITION FROM INDIVIDUAL AND FACE-TO-FACE COLLABORATIVE CONCEPT MAPPING

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Abstract. *Collaborative learning* provides students the opportunity to externalise personal perspectives and compare their understanding of a subject matter area with their peers. *Concept mapping* is a tool that permits students to build visual representations of the relationships among concepts to form a meaningful artefact that models a domain of knowledge or gives an answer to a posed question. *Emerging pervasive devices*, such as interactive tabletops, offer new possibilities to support collocated collaboration and analyse the collaborative process as never before. The synergy between these three fields: collaborative learning, concept mapping and the use of interactive tabletops, offers the possibility to both analyse and support the process of collaborative knowledge building. We report a study of 60 students who created concept maps in the stages: individual pre-concept maps, group concept mapping and individual post-concept maps. We analysed similarity between these and whether individual students were affected by the group collaboration measured through an automatic model. We found that students who contributed most to the group map maintain their understanding in the post-map; while those who contribute least to the group map tend to change their individual perspective. We also found that after students build a concept map at the tabletop their level of agreement is significative higher. The main contributions of this paper are the approach to study individual and collaborative concept mapping; and the analysis of knowledge acquisition and collaboration by tracking the flow of use of propositions.

1 Introduction

The goal of this paper is to present an approach to study the flow of knowledge, *created and acquired*, that occurs when students construct a concept map as a group, aided by a multi-touch interactive tabletop. The synergy between collaborative learning, concept mapping and the use of interactive tabletops offers the possibility to both support and analyse the process of collaborative knowledge building. *Collaboration* includes a series of activities such as discussions, explanations, disagreement, regulation and other group dynamics. These can trigger cognitive mechanisms that do not occur when students work individually and that may enhance learning (Dillenbourg, 1998). Group work provides students the opportunity to externalise their personal perspectives, compare their understanding of the subject matter with others, reach common ground about the concepts under discussion, and integrate individual with group ideas to generate new knowledge (Stahl, 2006). As a result, learning collaboration and argumentation skills is important for value generation in both educational and workplace scenarios (Scheuer et al., 2010). However, truly collaborative relationships do not necessarily occur when students work on a group activity even though computer-based learning systems have been created to facilitate such situations (Kreijns et al., 2003). The role played by teachers and facilitators in the classroom is crucial for helping students to be more aware about their group dynamics and learn collaboration skills (Dillenbourg et al., 2011b). Thus, teachers need resources to improve their awareness about collaboration and the flow of knowledge produced during small-group learning activities.

This paper links collaborative learning with a *concept mapping* activity. Concept mapping is a technique that can help students to create visual representations of the structure of their understanding about almost any knowledge domain, affording meaningful learning (Novak, 1990). Concept maps are directed graphs in which the nodes represent concepts of the learning domain and the relationships between them, called *propositions* or principles, represent a meaningful statement. Concept maps can be regarded as artefacts that model a domain of knowledge as perceived by the creator(s) and can serve as a vehicle for discussion and negotiation of meanings between students and facilitators (Novak, 1995). Thus, concept maps can effectively be used in facilitating collaborative learning and for enabling students to negotiate understanding in small group work (Novak, 1995; Stahl, 2006; Torres et al., 2010). The collaborative construction of a concept map for a given domain of knowledge can offer group members the opportunity to discuss and externalise ideas, represent knowledge from multiple angles, identify misunderstandings, reach agreement, or agree to disagree (Chaka, 2010).

The third element of our work involves the use of *emerging pervasive shared devices*, such as multi-touch interactive tabletops. These offer new possibilities to both support collocated collaboration and capture the *digital footprints* of students' interactions. These data can be exploited to analyse the collaborative process in radically new ways (Martinez et al., 2011a). Conventional tabletops are natural working spaces around which people discuss and work together in activities that require the expertise or consensus of all group members. Interactive tabletops offer an augmented shared space in which all students have equal opportunities of interaction with digital tools, content and communication artifacts, in addition to a natural space for face-to-face discussion, rich group awareness and instant communication (Dillenbourg et al., 2011a).

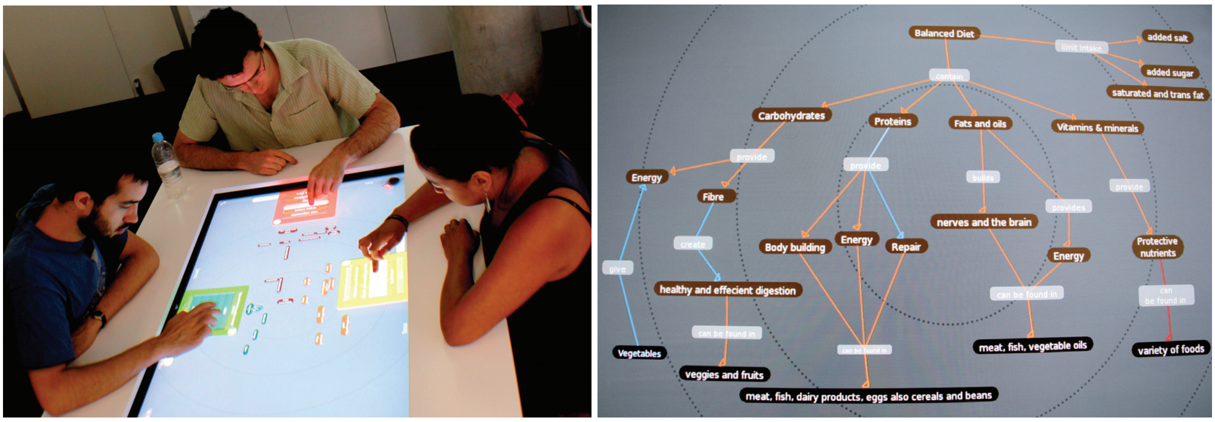

Figure 1. Concept mapping at the multi-touch tabletop. *Left*: Three students starting to add some concepts to build a group concept map. *Right*: An example concept map mainly built oriented towards one of the students. The colours of lines and concepts indicate who created each concept or proposition

This paper focuses on defining a method to track and analyse the flow of knowledge that is created, shared and acquired as a result of group concept maps construction at tabletops. To achieve this goal our work aims to exploit the activity logs that can be obtained during both the individual as well as from collaborative concept mapping activities that were performed, first, in private, using a desktop application, and then, using an interactive tabletop (Figure 1). The information about the flow of knowledge that is shared, in the form of propositions, and its relationship with groups' collaboration can help teachers or students to be more aware about their learning performance, the knowledge domain and their collaborative processes. The main contributions of this paper are the approach to study individual and collaborative concept mapping and the analysis of knowledge acquisition and collaboration by tracking the flow of use of propositions.

The remainder of the paper is organised as follows. The next section describes other studies that have explored the study of collocated concept mapping at the tabletop. Section 3 describes the design and implementation of our study and the learning environments. Section 4 presents the results of the analysis and the discussions. We conclude with a description of ways in which this approach can be adapted to a real classroom scenario and the future work for this project.

2 Related Work

A number of researchers have explored the suitability of concept mapping for interactive tabletop environments (Do-Lenh et al., 2009; Martinez et al., 2011d; Oppl et al., 2011). One of the first of these corresponds to the work done by Baraldi et al. (2006) who built a system that uses concept maps to navigate through wiki's content. Tanenbaum et al. (2009) presented a tabletop system that provided support to students to create a concept map through the use of tangible objects on the interactive tabletop. This system was limited to one user so the opportunity to use the interactive tabletop for discussion and collaboration was restricted. Do-Lenh et al. (2009) performed the first study to explore the benefits of using an interactive tabletop to help collaborative concept mapping, compared with the use of a personal computer. Results were negative for the interactive tabletop as authors did not find significant differences between concept mapping at the tabletop or sharing via conventional desktop computers. Indeed, they found that a group sharing a desktop computer showed healthier aspects of collaboration such as discussion and negotiation. However, the comparison was not entirely fair because sharing one desktop computer means that one mouse and one keyboard must be shared. Therefore, there is a restriction that does not exist at an interactive tabletop, in which all students have the same opportunities for interaction. Later, Oppl and Stary (2011) designed a study to look for advantages of concept mapping aided by an interactive tabletop. They found that concept mapping at the tabletop offers students equal opportunities of participation to share their individual understandings and build a collaborative concept map when compared with other mediums (e.g. a networked system). The work reported in this paper presents research that goes beyond the previous work as our approach provides valuable insights about the *process* to create a combined concept map as they come together after working individually on personal concept maps.

3 Description of the Study

Next, we describe the methodology that was followed and the concept mapping collaborative learning system. One approach that has proven successful, both as a teaching technique and a research approach, is to follow the construction of individual concept maps in private with the construction of a collaborative concept map (Engelmann et al., 2010; Novak, 1995). This provides the opportunity for students to reflect in private and define a personal perspective about the knowledge domain at their own pace. After this, they then focus on the demanding task of collaboration to establish common ground with other students, negotiate their personal perspectives and appropriate the knowledge generated by the group. This strategy is supported by the theory of *Group Cognition* in which the process of knowledge building is modelled as a continuous loop of individual and collaborative moments of learning (Stahl, 2006). Our approach grounds on this theory by providing both an individual and a shared space for group members to build a number of concept maps about a chosen domain. The goal of our study was to analyse the flow of the use of propositions by group members, from individual to collaborative learning, linked with the level of collaboration. We aimed to investigate the following hypotheses:

- *Hypothesis 1. There exists a positive correlation between the quantity of propositions included by one student to the tabletop group map and the extent of permanence of their individual perspective.* In other words, students that contribute more to the *group* concept map at the tabletop demonstrate less change in their perspectives after the group concept map building task, whilst the less contributing group members modify their perspectives more, appropriating new information from the group.

- *Hypothesis* 2. *There is more agreement among group members after building a group concept map at the tabletop.* Building a group concept map at the tabletop makes an observable impact on the shared knowledge and persists after the activity.

- *Hypothesis 3. There exists a positive correlation between the extent of collaboration of a group and the new knowledge represented in the group concept map.* The theory of group cognition and a wide range of studies on collaboration indicate that one of the main outcomes of healthy collaborative interactions is the generation of "new knowledge". This takes the form of ideas that were not present in the individual perspectives (concept maps) but are discovered by the group cognition (Stahl, 2006).

- *Hypothesis 4. There is a negative correlation between the similarity of perspectives among group members and new knowledge represented in the group concept map.* In other words, those groups in which the group members have divergent points of view about the topic will come up with more conflicting ideas that will drive the generation of completely new ideas in the form of propositions that were never considered by any of the group members before the group session.

Hypothesis	**Formulation**
Students who have more of their propositions in the group map well reproduce most of their initial concept map after the group session.	ρ $(d(m_i,m_g)),(d(m_i,m'_i))> 0$
There is more agreement in the maps of group members after they build a group concept map at the tabletop.	$Avg\ (d'_{1,2,3}) < Avg(d_{1,2,3})$
Groups that are more collaborative generate more new knowledge represented in the group concept map.	ρ $((m_g - \{m_{1,2,3}\})\ ,(collaboration) > 0$
Groups of where students have more different individual maps generate more new knowledge represented in the group concept map.	ρ $((m_g - \{m_{1,2,3}\}), Avg(d_{1,2,3})) < 0$

Table 1: Hypotheses overview. The formulation of each hypothesis refers to elements of Figure 2

3.1 Participants and Approach

A total of 60 students enrolled mostly in engineering and science courses participated in the study. An initial focus question was posed to the students: *What types of food should we eat to have a balanced diet?* The goal for students was to create concept maps after studying the Australian Dietary Guidelines (2011) published by the National Health and Medical Research Council of Australia in the form of concept maps. Participants were organised in teams of three students mainly grouped so group members knew each other. Before the activity, students received basic instruction about concept mapping and were requested to draw an example concept map not related with the Australian Dietary domain. Then, they were asked to read a one-page article based on these guidelines and draw a concept map individually at a personal computer using the well-known CmapTools (Novak et al., 2008) (Figure 2, 1). Then, each group of three students was asked to build a concept map collaboratively at the multi-touch interactive tabletop using an application called Cmate (Martinez, et al., 2011d) (Figure 2, 2). This application was loaded with the individual concept maps previously built, using the Concept-mapping extensible language for describing the content of concept maps (CXL). This allows group members to have access to the concepts, linking words and an image of the concept map that they created individually. This gave opportunity to students to compare their perspectives, a key aspect to enhance the collaborative learning process (Tifi et al., 2008). Afterwards, each group member was asked to draw an individual concept map again, from scratch, without looking at their initial individual or the group concept maps (Figure 2, 3).

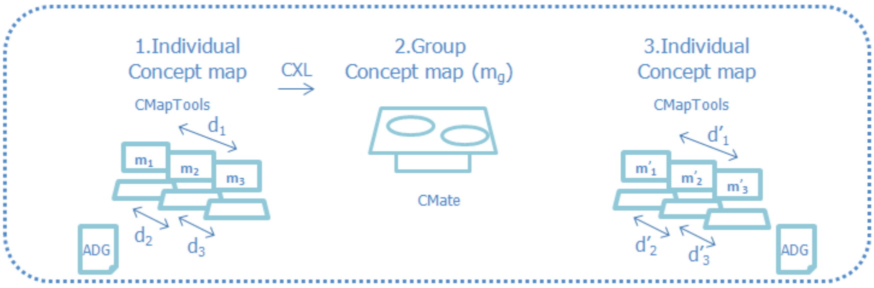

Figure 2. Approach. 1) Pre-individual concept mapping (creating m_1, m_2, m_3), 2) Group concept map (m_g) and, 3) Post- individual concept mapping (creating m'_1, m'_2, m'_3). Where = $d(m_i,m_g)$= similarity of pre-individual maps and the group map; $d(m'_i,m_g)$= similarity of post-individual maps and the group map; d_1, d_2, d_3 = similarity among pre-individual maps of a group. d'_1, d'_2, d'_3 = similarity among post-individual maps of a group. $d(m_i,m'_i)$ = similarity between each pre- and post individual map per student. ADG = One-page Australian Dietary Guidelines.

3.1.1 Individual concept mapping

In this paper, we consider individual concept maps as graphical knowledge representations of a student's understanding of the domain. Moreover, following recomendations for the concept mapping practice (Cañas et al., 2004), students were free to use their own words to label the concepts, links and to follow the arrangement and structure that they wanted to use. We suggested an initial list of concepts extracted from the text to increase the chances of having *comparable* maps. However, students were free to use them, ignore them or create their own concepts and linking words at any time. Figure 3 shows two individual concept maps created by 2 students from the same group. In this example we can notice how different the students' perspectives can be even when all students had access to the same material and started with the same list of suggested concepts.

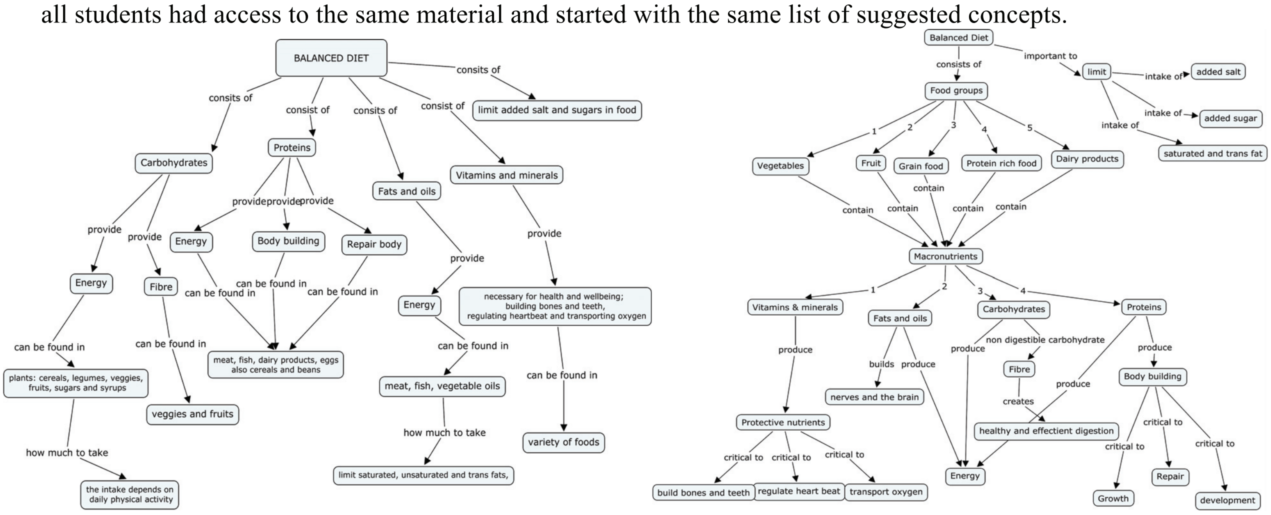

Figure 3. Example pre-individual concept maps built by two students from the same group that ended up building the group concept map shown in Figure 1 (right). The individual concept map at the left predominated in the group final map. Only, some propositions of the map at the right were included in the group map. The third individual map of the group (not shown) was very different and it was barely considered by other group members during group map building.

3.1.2 Collaborative concept mapping

The system used to capture the learners' face-to-face interactions consists of an augmented interactive tabletop that permits students to discuss and work on building a joint solution in the form of a concept map (Martinez et al., 2011b) (Figure 1). The tabletop hardware can detect multiple simultaneous touches. To distinguish between users' touches, an overhead depth sensor (*www.xbox.com/kinect)* recognises which users provided each input by tracking the position of each student around the table. Each single touch performed on the interactive surface is associated with a student. Verbal communication of group members is captured by a microphone array located at one side of the tabletop (www.dev-audio.com). This recognises when each learner is speaking.

The tabletop application Cmate (Martinezet al., 2010) permits learners to draw a concept map that represents their collective understanding about a topic. Students can build a totally new group concept map, but the application also provides each student with a personal menu to add the concepts from their individual concept mapping task at the personal computer (Figure 4.2). When students create new links, a menu appears around the new link to ease the selection of any of the top 6 linking words they used before (Figure 4.3). They can decide to type a new linking word (Figure 4.4). Students have also access to an image of the individual concept map they created to recall or share with others their initial perspective.

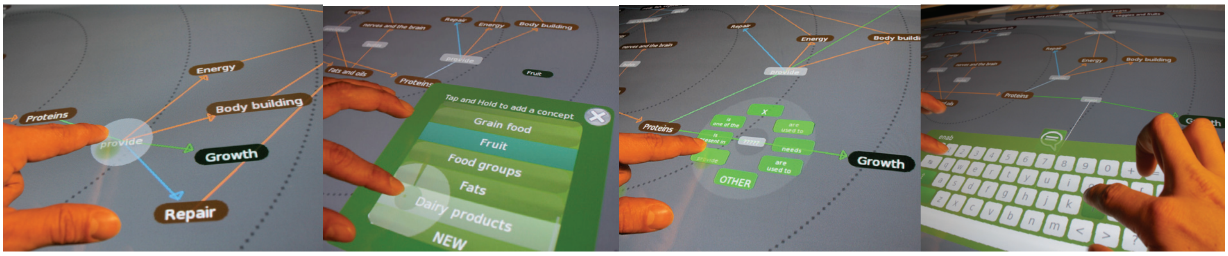

Figure 4. Interactive tabletop application for concept mapping. 1) Partial view of a concept map being built at the tabletop 2) Personal list of concepts used in the individual stage loaded to the tabletop. 3) List of suggested linking words available when a student creates a new link at the tabletop (e.g. Proteins – provide – growth). 4) Students can add new concepts and linking words at any time or edit the links (e.g. for the same link change the word “provide” to “enable”).

3.2 Data Description and Measures of Similarity and Collaboration

The data used in this study includes all the seven final concept maps built by each group. These are the three maps built by each student initially (m_1, m_2, m_3), the group map built at the tabletop (m_g), and the three post-individual maps (m'_1, m'_2, m'_3) (see Figure 2). In order to test the hypotheses, a basic measure of similarity between concept maps was implemented. We used a modified technique inspired by the method for scoring open-ended concept maps developed by Taricani et.al. (2006). This technique is based on the use of a two-dimensional graphic network representation of a concept map, considering that this can be reduced to a relationship matrix. According to the original method, the relationship data is compared with a referent master concept map to produce a score that represents how “similar” the assessed concept map is to the master map. This automatic technique proved successful and very close to ratings performed manually by a human. In our study, this technique is used to automatically measure the similarity or “distance” between the propositions contained in any 2 concept maps. In this way, we calculate the similarity between each student’s pre- and post-concept map (s_1, s_2, s_3), the distances among the individual concept maps of each group that were built before (d_1, d_2, d_3) and after (d'_1, d'_2, d'_3) the group map, the distances between each pre- and post- individual concept map and the group map (dg_1, dg_2, dg_3 and dg'_1, dg'_2, dg'_3; using the grouped average Dg and Dg’ respectively). We do not use any referent map and we do not consider *correctness* of the propositions.

Another important indicator needed for Hypotheses 2 and 3 is the measure of the extent of groups’ collaboration. For this study, we automatically measured the “level of collaboration” detected by the system as a summary of group communication and equality. It is based on a model developed by Martinez *et al.* (2011c) using the data mining prediction Best-First tree algorithm. This model classifies each block of half a minute of activity according to a set of features that can be captured from collocated settings such at an interactive tabletop. These features are: the number of active participants in verbal discussions, amount of speech, number of touches and symmetry of activity measured with an indicator of dispersion (Gini coefficient). The system labels each 30 second episode as one of three possible values: Collaborative, Non-collaborative, or Average. This means that, for example, for 30 minutes of a collaborative concept mapping session, the algorithm obtains 60 blocks with 60 individual labels. We take the average of the labels to define whether each group was collaborative or not.

4 Evaluation and Discussion

Next, we describe the evaluation of the hypotheses listed above.

Hypothesis 1: There exists a positive correlation between the quantity of propositions included by one student to the tabletop group map and the extent of permanence of their individual perspective. A Pearson correlation coefficient was computed to assess the relationship between: the similarity of the pre-individual and the group map; and the similarity of the pre- and post- individual maps (ρ ($d(m_i,m_g)$),($d(m_i,m'_i)$)). There was a positive correlation between the two variables, r = 0.503, n = 60, p <= 0.0002. Students that contribute more to the group concept map, measured by the similarity between the pre-concept maps and the group map, present less change in their perspectives after the group concept map building task. This is indicated by higher similarities between the pre- and post- individual maps for each student. At the other end of the spectrum, those students who did not include much of their perspectives into the shared concept map presented significantly more change on their perspectives indicated by less similarity between their pre- and post- maps. This suggests that those students that tended to dominate the collaborative activity had more chances to influence others to modify their perspective accordingly. This situation might be desirable in the case in which the high participants built a coherent concept map about the knowledge domain, but this might not be not necessarily the case.

Hypothesis 2: There is more agreement among group members after building a group concept map at the tabletop. This indicates that the similarities among post-individual maps are higher than the similarities among pre-individual maps, as a result of the construction of the group map at the tabletop. This was calculated by comparing the averages of these distances per group as Avg ($d'_{1,2,3}$) < Avg ($d_{1,2,3}$). We found a very statistically significant difference for group map construction of these two conditions, t(19) = 6.73, p < .0001. Overall, groups increased their levels of agreement as a result of concept mapping at the tabletop. We further wanted to know if this increase in the level of agreement was favoured by high collaborative groups or the less collaborative ones. In fact, we found that the less collaborative groups presented higher levels of agreement after the tabletop session (t(8) = 7.86, p < .0001). For the less collaborative groups, the average similarities jumped from 0.29, for the pre-concept maps, to 0.50 for the post-concept maps. For the collaborative groups the agreement came from 0.30 to 0.43 (t(10) = 3.67, p < .0043). These findings could suggest a contradiction with theories on collaboration that affirms that one outcome of collaborative work is the establishment of common ground and possible agreement on the same group perspective (Stahl, 2006). Nevertheless, this is not necessary true, at least for concept mapping, since one or two group members can convince others to change their perspectives or dominate the activity in such a way that collaboration is less effective. In our study, students who belonged to less collaborative groups tended to appropriate more of the group propositions than collaborative groups.

Hypothesis 3: There exists a positive correlation between the extent of collaboration of a group and the new knowledge represented in the group concept map. The relationship between the quantity of new propositions created during the group task (m_g - $\{m_{1,2,3}\}$) and the level of collaboration as indicated by the automated model was computed using Pearson correlation (ρ (m_g - $\{m_{1,2,3}\}$),(collaboration)). We found a positive correlation between the two variables (collaboration and new knowledge created), r = 0.33, n = 20, p <= 0.06. This correlation is not strong enough for fully accepting the hypothesis (p>0.05). A deeper analysis on the way collaboration is assessed should be carried out (e.g. by using video analysis in order to judge whether each group was indeed collaborating). However, there was not a strong tendency of collaborative groups to create more new propositions that were not considered individually.

Hypothesis 4: There is a negative correlation between the similarity of perspectives among group members and new knowledge represented in the group concept map. This hypothesis aims to set a relationship between the average of the similarity among pre-individual concept maps of a group (Avg($d_{1,2,3}$)); and quantity of new propositions that were created during the group concept mapping task (m_g - $\{ m_{1,2,3}\}$). In this case, we found some negative correlation between the two variables, r = -0.36, n = 20, p <= 0.059. This correlation is at the borderline to accept the hypothesis (p>0.05). Groups in which students presented more agreement tended to create sensibly less new knowledge, focusing more on the integration of the propositions that each of them already created. On the other hand, groups in which their individual perspectives were more different from each other tended to create a new group map with more new content.

The four hypotheses posed in this paper sought to find out evidence contained in the concept maps that can provide information about acquisition of propositions, knowledge creation and extent of collaboration of the group members. Two out of four of the hypotheses were statistically supported. The last two hypotheses showed a less strong tendency but still provided some information about the usefulness of the approach that can be followed to analyse groups' collaboration and the flux of knowledge. The first finding (hypothesis 1) showed that students who actively contribute to the group work tend to convince others to adopt a similar point of view; therefore, these students are inclined to maintain their perspectives. A number of collaboration sub-processes can be involved in this effect for example elicitation, negotiation and conflict resolution. The scope of this hypothesis is limited to study whether is possible to inspect the similarities between concept maps to analyse the flux of knowledge before and after collaboratively concept map building at the tabletop. The second hypothesis tackles a different angle of the group outcomes: agreement after the group activity. Overall, the study proved that after building a concept map at the tabletop group members built common ground and could individually represent parts of their shared artifact after the group work. However, a deeper analysis of this hypothesis showed that less collaborative groups strongly agreed after the group session. Examples of less collaborative group behaviours includes the presence of a dominant student who performs most of the work without consulting others; independent work; having one student sub-participating or being just a free-rider (Martinez et al., 2012). Hypothesis 3 and 4 were not fully accepted but they showed some tendency that can be observed in some groups. Hypothesis 3 links the level of collaboration with the amount of new knowledge generated. Studies on collaboration support a positive correlation between these two indicators (Stahl, 2006). However, the purpose of this hypothesis was to investigate whether the concept maps contain enough evidence to confirm this positive effect of collaboration. Most of the high collaborative groups showed higher levels of communication but this is not necessarily always reflected in the final concept map. The range of possibilities is wide: some of the better ideas may not be have translated into propositions, partial solutions can have more quality than the final concept map or simply the way students draw their concept map as a group does not reflect their discussions. Regarding Hypothesis 4, studies on collaborative learning have provided evidence to support that that groups with more divergent points of view tend to generate more new ideas (Dillenbourg, 1998; Stahl, 2006). Similarly to Hypothesis 3, the goal was to analyse whether the concept maps can contain enough traces of information to confirm such relation. The negative correlation was not strong enough to generalise that divergent points of view in the individual concept maps generate an increment on the new knowledge under discussion but showed that the tendency is close to be significant (r= -0.36).

5 Conclusions and Future Work

Concept mapping is a tool that provides enormous learning advantages to represent knowledge and enhance meaningful learning. It has also been proven that it is effective as a collaborative activity to build knowledge, share perspectives and help understanding a knowledge domain from different angles (Torres, et al., 2010). This paper aims to motivate research in the field by combining the affordances of new shared devices to help analyse aspects of the process and outcomes of collocated collaborative concept mapping. Specifically, this paper responds questions about the flux of the knowledge contained in the propositions created in the individual and group stages of the concept mapping activity. Our goal is to highlight the value of investigating the interactions of the students and the final products of the collaborative concept mapping process to offer insights that can help students or their teachers improve collaboration, learning or their concept mapping skills. The study had some limitations: simple text analysis was used to compare concepts and the usage of synonyms, writing errors or slight changes in the words were not captured; the context of learning was not totally real, students did not have to learn the content to get marks or pass a subject; students might have been affected by fatigue, specially for drawing the second individual concept map thus affecting the quality of their work; and the student population was chosen from a number of disciplines of science. The contribution of this paper is the approach and the exploration of the possibilities behind the synergy of different technologies and theoretical principles to study collaborative learning from a different perspective. This approach needs to be complemented by other means of input such as teachers' observations, qualitative assessment of the concept maps and a deeper analysis on the application logs. Future work on this research includes the usage of other techniques such as data mining to keep track of the evolution of the concept map and the process of collaboration by inspecting the student-computer interaction logs from the tabletop and the Cmap Recorder feature of CmapTools.

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APLICACIÓN DE LOS MAPAS CONCEPTUALES EN LA DEFINICIÓN Y LA INSTITUCIONALIZACIÓN DE LOS PROCESOS PARA LA PRODUCCIÓN DE SOFTWARE

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Abstract. En este trabajo se propone el uso de mapas conceptuales en la definición e institucionalización de un proceso de producción de software. Esta investigación utilizó dos métodos: Survey con la participación de 121 profesionales en la producción de software y experimento con la participación del sector de una empresa de producción de software, que se encuentra en el estado de Paraná. La empresa ha cartografiado e institucionalizado el proceso de software utilizando mapas conceptuales. Los resultados de estos estudios muestran una alta aplicabilidad de los mapas de la representación del conocimiento y de producción de software.

1 Introducción

La producción de software en Brasil es muy deficiente si es mirada desde la perspectiva de la balanza comercial. De acuerdo con el Ministerio de Fomento, Industria y Comercio Exterior, en 2010 el país importó alrededor de US$ 3 mil millones y las exportaciones alcanzaron casi US$ 600 millones. Para fines comparativos, de acuerdo con la Asociación Brasileña de Productores y Exportadores de Software (BRASSCOM), los países emergentes como India y Irlanda exportan alrededor de diez veces lo que importan.

Los principales inversores en tecnología de la información (TI) siguen siendo los Estados Unidos (alrededor de US$ 1,2 billón dólares/año), seguido por Japón (alrededor de US$ 300 millones/año), el Reino Unido y Alemania. En 2010 el mundo gastó un estimado de US$ 3 billones en TI. Las inversiones en Brasil llegaron a la cifra de los US$ 30 millones, superando India, Corea, Rusia, México y Argentina, los países fueron clasificados como emergentes en el escenario económico mundial. En 2011 la inversión llegó a US$ 36 millones en las compañías brasileñas.

A pesar de encontrarse entre los 10 primeros inversores de TI en el contexto global, el mercado productor de software del Brasil no tiene estándares de calidad necesarios para alcanzar el mercado de exportación. En la actualidad pocas empresas brasileñas producen software con estándares de calidad reconocidos por los modelos de madurez. Este hecho puede ser probado por el análisis de la cantidad de empresas certificadas en el Modelo de Capability Maturity Model Integration (CMMI), Brasil cuenta con 125, sólo siete de ellos tienen alto nivel de certificación (fuente: www.sei.cmu.edu). Para fines comparativos, China tiene 1.557 (35 nivel 5) y la India 462 (108 nivel 5).

Esta realidad, junto con la elevada presión fiscal y la discapacidad en la formación de personal cualificado en TI, específicamente en el área de ingeniería de software, se caracteriza como una fuente de inhibir el proceso de expansión externa de este sector en Brasil. Universidad, empresas y gobiernos deben desarrollar mecanismos que alteren este escenario.

El contexto presentado comprende plenamente el objetivo de este artículo, aplicar mapas conceptuales en la definición y la institucionalización de procesos en el área de producción de software. La idea de aplicar estos mapas a estas empresas se produjo en una consultoría celebrada en 2011. Durante la definición del proceso de software los mapas conceptuales fueron eficaces (véase la sección 5) en la representación y difusión del conocimiento en el ámbito de los negocios.

2 Marco teórico sobre los mapas conceptuales

Los mapas conceptuales han surgido de la investigación de Novak (2006) a principios de los 60 y se entienden como una representación visual utilizada para compartir el significado de una estructura abstracta de datos (Tavares, 2007).

El trabajo de Rivera (Rivera, 2010) indica que los mapas conceptuales permiten recuperar y representar el conocimiento en un dominio específico, y el resultado en una herramienta útil para compartir la información entre los especialistas. Para Dandolini (2010) entre los idiomas disponibles, los mapas conceptuales se destacan como un mecanismo diferenciado para representar el conocimiento y se puede utilizar con eficacia en la enseñanza y el aprendizaje. Fourie, (Fourie, 2008) define mapas conceptuales como una representación bidimensional de la estructura cognitiva presentada jerárquicamente mediante conexiones unidireccionales (ver Figura 1).

Es importante destacar que los mapas conceptuales son utilizados en la representación del conocimiento en diversos campos, en este documento se destacan algunos: 1 – enseñanza y aprendizaje de las matemáticas (Flores, 2006), 2 – educación superior (Renauld, 2006), 3 – Revisión literaria (Alias y Suradi, 2008), 4 – mejora de procesos software (Fabri, 2011) 5 – modelaje del negocio y alineamiento estratégico en entornos informáticos (Niskanen y Kyrö, 2008).

Un ejemplo de la capacidad de comunicación y representación del conocimiento de un mapa se puede observar en la Figura 1. El mapa conceptual presentado en la Figura 1 muestra como puede ser construido un proceso (un proceso de software tiene actividades, las actividades son divididas en tareas y la tarea es generar artefactos).

3 Marco teórico sobre el proceso de software

Segundo Paula Filho (2003), un proceso es descrito como un conjunto parcialmente ordenado de las actividades constituidas por métodos, prácticas y transformaciones utilizadas para lograr cierta meta. El proceso puede verse como una "receta" que es seguido por un proyecto. Por lo tanto, el proyecto es considerado un registro del proceso. Es importante destacar que no hay que confundir un proceso (por ejemplo, una receta de torta) con el producto en cuestión (torta) o con la ejecución del proceso mediante un proyecto (hacer una torta para un cocinero particular en un momento dado). Con base en el ejemplo de la receta de la torta figurativo, el autor afirma que un proceso se compone de los pasos (abarcaba las actividades para hacer la torta), por personas (que se define por el papel de la cocinera), por los insumos (productos utilizado para fabricar la torta, por ejemplo, harina de trigo) y, finalmente, el producto final producido con la aplicación del proceso (torta). Una comparación entre el proceso de producción de una torta y un software se puede ver en la Tabla 1.

Peters y Pedrycz (2001) presentan el proceso como una secuencia de actividades que producen diversos documentos, que culmina en un producto satisfactorio que puede ser utilizado por el consumidor. En el caso de un proceso de software, el producto es clasificado como un programa ejecutable. Los autores señalan que un proceso debe tener una retroalimentación, una característica que garantiza su evolución.

Sommerville (2003) define el proceso como un conjunto de actividades y resultados asociados que impulsan la producción del producto de software. El autor destaca que el proceso de software es complejo y se caracteriza como una actividad intelectual, hecho que establece limitaciones en relación a su automatización.

Processo	**Culinário (torta)**	**Software**
Actividades	Revolver, mezclar, cocinar, descansar, dorar	Planificar, acompañar el proyecto, codificar, probar
Papeles	Cocinero, Ayudante de Cocina	Coordinador de Proyecto, Analista, Programador, otros
Insumos	Harina de trigo, azúcar, vainilla	Documentos de especificación, código de prueba, plan del proyecto
Trabajo de producto (intermedio o final)	La guinda de la torta (intermedio), torta (producto final)	Plan del proyecto (producto intermedio), software (producto final)

Tabla 1: Comparación del proceso de producción: el software x torta

Para Sommerville (2003) no hay un proceso universal de desarrollo de software. En la actualidad, las empresas que desarrollan este tipo de producto, establecen diferentes relaciones dinámicas entre las actividades, estableciendo así, su propio proceso de software.

Pressman (2002) define un proceso de software como un conjunto de pasos predecibles (o estructura) que se utilizan para la construcción del producto de software. El proceso establece el enfoque dinámico que es adoptado cuando el software es desarrollado. Los participantes en el proceso de producción de software son: administradores, ingenieros de software y los usuarios, estos últimos desempeñando un papel clave en el proceso. Para la producción, el proceso de software necesita ser detallado, y este hecho depende de las características del producto que se desea construir, una unidad de producción. Por ejemplo, un proceso puede ser apropiado para crear un software que controla la electrónica de una aeronave, mientras que un proceso completamente diferente sería adecuado para la construcción de un software de control de inventario para un gran almacén. En su definición de procesos de software, el autor enumera una serie de productos de trabajo, entre ellos se encuentran: programas, documentos y datos producidos como resultado de la ejecución de las actividades definidas en el proceso.En su obra, Pressman prevé que la caracterización de un proceso es establecido por un pequeño número de actividades aplicables a un proyecto de software, independientemente de su tamaño y complejidad.

Slack (2002) destaca que un proceso de producción genera bienes o servicios o una combinación de ambos. El proceso consiste en un conjunto de recursos e insumos (inputs) utilizados para convertir algo en bienes y servicios (productos).

Con base en las definiciones dadas, este trabajo enfrenta el proceso de producción de un producto categorizado como software, como un conjunto de actividades bien definidas y documentado que cuando se aplican sistemáticamente garantizan un determinado nivel de calidad en la fabricación del producto. Más allá del conjunto de actividades, el proceso tiene otros atributos, tales como: materia prima, mano de obra y recursos. Estos atributos son considerados los insumos del proceso de producción. Cabe destacar que el proceso debe tener el concepto de retroalimentación con el fin de garantizar el carácter evolutivo del mismo. La visión embrionaria del proceso de producción de software se muestra en la Figura1.

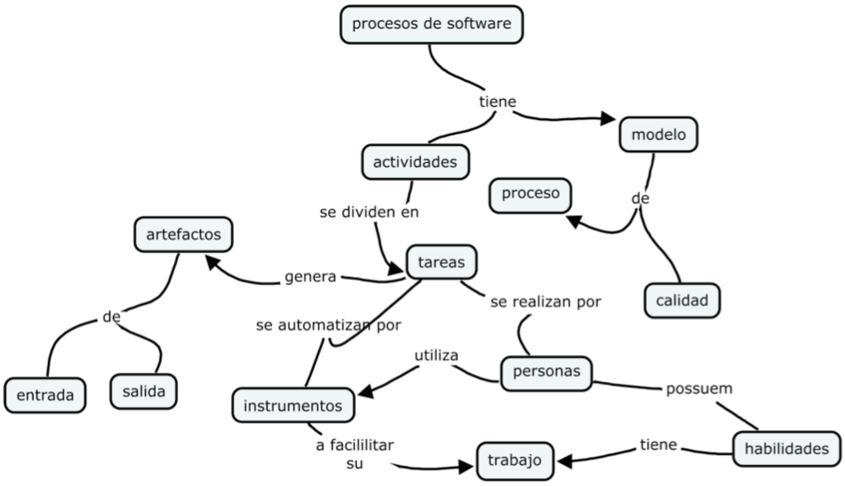

Figura 1– Mapa conceptual (generada en el CmapTools representa la visión embrionaria de un proceso de software.

4 Metodología para el desarrollo del trabajo

La idea de aplicar los mapas conceptuales en la definición y la institucionalización de procesos de software, surgió de una consultoría efectuada para una empresa del sector productivo de esa zona, en 2011. Para apoyar la aplicación de los mapas, los consultores utilizan una metodología de investigación híbrida compuesta por:

- Aplicación de *survey* - Objetivo: comprobar si los mapas conceptuales tienen la capacidad de expresar de forma clara, concisa y coherente con los profesionales en el área de producción de software, conocimientos relacionados con el proceso de software.
- Aplicación de un experimento - Objetivo: comprobar la posibilidad de institucionalizar un proceso de software en un entorno empresarial, utilizando los mapas conceptuales.

4.1 Caracterización del Survey

El método *survey* (caracterizado como cuantitativo) tiene como objetivo recoger los datos. Freitas et al. (Freitas, 2000) declara que el *survey* puede ser caracterizado como la recogida de información sobre las características, acciones u opiniones de un grupo de personas, representado por una muestra por medio de un instrumento de investigación, por lo general un cuestionario.

Para utilizar este método es necesario realizar las siguientes actividades:

- Definición de la hipótesis.

- Elaboración de un protocolo que guiará la aplicación del *survey*: Conjunto de reglas de comportamientos y ambientes en el que se ajusta la investigación.

- Ejecución del *survey*.

- Análisis de los resultados.

A) Definición de la hipótesis: Dado que el objetivo del *survey* es comprobar que un mapa conceptual es capaz de representar el conocimiento sobre el proceso de software, los autores de este trabajo, durante la ejecución de esta investigación proponen la siguiente hipótesis: La especificación presentada en el Figura 2 expresa en forma clara, concisa y coherente el primer contacto con un cliente durante la actividad de levantamiento de requisitos.

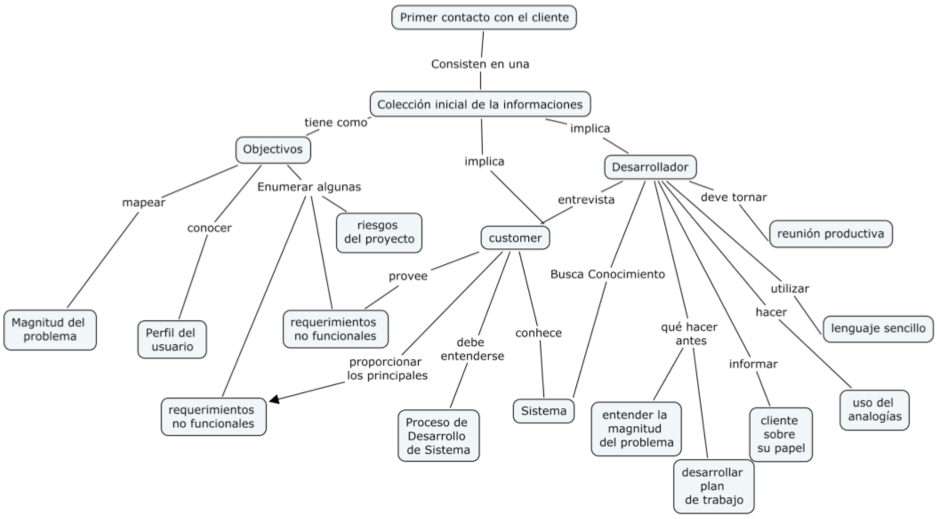

Figura 2 – Mapa conceptual (generado en CmapTools) representando la actividad de levantamiento de requisitos de software.

B) Protocolo de guia del *survey*

El protocolo del survey utilizado en este trabajo se puede ver en el cuadro 1.

C) Ejecución *survey*: Definir la forma de distribución del cuestionario (correo, Internet ...), el costo, los sitios de aplicación y los aspectos culturales que se ajusten a las entidades investigadas. Con el objetivo de reducción de costos y facilidad de acceso, el cuestionario fue colocado en la Internet y un correo electrónico fue enviado a 2453 profesionales por los autores de este trabajo, solicitando la respuesta de los mismos.

D) Analizar los resultados: Compruebe si existe la posibilidad de generalizar los datos obtenidos durante la investigación. El análisis se presenta en la sección 5.

4.2 Caracterización del Experimento

El método de la investigación experimental llevando a cabo pruebas de hipótesis por medio de un experimento controlado, diseñado para producir los datos necesarios, se puede realizar en el laboratorio o en el campo (Nakano y Fleury, 1996).

Para utilizar este método es necesario ejecutar las siguientes actividades:

- Definición de las hipótesis.

- Concepción del protocolo experimental. Conjunto de normas ambientales y de comportamiento en el que se ajusta al experimento.

Cuadro 1 – Registro del protocolo para la aplicación del *survey*

Tipo del suvey: Descripción - Dado que el enfoque del artículo es comprobar si los mapas conceptuales se ajustan a la especificación y la institucionalización de un proceso de software, la percepción de las características de la aplicación de los mapas en ese contexto y las opiniones de los analistas de la realidad centrado en los sistemas (población), garantiza la característica descriptiva de la obra. **Momento de la Recogida:** Fue lanzado[1] el 18 de octubre de 2010 y su aplicación es recurrente. **Unidad de análisis:** Los analistas de sistemas y quienes desarrollan el software. **Definición la populación:** La población fue definida por la comodidad, el cuestionario fue enviado (por correo electrónico) a los profesionales en la producción de software (alrededor de 2453), graduados en tres instituciones educativas (todas sin fines de lucro(s)), dos del Estado de São Paulo (más precisamente en el oeste) [2] y uno del Estado de Paraná (región norte)[3]. Dos de los autores de este trabajo colaboraron en las dos instituciones en el estado de Sao Paulo entre los años (1998-2006), y todos trabajan en la institución en el estado de Paraná. **Definición de tamaño de la muestra:** 121 cuestionarios fueron completados, el margen de error para la población es de 5 puntos por encima o por debajo. **Definición y formato del cuestionario:** El cuestionario tiene el siguiente formato: Un mapa conceptual que ofrece la primera aproximación a un cliente durante la actividad de levantamiento de requisitos se presenta a los profesionales en el campo de la producción de software. Además de mapa, el cuestionario tiene un tema específico y se caracteriza de la siguiente manera: ¿Usted entiende la información presentada en el mapa conceptual? **Validación del cuestionario**: Validación del cuestionario fue realizado por cinco profesores en el grupo de tecnología de la información en el campus de Cornélio Procópio de la Universidad Tecnológica Federal de Paraná. Los criterios considerados en la validación fueron: la claridad, la precisión de los términos y diseño del cuestionario.

- Ejecución del experimento.
- Análisis de los resultados (asignado a una sección específica debido a su importancia).

A) Definición de la hipótesis: Como esta es la definición e institucionalización de un proceso de software en un entorno empresarial, los autores de este trabajo proponen la siguiente hipótesis. Es posible institucionalizar un proceso de software en un entorno empresarial, utilizando los mapas conceptuales.

B) Protocolo experimental: El protocolo experimental utilizado en este trabajo se puede ver en el cuadro 2.

Cuadro 2 – Registro del experimento de ejecución del protocolo

1. Entidades: Empresa del sector productivo de software. **2. Caracterización:** 2.1. Número de empleados: 20. 2.2. Ubicación: Estado de Paraná. 2.3. Caracterización de los clientes[4]: Los clientes brasileños de diversos segmentos de mercado 2.4. Participan: Representantes de todo el sector productivo de software empresarial (analista de sistemas, programador) 2.5: Formación de los implicados: profesionales con educación superior - Análisis de Sistemas y/o cursos relacionados. 2.6. Tiempo de experiencia: 2 a 10 años. **3. La definición de la muestra:** Diseño de la muestra: 5 entidades (empleados de la compañía seleccionada al azar) - todas ellas caracterizadas como analista de sistemas. **4. Forma de acceso a las muestras:** Acceso a las entidades sincrónicas fue caracterizado en la consultoría inicial celebrada en esa empresa. La participación directa de los autores de este trabajo en consultoría ha facilitado el acceso a las entidades que participan en el experimento. Es importante destacar que existía limitación del tiempo de acceso. **5. Forma de recogida de datos:** un cuestionario y la observación directa de las entidades ante el cuestionario (punto C en la sección 4.2) **6. Validación:** Validación del experimento fue realizado por cinco profesores en el grupo de tecnología de la información en el campus de Cornélio Procópio de la Universidad Tecnológica Federal de Paraná. Los criterios considerados en la validación fueron los siguientes: claridad, precisión y formato de los términos de la especificación, y el cuestionario y la calidad de los artefactos generados por la tarea**.**

C) La aplicación del experimento:

La aplicación del experimento se dividió en dos etapas:

- Las entidades que participan en el experimento fueron expuestas a la especificación (definido por un mapa conceptual) de una tarea relacionada con el proceso (fase 1).

[1] Dirección para acceder al cuestionario: http://engenhariasoftware.wordpress.com/2010/10/18/mapas-conceituais-na-descricao-de-um-processo-de-software/

[2] **Fundación Educacional do Municipio de Assis** – licenciados en Ciencias de la Computación (inicio del curso: 1999 - 4 años de duración) y Tecnólogo en Análisis de Sistemas y Desarrollo (inicio del curso: 1988 - Duración: 3 años) - www.fema.edu.br. Total de estudiantes de postgrado en la Fundación 1049. **Facultad de Tecnologia de Ourinhos** – Diploma Tecnólogo en Análisis de Sistemas y Desarrollo (duración: 3 años) - Total de graduados de FATEC 1150.

[3] Universidad Tecnológica Federal do Paraná – Campus Cornélio Procópio – Diploma Tecnólogo en Análisis de Sistemas y Desarrollo (duración 4 años). Total de graduados en los últimos 13 años: 254.

[4] La compañía no permitió una descripción detallada de su base de clientes.

- Se solicitó a las entidades que desarrollen las tareas de acuerdo a las especificaciones.

- El desarrollo de las tareas fue observado directamente por los involucrados en el proceso y consultoría.

- Después del desarrollo de la tarea, los involucrados respondieron un cuestionario con 5 preguntas (Tabla 1) (fase 2).

D) Analizar los resultados: Compruebe si existe la posibilidad de generalizar los datos obtenidos durante la investigación. El análisis se presenta en la sección 5.

5 Resultados Obtenidos

En esta sección se presentan los resultados obtenidos con la aplicación de la investigación (*survey*) y la ejecución del experimento.

5.1 Resultados obtenidos con la aplicación del survey

Como se muestra en el Cuadro 1, el cuestionario fue sometido en octubre de 2010, a 2.453 profesionales en la producción de software, de éstos, 121 respondieron al cuestionario (junio de 2011), y el 84% entiende la información presentada en el mapa conceptual (ver Figura 2). Este índice fue la base para la aplicación de estos mapas en estas empresas (ver sección 5.2).

El índice que se presenta caracteriza como verdadera la hipótesis: la especificación presentada en la Figura 2 se expresa en forma clara, concisa y coherente para establecer el primer contacto con un cliente durante la actividad de levantamiento de requisito.

5.2 Resultados obtenidos con la ejecución del experimento

Tal como se define en el inciso C sección (sección 4.2), la ejecución del experimento se dividió en dos fases:

- Resultado de la fase 1: 4 de 5 entidades que participan en el experimento realizaron la tarea perfectamente. El tiempo medio para ejecutar la tarea fue de 3 minutos.

- Resultado de la fase 2: El resultado descrito en el cuestionario se puede encontrar en la Tabla 1. La primera columna de la tabla proporciona el foco de las preguntas, la segunda presenta la respuesta de cada entidad (S para el **Sí** y N para **No**), la tercera muestra el porcentaje de respuestas positivas y negativas y la cuarta muestra el grado de certeza de la respuesta de cada entidad.

Tabla 1 – Resultados obtenidos con ejecución del experimento.

Cuestiones[5]	Respuestas	Total		Certeza[6]
		Sí	No	
1 – Identificación de la actividad presente en el proceso	S S S S N	80%	20%	3 3 4 5 3 (3,6)[7]
2 - Identificación de las tareas	S S S S S	100%	0%	4 5 4 5 4 (4,4)
3 - Identificación de los artefactos de entrada	S S S S S	100%	0%	5 5 5 5 5 (5,0)
4 - Identificación de los artefactos de salida	S S S S S	100%	0%	4 5 5 5 5 (4,8)
5 - Facilidad de lectura de la especificación[8]	3 4 5 4 4	4 (média)		3, 5, 5, 4, 3

[5] Todas las preguntas se caracterizan por ser cerradas. Las preguntas 1, 2, 3 y 4 tiene una respuesta alternativa sí (S) o no (N) opciones. A fin de validar cada respuesta, y contestar sí o no a estas preguntas, la entidad participante del experimento reportó textualmente la actividad (pregunta 1), la tarea (2), artefactos (3 y 4).
[6] El grado de certeza utiliza la escala de Likert (1 - muy bajo, 2 - baja -, 3 - promedio, 4 - alta, 5 - muy alto).
[7] Grado medio de certeza encontrado.
[8] Pregunta 5 utiliza la escala de Likert (1 lectura muy difícil, 2 difícil, 3 dificultad media, 4 fácil y 5 muy fácil lectura).

6 Análisis de los Resultados y Conclusiones

La relación de los resultados obtenidos con la aplicación y ejecución del estudio del experimento en consideración al objetivo inicial trazado (aplicar mapas conceptuales en la definición y la institucionalización de procesos en el área de producción de software) puede ser determinado por medio de los resultados cualitativos y cuantitativos. Los artículos que siguen muestran estos resultados:

Calidad de producto y proceso: Con la creación de instancias y la institucionalización del proceso, usando mapas conceptuales, los profesionales que trabajan en la compañía de software (objeto de la consultoría) se dieron cuenta de un aumento en la calidad y la productividad, el tiempo para el desarrollo de artefactos (productos) se redujo y la calidad del software y la satisfacción del cliente se maximiza.

Las directrices sintácticas y semánticas aplicadas a los mapas fueron de fundamental importancia para la creación de instancias del proceso. En esta etapa el papel del consultor es sumamente importante, las directrices fueron eficientes y eficaces para el éxito pretendido por la empresa.

La lectura y la institucionalización de las prácticas modeladas con los mapas tienen gran agilidad si son comparadas con la forma antigua utilizada por la empresa, un hecho denunciado por los profesionales en la empresa.

Finalmente, es importante señalar que el resultado obtenido por la aplicación del *survey* formó la base para la realización del experimento y esto a su vez forma la base para la especificación y la institucionalización del proceso de software en la compañía en cuestión, un hecho que llevó al éxito de la consultoría y resultó en la materialización de este trabajo.

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APPLYING CONCEPT MAPS TO ANALYSE THE LEVEL OF SUSTAINABLE DEVELOPMENT AWARENESS HELD BY POLICY MAKERS IN MALTA

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Abstract. There is the need to create a common purpose in the world's governmental sectors so that the world can adapt to future change. Various practices are being adopted worldwide to promote sustainable development. Such practices should also be upheld in Malta, so that like other countries, it can contribute effectively to building a sustainable future. The road to sustainable development requires both an understanding of this concept and a commitment from all the policy makers. This study was conducted to explore the level of awareness of sustainable development held by policy makers. It also looks into the sustainable practices promoted by them in their workplace and in their personal lifestyle. Concept maps were used to identify key ideas and underlying interconnections between the policy makers' perceptions of sustainable development and whether they have developed the necessary values and attitudes required to promote sustainability. The study brings valuable insights into issues related to sustainable development implementation at both local and national level. It provides suggestions that focus on educational target points required to improve current practices of sustainable development to make this a successful agenda in the Maltese Islands.

1 Introduction

Today, more than ever before, the majority of the world leaders have understood the need for sustainable development. Cooperation by all states is also required to respond to the special circumstances and particular vulnerabilities of countries, especially small island countries, through adequate and specific approaches. As an EU and SIDS (Small Island Developing State) member, Malta is expected to adopt sustainable practices and adhere to the national sustainable development programme. One of the main concepts inherent within definitions of sustainable development is 'Quality of Life'. A good quality of life rests on three interrelated components: environment, society and economy. Nowadays sustainability is also incorporating the cultural dimension. Malta has an obligation to provide a good quality of life for its current citizens and build a better future for the forthcoming generations. This can be done by putting the country on a sustainable pathway. Although in recent years 'sustainability' has become the latest 'buzz' word and is being referred to as the "latest fashion accessory" (Hawkins & Shaw, 2004), many nations have, in fact, recognised the value of sustainable development and today work together striving to attain a good 'Quality of Life'.

In Malta, only a collaborative effort by policy makers and citizens, who have a heightened education about the subject, can steer the island towards sustainability. However, smallness and insularity produce specific behavioural responses (Sultana & Baldacchino, 1994). Although Local Agenda 21 insists that sustainability should be tackled through a top-down, bottom-up approach, the Maltese population tends to have a predominant mentality that change has to come from above, rather than from the grassroots. Malta's archipelago scores as one of the smallest island states in the world. However, Malta's strategic position, placed in the middle of the Mediterranean, has always fuelled interest in various powers that sought to dominate the Mediterranean arena. Following hundreds of years of domination by foreign powers, it seems to have become engrained in the Maltese generations to be followers rather than rulers.

As is typical of developing post-colonial states, there is in Malta an observable tendency to emulate and mimic the behavior of foreign significant others. (Sultana & Baldacchino, 1994.p.15) Unfortunately, Maltese citizens are still rather limited in exposure and inclusion of ideas. Public opinion and confidence in citizen power quickly changes and develops in countries such as Luxembourg which are similar in size to Malta but benefit from constant communication with larger neighboring countries. However, in Malta citizens tend to have lower expectations about the importance and influence of public participation. The younger generation should, however, be getting a better experience and understanding of the world. Various reports suggest that there is a level of concern about sustainable issues in the Maltese Islands, especially environmental ones, among the Maltese citizens. However, this is not often translated into individual action (MEPA, 2005, p.1). It is usually NGOs who try to make a stand and promote a sustainable vision. Although sustainable development features in many official Maltese agendas and policy documents, prior to this study, no investigations regarding awareness and commitment of policy makers to promoting sustainability had been conducted. Although the National Strategy towards Sustainable Development was set to start in 2007, the political will to implement it seemed rather slow. Achievement of its goals seemed sporadic; sometimes also uncoordinated and conflicting. For example, while government commissioned a report on the abatement of greenhouse emissions (Climate Change

Committee, 2008) the Ministry of Infrastructure, Transport and Communications signed a contract for the building of a diesel-engine for the power station which runs on heavy fuel oil (Falzon, 2009). This did not seem congruent with Malta's international obligation towards building a sustainable future.

In a country like Malta which is basically run by individuals, the actions and efforts of every individual matter – especially those of policy makers. Policy makers have the responsibility to devise, fund and implement the national sustainable development strategy. They need to orientate their existing practices to address sustainability.

Bearing in mind the above sociological perspectives, this study was conducted to explore the level of awareness of sustainable development of people in governing bodies as I believe that a positive attitude and awareness of the necessity of sustainable development at this level is imperative to jump start the required changes in my country.

The first aim of this study was to explore whether the level of awareness of sustainable development and related practices of policy makers has an influence on the progress of sustainable development in Malta. The research examined the degree of sustainable development being promoted in the workplace of each interviewed policy maker and in his/her personal lifestyle. It brings valuable insights into issues related to sustainable development implementation in Malta. The second aim of this research was to compile suggestions that focus on educational target points required to improve current practices of sustainable development to make this a successful agenda so that Malta can also contribute effectively to the efforts made worldwide to promote sustainable development.

2 Methodology

2.1 Research Design

The methodology undertaken in this study was primarily qualitative. This was preferred to quantitative analysis as besides focusing on whether there is a statistically significant relationship between two concepts, qualitative analysis goes further in revealing whether the relationship between them is appropriate (Cañas et al, 2004). This study was planned to investigate Maltese policy makers' concepts regarding sustainable development through the use of open-ended but structured interviews which took an average of forty-five minutes to one hour. "The empirical studies that the actual roles planners adopt and use in practical situations reveals both the real demands for a policy makers' knowledge and competence, and the tensions planners face in trying to further the goals of sustainable development" (Brasouillis, 1999, p900).

An analysis of policy makers' commitment to sustainable development practice as reflected in their lifestyles, their current work and their agenda for the future was conducted. Through the use of interviews and data analysis, the study aimed to develop a detailed picture of issues influencing decision-making. The study provides insight on why certain decisions concerning sustainable development are or are not taken.

The structured but open-ended interview was chosen on the grounds that it allows for greater depth than the other methods of data collection (Cohen & Manion, 2000). The questions were grouped into four sections:

A. Sustainable Development Awareness
B. Inclusion of Sustainable Development in Personal Lifestyles
C. Inclusion of Sustainable Development in Work Activities
D. Awareness regarding Sustainable Development Policy Making

Questions in Section A were planned to elicit the policy makers' knowledge about sustainable development concepts at a national level. Section B and C comprised questions that allowed interviewees to think about their commitment towards sustainable development, their achievements so far and their future aspirations. These sections also allowed me to probe the feelings and thoughts that support their actions. Questions in Section D were tailored to determine the interviewees' knowledge about implementing and sustaining this concept on a local level. They also allowed participants to voice their concerns about local policy making and difficulties encountered during implementation.

2.2 Participants chosen

The research targeted policy makers as I believe that they have an impact on various aspects involved in preparing Malta for the challenges of the 21st century. It is pertinent that the attitudes and values of all those involved in moulding Malta's future understand what the course of sustainable development entails. At the root of my choice, there was not a desire of finding some definite answers through the policy makers' responses, but to develop a deeper understanding of their commitment towards sustainable development through their personal reflections and expertise.

The policy makers chosen where: members of parliament, green leaders, local councilors and mayors from both political parties – 13 men, 7 women; 2 Gozitans, 18 Maltese. Politicians have a say on a national basis and are direct stepping stones to laws being passed in favour of sustainable development. Local councils set up in 1993 in response to LA21 are managed by local councillors who have specific control in their locality and ensure that their locality implements sustainable strategies on a local level. Green Leaders were approached to participate in this study since they were appointed by the government in 2005 to create environmental awareness and promote environmentally-friendly practices within their Ministries. The selection of participants was determined by random sampling and it was ensured that both sexes and political parties were represented in accordance with the actual governmental system. Although all respondents were expected not to let their political bias influence their replies, I did notice that some of them were subjective so their political inclinations were included. Obviously, this had to be done with all the respondents to avoid signalling out any individuals.

It was very difficult to find people willing to participate – over 100 emails were sent, 47 replied. As informed consent was required, before arranging for the interviews, an e-mail was sent to the forty-seven respondents to advise them of the topic and purpose of the interview. Once informed about the thesis, the number of participants decreased to 20. People involved were high profile people and probably feared they could have been identified. Some also commented that sustainable development strategies were not in their line of work and were reluctant to be interviewed. The views presented in the thesis reflect the thoughts of the twenty policy makers who accepted the request. This leads one to assume that, to some extent, the majority of the respondents felt confident being interviewed about sustainable development as they had a certain amount of knowledge on the subject. It is interesting to note that the Maltese government has declared that sustainable development should be given a horizontal priority on all policies and should therefore be incorporated in the agendas of all ministers and members of parliament. The NCSD advocated national sustainable development across all sectors. The final version of the Maltese NSDS reaffirmed that sustainable development should be a cross-cutting strategic issue and for sustainable practices to be successful, they should be given priority on everyone's agenda.

3 Data Analysis

3.1 Using Concept Maps

The data collected was analyzed after transcripts were approved by the relevant interviewees. This research generated a large amount of information that could not be sorted into neat categories. To make analysis simpler, key concepts were identified. The main concerns identified by the individual participants where categorized according to which of the three main sustainable development sectors (i.e. the environmental, the social and the economic) they fell under. In qualitative research, voluminous amounts of data need to be reduced to a manageable form without losing the embedded meaning. For this reason concept maps for the individual participants were constructed to determine what the participants understand by 'sustainable development', their readiness to collaborate with others to promote sustainable development policies and their commitment in setting an example. They were also used to highlight what, in their opinion, is hindering the progress of sustainable development in the Maltese Islands.

Concept maps (Novak's tool developed to represent the expert knowledge of individuals – amongst other uses) were used to reduce the qualitative data so as to facilitate the process of understanding key ideas (eg. Figures 1, 2 and 3). They were also used as an efficient way of presenting findings. The maps therefore allowed analyses of key themes. Reducing the data to a one page concept map per participant facilitated the process of outlining similarities and highlighting differences when focusing on the participants' meaning. The Cmaps made it easier to see the underlying interconnections between the emerging concepts. The vertical links displayed how the participants differentiated the concepts while the horizontal links displayed how the participants connected and related different areas of sustainable development and sustainable practices.

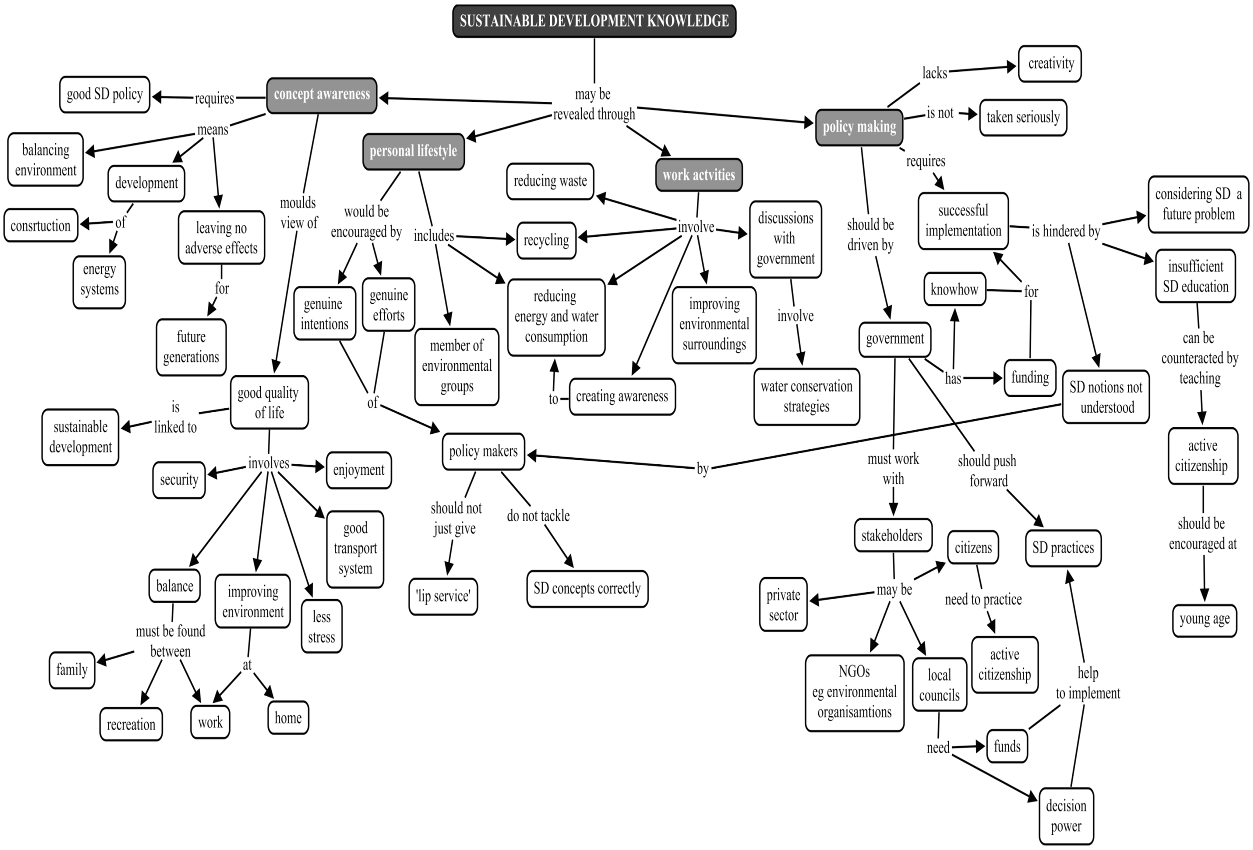

Figure 1. Concept map developed for Policy Maker 1

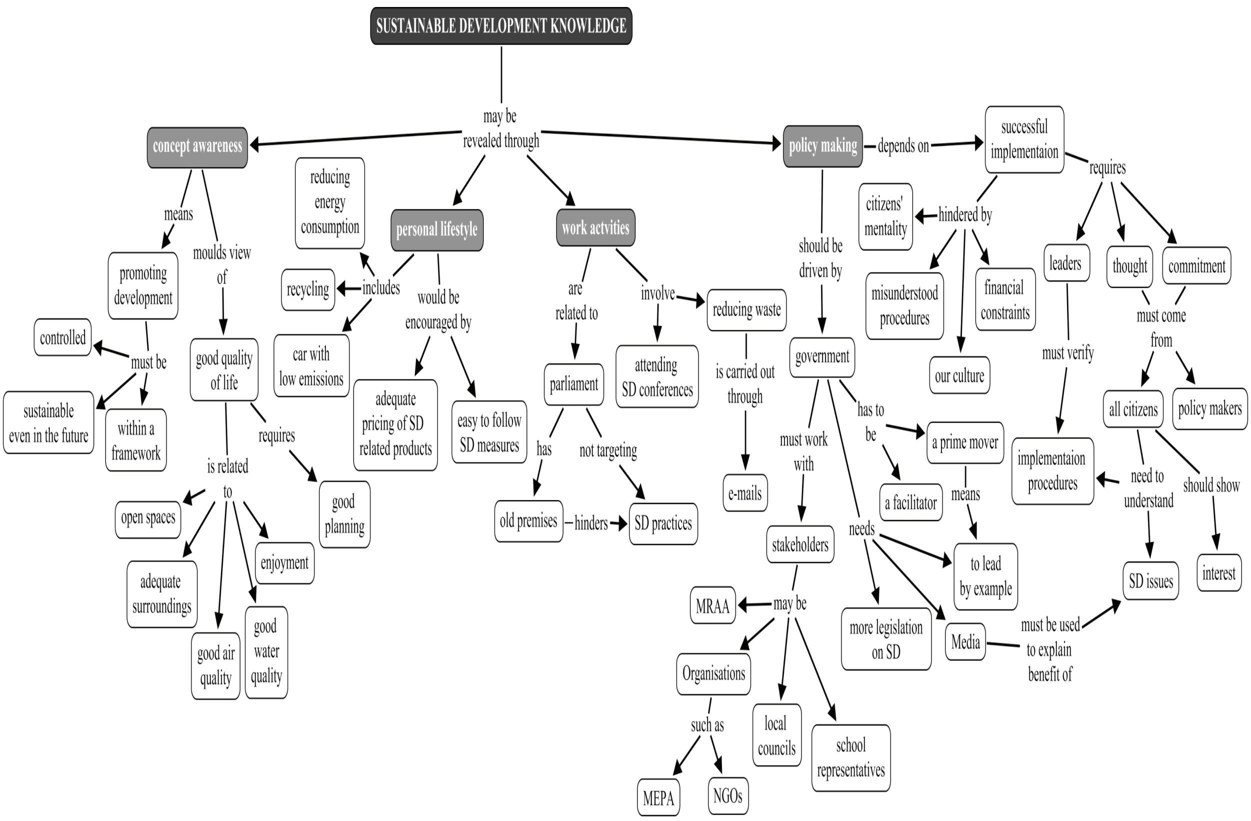

Figure 2. Concept map developed for Policy Maker 2

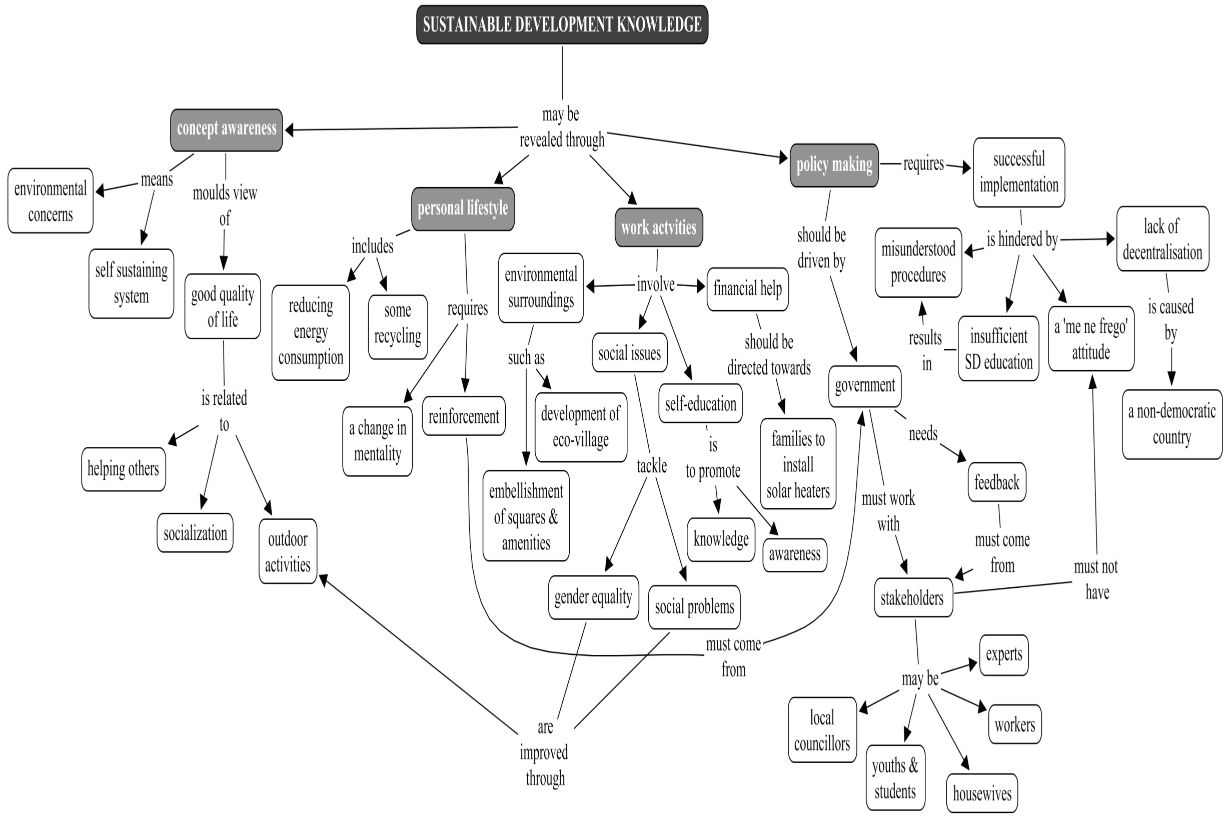

Figure 3. Concept map developed for Policy Maker 3

The Cmaps provided an insight to the policy makers' perceptions of sustainable development and whether they have developed the necessary values and attitudes required to promote sustainability. They also indicated whether the decisions taken by policy makers are rooted in a clear understanding of the holistic nature of sustainable development. The degree of horizontal linkage for each participant also brought to light whether the policy makers recognize that sustainable development involves complex schemes that are multidisciplinary and require long term goals.

3.2 Interviewees' Perceptions of Sustainable Development

When analysing the collective feedback that emerged through the Cmaps there seemed to be quite a substantial amount of knowledge of what sustainable development entails. However, one needs to bear in mind that all the data gathered reflects the views of all policy makers. When viewed individually, few were those who managed to give due importance to all three major pillars of sustainable development. Apart from these few, the rest across the board were very knowledgeable in a particular aspect of sustainable development and slightly less knowledgeable in others. This mostly depended on their area of expertise due to the position in which they were delegated.

Policy makers have different perceptions and experiences that together shape their views of what constitutes sustainable development. Environmental concerns prevail in the majority of Cmaps. This indicates that, to a certain degree, environmental concerns have become an important part of the political agenda. On the other hand, it is still a thwarted image of sustainable development and a possible explanation why sustainability projects undertaken up to now were predominantly concerned with environmental issues.

The Cmaps clearly illustrate that the majority of respondents interpreted the social dimension of sustainable development in terms of social welfare with minimal or no reference to the notions of social equity and justice. In the case of economic development, most interviewees were conscious of environmental objectives being compromised by economic pressures and pointed out that economic development usually prevails in decision making. Improving the existing levels of education on sustainable development was the only issue common to all respondents. Other domains required for a good, sustainable economy (eg. improving the efficiency of the public sector, better work conditions, and more women in the workforce) were completely omitted by the majority of policy makers.

The underlying concept seems to be that due to its perceived environmental slant, sustainable development policies limit social and economic development. Consequently when policy makers are faced with tough decisions concerning the social and/or economic forum (e.g. unemployment and boosting the tourism industry) environmental concerns are considered as a liability. Although not an easy task, policy makers need to understand that development that is not sustainable, i.e. that does not integrate the three concerns so as to create a balance between them, is not true development. If any one of the aspects is ignored, the impact of this negligence will return to erode any achievements made by the sustainable development adopted.

One might argue that the causes of a country's unsustainability are often, though not solely, traceable to political decisions. Although some politicians try to do their bit for its promotion, sustainability is often compromised at government level (as indicated in some of the Cmaps) because of "clashing interests", a "fear of diminishing popularity" and "loss of votes". These 'priorities' can easily be given precedence over planning choices thus hindering objective sustainable proposals. This reality has an even greater impact in a Small Island State with a very high population density like Malta.

It is ultimately the government who has the resources to enable the implementation of the required sustainable changes to take place. In reality, sustainability is usually dependent on the political whim and personal convictions of individuals in power. People in authority, who aim to provide good governance, need to place values and attitudes conducive to sustainability before their personal interests and opinions. Stalling sustainable development policies and their implementation will ultimately be to the detriment of the nation's environment, economy and society.

Many of the Cmaps illustrating the local councillors' perceptions of sustainability and related practices confirmed that politically motivated conflict and clash of egos are not that common among council members. Analysis of the information shown in these Cmaps indicate that it would be easier to agree on good sustainable practices at the local level, where the prime concern of councillors is to improve the quality of life of all their locals. Therefore, the necessary authority should be primarily invested in local councils particularly if the required decisions for a sustainable future are not being addressed at a higher level.

Most of the councillors argued that they feel that they are not being considered as policy makers. Their contribution is a secondary role: they feel that they are being presented with a fait accompli and that decisions have already been taken when asked for their contributions. They also feel restricted in the initiatives they take at a local level because of limitations, such as lack of proper funding.

Another valid point that emerged through analysis was that it is not enough to introduce good sustainable development policies; they also have to be faithfully implemented and monitored. It was suggested that qualified persons should be employed just to oversee sustainable development incentives in all government departments. A common complaint was that the job of monitoring sustainable development practices in the different departments was entrusted to persons already holding a full day's work load with the result that the additional sustainable development chores are placed on the back burner. In essence, this was the reason why the Green Leader initiative did not effectively achieve the targets it was set up for. If sustainable development is a national priority for Malta, ensuring its implementation should not be left to chance or to sporadic initiatives, but meticulously planned and monitored.

Policy makers should not shoulder all the responsibility of steering a country towards sustainability. Almost all Cmaps reveal a common key concept: the government should have a major role in instituting sustainability, implying that a top-down approach is essential. This is because the government owns the financial and human resources to enable good policy making. However, it was also noted that the public has to demonstrate active citizenship by showing initiative and ownership. This implies that many policy makers also believe in a bottom-up approach. Civil society was mentioned by all interviewees as an important stakeholder. The general feeling among the participants was that they are at opposing ends with the public and they feel that they are swimming against the current when it comes to introducing new practices to the people. True to human nature, most interviewees shifted the blame to their superiors (politicians when this was applicable) or their subordinates (the citizens).

Analysis of this data draws attention to the need of an equally synchronized commitment from both ends to achieve an optimal result. Policy makers must understand that if they expect the public to cooperate, they themselves must be capable of sharing their knowledge with the public in an explicit and coherent manner.

Sustainable development puts the individual at the centre of any significant step towards sustainable lifestyles and hence promotes participation and partnership.

The government also needs to invest in methods or professionals that are capable of fuelling interest in citizens making them accountable and willing to participate in any sustainable projects. Citizens need education regarding sustainable development to help them understand that sustainability is a necessity and should be adopted as a way of life. It is only when citizens are themselves prepared to 'live sustainably' that the necessary behavioural, economic and social changes will be realized (IUCN, 1991). The concept of active citizenship is, once again, dependent on the government's readiness to decentralise power and allow citizens to voice their opinions in public debates, value their contribution and provide feedback on improved provisions.

As pointed out earlier Malta's progress towards sustainability is actively hindered by a mentality that considers citizens as followers rather than leaders – the legacy of Malta's foreign dominancy background. Achieving our commitments towards a sustainable future requires a radical change in the way we perceive ourselves, our responsibilities, our decision making practices and our lifestyles. At the heart of this radical change is the commitment towards ESD targeting policy makers' and citizens' sustainability awareness. This can lead to a new generation of leaders who are ready to take the necessary steps in the right direction for prompt implementation of sustainable practices. Some interviewees remarked that public involvement and implementation is hindered as not all policy makers are sufficiently knowledgeable about what constitutes sustainable development. If this is really the case, then it clearly indicates that there is a dire need for ESD among policy makers. The implications of the findings and the conclusions about policy makers' practices and awareness could be of use in considering what educational steps and research programmes need to be taken to expedite implementation of sustainable development in Malta.

4 Conclusion

This research analyses the commitment of policy makers towards sustainable development practices as reflected in their lifestyles, their current work and their future agendas. Concept maps were used in this qualitative research to condense and organise the large amount of data collected and to create key themes and categories. Cmaps were central in the data analysis, revealing clear interconnections between repeated concepts of knowledge regarding sustainable development and related practices. Analysis of Cmaps indicated that sustainable practices are being incorporated in Maltese policies yet there is the necessity to prioritize all the needs of sustainable development to facilitate its implementation. This can be done by providing the opportunity for both policy makers and the public to increase their knowledge and understanding of the purpose of Local Agenda 21.

It is hoped that this research reminds policy makers that actions speak louder than words and they therefore should orientate their existing practices to address sustainability. The challenge for any government is not only to make sustainable development the aim of its policy, but to attain the targets it sets in these policies within the stipulated time-frames. It is essential that sustainable development is not considered to be an add-on but it is seen as integral to our way of life. In decisions concerning society and life, there will never be a formula that will please all citizens and this also applies to sustainable development. For every policy that government decides on, there will always be opposing fronts who disapprove of the decisions taken. However, if policy makers become proficient in sustainable development and believe in what they are promoting, they will recognize and believe in the importance of small improvements alongside the major changes.

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ASSESSING DIVERSITY AND SIMILARITY OF CONCEPTUAL UNDERSTANDING VIA SEMI-AUTOMATED SEMANTIC ANALYSIS OF CONCEPT MAPS

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Abstract. The development of common conceptual understanding is one of the essential steps in professionalization of a field of practice. To support this process, we collected Concept Maps (CMaps) from practitioners in the field answering the same focus question. Our goal was to expose variability in the understanding of the concept under investigation and to identify common themes, which could be later taken as the basis for the development of a common definition. Collected maps were open-ended, they consisted of varying numbers of concepts and propositions, had different structures, and had little overlap of concepts and concept connections. In order to extract common themes from this set of maps, we used Latent Semantic Analysis to compare CMaps' semantic elements (e.g., concepts, propositions and maps) to each other. Based on this semi-automated analysis we were able to extract a set of concepts and propositions that are semantically representative of the collection.

1 Introduction

Having a shared understanding of common terms and core concepts is an important precondition for communication all professions and disciplines. Clear, consensual definitions reduce the ambiguity and vagueness of terms, thus minimizing the chances for misunderstanding. The development of a common lexicon is one of the essential steps toward a field's professionalization, and this process begins with the assessment of the existing diversity of conceptual meanings. One community of practice where professionalization efforts have only recently begun is intelligence analysis. Intelligence analysis has a long history of practice; however it has been practiced more as a "craft" with largely undefined standards, terminology, and best practices (Bruce & George, 2008). Consequently, many terms lack widely shared definitions. In order to assist the intelligence community in developing a common lexicon, and building on our earlier work applying CMapping in the domain of intelligence analysis (e.g., Derbentseva & Mandel, 2011), we collected definitions of one central concept—analytic integrity—from a number of intelligence practitioners. We used the elicited definitions to assess the variability in the conceptual understanding that exists among the practitioners.

The goal of our study was to expose variability in the understanding of the concept and to identify common themes, which could be later taken as the basis for the development of a common definition. The task of assessing variability in conceptual understanding is not a trivial one and requires integration of methods for data collection and analysis. We used a graphical knowledge representation technique called Concept Mapping (CMapping, Novak, 1998; Novak & Cañas, 2006; Novak & Gowin, 1984) to capture the conceptual understanding of practitioners (see Figure 1 for an example CMap collected during the study), and then focused our analysis on the two main aspects of the CMaps – their structure and their content. The collected CMaps were analyzed and compared along several dimensions. Although there is a great deal of research on scoring and evaluating CMaps in the educational setting, many of these approaches could not be applied to open-ended CMaps in the domain where there is no criterion list of correct propositions or expert-drawn CMaps for comparison.

We chose to use CMapping for data collection because of its unique properties that fit well with the goals of the project. CMapping yields a concise representation of the mapper's subjective understanding of the topic that the map describes. The process of CMapping "…encourages – perhaps even forces – the mapper to reach for crystal clarity about what he or she wishes to express" (Crandall, Klein, & Hoffman, 2006, p.54). Such clarification results in a representation that focuses on essential concepts and their relationships while minimizing word redundancy associated with written texts. A strength of CMapping is that it encourages a mapper to clearly externalize the conceptual relationships that he or she wishes to express, which allows map readers to identify divergent or missing relationships more easily. In addition, CMapping has been successfully applied to various aspects of knowledge elicitation, codification and management (e.g., Coffey et al., 2003; Crandall, et al., 2006; Harter & Moon, 2011; Hoffman & Lintern, 2006; Moon, Hoffman, & Ziebell, 2009). Harter and Moon (2011), in particular, applied CMapping as an intermediate step in the development of a common lexicon in the field of security analysis and risk management. The original definitions in their study, however, were collected in text form and were later converted into CMaps by expert CMappers (rather than expert practitioners).

Analysis of the content of open-ended CMaps without a set of criterion propositions or an expert map for comparison is a laborious task that requires human coding and interpretation. Natural language processing algorithms (NLP) have been applied to automating CMap construction tasks to identify and suggest map elements for inclusion into the map (e.g., Kowata, Cury, & Boeres, 2010; Valerio & Leake, 2006). However, NLP algorithms can also aid in analyzing and comparing content of CMaps on a semantic level. In particular, NLP algorithms can be used to assess semantic similarity of concepts and propositions within and between maps, as well as the semantic similarity among a set of maps.

Latent Semantic Analysis (LSA) is one of the statistical models of language processing that is widely used in information retrieval and study of human memory (Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998). Analyzing a large collection of unstructured documents, LSA constructs semantic representations for words based on a statistical analysis of the terms' occurrences across documents. The frequencies are expressed as a matrix, the dimensionality of which is reduced via singular value decomposition. LSA allows one to compare the semantic similarity of words, phrases, and texts, by taking the cosine of the angle formed by their vector representations. Cosine values ranges between -1 and 1, with values closer to 1 indicating higher degree of semantic similarity.

In this study, we used LSA trained on a custom corpus of documents from the intelligence domain. We analyzed the semantic similarity of main contextual elements of the CMaps – concepts and propositions – within each map and between the maps, and we compared the collected maps (as collections of all their propositions) to each other. The following section reports the results of our investigation.

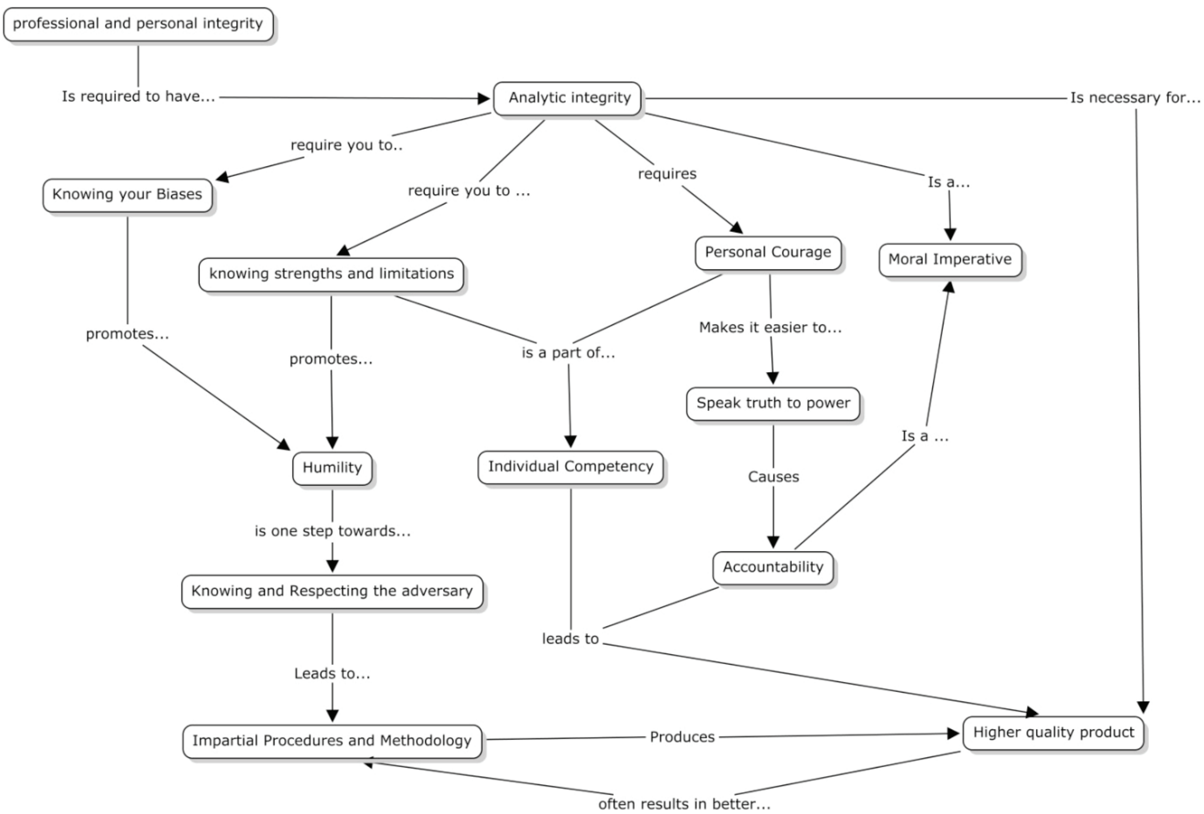

Figure 1. An example CMap constructed by a group of intelligence practitioners to answer the focus question "*What is Analytic Integrity?*"

2 Method

We used CMapping to gather various conceptualizations of *analytic integrity* from practitioners. Instead of collecting textual definitions of the term and then converting them into CMaps, as was done by Harter and Moon (2011), we asked practitioners to construct CMap representations of the term themselves (see Figure 1 for an example of a map collected during the study). This approach served a dual purpose. On the one hand, it introduced practitioners to CMapping as a knowledge representation technique and allowed them to experience its functionality firsthand. We postulated further that such experience is more likely to facilitate adoption of the technique in the future. On the other hand, engaging practitioners in the CMap construction process encouraged them to refine and clarify their ideas on the topic and provide us with a concise representation. This approach removed the necessity to interpret and infer the intended meaning from potentially ambiguous textual accounts; and allowed us to capture the conceptual relationships that practitioners deemed important to represent.

2.1 Data collection procedure

Defence R&D Canada's Human Research Ethics Committee reviewed and approved the study. Overall, we conducted four study sessions, during which we collected definitions of *analytic integrity* from 52 civilian and military practitioners who volunteered to participate in the study. Participants had varying level of experience in the field of intelligence, ranging from novices with little practical experience to senior practitioners with decades of experience in the field. All participants were novice CMappers and the study was their first introduction to the Novakian CMapping technique. Each of the four study sessions had between 8-18 participants. A study session began with a 45-minute training session on CMapping and was followed by a small group collaborative CMap construction task. CMap training was designed for the purposes of this study and included the following components:

- Introduction, a brief history of the development of CMapping and its current applications;
- Main properties of CMaps, including definitions and examples of concepts, linking phrases, propositions, the propositional coherence principle, the overall organization of a CMap;
- The process of CMap construction as outlined in the IHMC flowchart (IHMC, 2006) including exercises that gave participants practice with each of the steps in the CMap construction process;
- Basic introduction to the CmapTools software (IHMC, 2008) that allowed participants to comfortably construct basic CMaps.

After the training, participants formed groups of 4-5 members to collaboratively construct a CMap answering the question, "*What is analytic integrity*?" The map construction task was open-ended with no restrictions imposed. Moreover, no structural constraints were specified and no list of potential concepts or linking phrases was given. Each group worked in separate quarters, equipped with a laptop running CmapTools software (IHMC, 2008) with a new map window opened displaying the focus question. Groups were given about an hour to complete the task. We used a collaborative approach to constructing CMaps for two main reasons. First, the goal of the study was not only to collect conceptual representations from participants, but also to promote the discussion and exchange of ideas on the topic. Group map construction is well suited for this purpose. Participants commented that they enjoyed the collaborative approach, finding it to be intellectually stimulating. Second, participants were novice CMappers and the collaborative exercise allowed them to assist each other in map construction.

2.2 Measures

As noted earlier, the aim of the study was to assess the variability in understanding of the term *analytic integrity* among the intelligence practitioners and to identify similarity in their conceptualizations that could serve as a basis for the development of a common definition. We used several measures to evaluate and compare the maps, including several structural properties of the maps, a semantic analysis of their content, and a subjective overall map evaluation. There was no expert CMap on the topic or a set of correct propositions that could be used for comparison.

2.2.1 Descriptive structural map assessment

The structure of collected maps was analyzed along a number of dimensions. The CmapAnalysis tool (Cañas, Bunch, & Reiska, 2010) was used to calculate some of the measures, such as *average number of propositions per concept* and *map taxonomy score*. Some other measures (e.g., *map density* and *normalized concept centrality*) were calculated based on the network analysis methods (e.g., Knoke & Yang, 2008; Scott, 1991). In the latter case, each map was treated as an undirected binary graph.

In particular, the *map density* measure was calculated as a proportion of links present in an undirected map-network relative to all possible links in the map, and it is an overall measure of a map's interconnectivity. The *average normalized concept degree* measure was computed to show the average proportion of other concepts in a map to which a concept is directly connected. In other words, it is a normalized measure of concept degree centrality when a map is treated as an undirected binary network. Both *map density* and normalized *concept degree* measures are normalized, thus allowing for a direct comparison among maps.

The structural measures were correlated with semantic and subjective measures (both are described below) to determine which measures are closely related.

2.2.2 Semantic measures

The content of the CMaps was analyzed in two ways:

- by identifying identical concepts and propositions among the maps, and
- by assessing semantic similarity of concepts and propositions within and between maps using LSA.

In the former case, identical concepts and propositions among the maps were identified by direct word matching. In the latter case, LSA was performed using Dennis and Stone's (2011) LSA implementation in the SEMMOD package (v 1.5). LSA provides potentially different results depending on which collection of documents (i.e., corpus) it is trained. For example, the term "tree" will have a different meaning (and will co-occur with different kinds of words) in the context of biology that it will in computer science. Therefore, to achieve the best LSA performance, we reasoned that the model should be trained on a collection of documents from the same subject domain to which it is subsequently applied.

A custom training corpus of documents on the topic of "*intelligence analysis*" was created for LSA. The corpus was created using Stone and Dennis's (2012) tool for custom corpus generation from a Wikipedia archive. A set of keywords from the intelligence analysis field was used as a query to find relevant documents, such as "intelligence analysis," "intelligence assessment," "strategic intelligence," "military intelligence," etc. The training corpus included 9,973 documents with 78,896 terms. Several algorithms in the Python programming language (for the Linux environment) were developed to apply LSA to the CMaps and their elements. To facilitate machine processing of CMaps, they were converted to CXL format.

The following LSA analyses were conducted:

1. All pairwise comparisons of concepts in a map: This analysis provides an indication of the *semantic diversity* of concepts in a map. *Concept semantic diversity* was measured as a range between the highest and lowest pairwise concept LSA cosines;
2. Comparison of each concept to its map document. This measure provides an indication of which concepts are most similar to the map as a whole, which can be seen as *semantic concept centrality.* A map document represents a set of all propositions in a map. The contribution of more frequently-occurring concepts to the map document vector was controlled by converting the frequency to its logarithm.
3. All pairwise comparisons of propositions in a map: Similar to concept pairwise comparisons, it provides an indication of *propositional semantic diversity* of a map;
4. Comparison of each proposition to its map document (a map document represents the set of all propositions in that map). This measure provides an indication of which propositions are most similar to the map as a whole; i.e., *semantic proposition centrality*;
5. Each concept from each CMap was also compared to the aggregated map document comprised of all CMaps collected. This measure provides an indication of which concepts are most similar (or central) to the entire collection of maps;
6. Similarly, each proposition was compared to the aggregated map document, indicating which propositions were the most representative of the map collection.

Semantic diversity of a map represents a range of observed cosine values for all pair-wise comparisons of either concepts (the measure of *concept semantic diversity*) or propositions (the measure of *proposition semantic diversity*) in a map. Maps that have some highly similar concepts and some concepts with low similarity will have a greater range of cosine values than maps with all highly similar concepts or all concepts with low similarity. Semantic diversity is an indication of the (moderate degree of) variability of ideas expressed in a map. Based on our measure, both too much variability (i.e., little similarity among the ideas) and too little variability (i.e., all the ideas are relatively similar) in a map will result in a low semantic diversity score.

2.2.3 Subjective rating

Two human raters scored each CMap on the basis of how well a map answered the focus question ("*What is analytic integrity?*") on a scale from 0 ("does not answer the question at all") to 10 ("answers the question very well"), with a good inter-rater consistency ($ICC = 0.81$, $p < .01$). Both raters had experience with CMapping and were familiar with the field of intelligence analysis. The average score from the two raters for each map is reported as its relevance to the focus question score. The subjective ratings represent qualitative evaluations from a reader's perspective and were used compared to other structural and semantic measures.

3 Results

3.1 Overall CMap analysis

We collected 12 group CMaps on the topic of *analytic integrity* (see Figure 1 for an example CMap). The average number of concepts per map was 11.8 (*SD* = 3.2) and the average number of propositions per map was 15.4 (*SD* = 5.5). Table 1 provides a descriptive analysis of each of the maps along several dimensions including the maps' structural properties, taxonomy score, subjective rating, and semantic diversity.

As is clear in Table 1, maps vary considerably along the different measures. Interestingly, the map that was judged to provide the best answer to the focus question by raters, Map 7, received a fairly low taxonomy score, 2. The average map density was 0.13 (SD = 0.04), which indicates that on average, maps included about 13% of all possible connections. Although 13% seems to be a fairly low proportion, it is worth noting that high map density is not necessarily desirable in a CMap, because a large number of propositions could potentially diminish a map's readability and, therefore, its usefulness. The optimum map density level needs to be determined.

#	Level of Experience	Structural measures					Map Taxonomy score	FQ subjective rating	Semantic diversity	
		# Concepts	#of propos.	Map Density	Av. # of propos per concept	Normalized concept degree			Concept	Proposition
1	M	10	14	0.16	1.40	27.8	4	6.00	0.371	0.856
2	M	10	15	0.17	1.50	33.3	2	7.00	0.509	0.739
3	M	13	19	0.12	1.46	23.3	4	8.00	0.845	0.680
4	M	9	10	0.14	1.11	27.5	3	5.25	0.550	0.552
5	M	9	16	0.22	1.78	40.0	4	6.00	0.486	0.795
6	M	13	21	0.13	1.62	26.7	4	7.25	0.427	0.716
7	L	15	26	0.12	1.73	23.2	2	9.25	0.731	0.937
8	L	15	20	0.10	1.33	17.9	5	7.00	0.917	0.806
9	L	10	12	0.13	1.20	26.7	5	6.25	0.682	0.804
10	H	11	13	0.12	1.18	21.7	2	6.00	0.317	0.778
11	H	19	14	0.04	0.74	7.8	5	5.75	0.827	0.744
12	H	8	5	0.09	0.63	15.7	2	4.00	0.501	0.146
Average		11.8	15.4	0.13	1.30	24.3	3.5	6.50	0.600	0.710
StDev		3.2	5.5	0.04	0.36	8.3	1.2	1.40	0.200	0.200

Table1 1. Overall descriptive analysis of the collected CMaps on a number of structural and semantic dimensions

Silva, Romano and Correia (2010) raised concerns regarding the quality of CMaps constructed by novice CMappers and the potential "naïve use of this technique". One of the measures on which novice maps significantly differed from expert maps in the study by Silva et al. was the average number of propositions per concept (the reported average was 1.0 proposition per concept). The observed average number of propositions per concept in the maps we collected was 1.3 (SD = 0.3), and was higher than the average reported for the novice maps in Silva et al. study (t = 2.96, $p < .05$). This is a positive indication that our CMap training addressed at least some of the concerns experienced by novices.

Most of the five structural measures – *number of concepts*, *number of propositions*, *map density*, *average number of propositions per concept*, and *normalized concept degree* – were significantly correlated. There was no correlation between the *number of concepts* and the *normalized concept degree* measure and the *average propositions per concept*. Also, there was no correlation between the *map density* measure and the *number of propositions*.

Surprisingly, there was no significant correlation between the *map taxonomy score* and any of the other measures, including structural, subjective and semantic.

As expected, there was a positive correlation between *concept semantic diversity* and the *number of concepts* ($r[10] = .66$, $p < .05$) and between the *proposition semantic diversity* and the *number of propositions* ($r[10] = .72$, $p < .01$). While concept semantic diversity did not correlate with any other measures, there was a positive correlation between *proposition semantic diversity* and the *map subjective rating* ($r[10] = .69$, $p < .05$).

This relationship could indicate that map readers look for a moderate range of ideas in a map to provide a rounded answer to their focus question. This relationship requires further investigation.

3.2 Semantic analysis of CMaps

There were total of 142 concepts and 185 propositions in the 12 maps collected. After collapsing identical concepts across maps, the number of unique concepts remaining was 89. Table 2 lists 13 concepts that were shared by three or more maps. Additionally, there were 13 concepts shared by two maps. In the 12 CMaps, only a single proposition matched in two maps in its entirety—namely, "Analytic Integrity requires Honesty". Four additional pairs of concepts were linked in two maps each, but with different linking phrases. These are indicated in the fifth column of Table 2, *Linked to the same concepts in two maps*.

	Concept	# of maps	% of maps	Linked to the same concepts in 2 maps	Average structural centrality	Semantic similarity to the aggregated map document (as percentage of the highest value)
1	Analytic integrity	8	67	Accountability, Credibility, Honesty	4.5	58 (72)
2	Honesty	6	50	Analytic integrity*	2.5	12 (15)
3	Credibility	5	42	Analytic integrity*, Quality, Sources	2.2	23 (29)
4	Objective	5	42	None	2.6	28 (35)
5	Accountability	4	33	Analytic integrity*	2.5	27 (33)
6	Accuracy	3	25	None	1.7	39 (48)
7	Bias	3	25	None	1.7	34 (42)
8	Evidence	3	25	None	2.7	29 (35)
9	Logical	3	25	None	1.7	36 (44)
10	Responsibility	3	25	None	3.3	28 (35)
11	Sources	3	25	None	4.0	39 (48)
12	Being thorough	3	25	None	2.3	24 (30)
13	Experience	3	25	None	3.3	36 (44)

* Represents the same links as indicated for the concept *Analytic Integrity* in the first row

Table 2. Concept and concept link overlaps in the CMap set

Table 2 also reports the average structural centrality of the concepts that appear in more than one map as well as their semantic similarity to the aggregated map document (i.e., a document that consists of all 185 propositions from the 12 maps), and the normalized measure relative to the highest observed semantic similarity measure is included in the parentheses.

This analysis reveals that there is little direct overlap in the concepts and their relationships that different groups used to express their understanding of *analytic integrity*. However, it does not necessarily mean that the maps are strikingly different. In fact, we conducted all pairwise LSA comparisons of the maps, and the average cosine value was 0.78 (SD = 0.08), which indicates a considerable semantic overlap in the maps despite the lack of the directly matching concepts and propositions.

The next step in our analysis was to identify concepts and propositions that are representative of the collection of the maps. This was achieved by comparing each of the concepts and each of the propositions to the aggregated map collection. The top 10% of the concepts having the highest semantic similarity with all the maps are listed in Table 3. These concepts have reasonable face validity. Note that there is not much overlap between the most frequently occurring concepts (see Table 2) and the list of most semantically similar concepts. The top 10% of propositions with highest cosine values are presented in a CMap in Figure 2.

Based on the semantic analysis, the map elements in Table 3 and Figure 2 are most representative of the overall collection of the maps generated by professionals. These elements could be taken as the basis for the development of a common definition by the community practitioners. Note that Figure 2 shows only those propositions that exist in the map collection, and thus is segmented. The map segments can easily be connected by adding relationships.

4 Conclusion

Analyzing CMaps' content and identifying commonalities in a set of maps with very little verbal overlap can be a daunting task. NLP algorithms could facilitate this process. With LSA we were able to extract a set of concepts and propositions that, according to our analysis, are representative of the collection of CMaps about analytic integrity that we collected from practitioners. An advantage of this approach is that the selection of most representative elements can be fully automated. Although this process will not produce a finished map or a concept definition, it can serve as a valuable starting point and input stage for later human assessment.

#	Concept	Cosine	Norm.	#	Concept	Cosine	Norm.
1	Broad subject knowledge	0.809	1.00	9	Policies and procedures	0.604	0.75
2	Quality sources	0.778	0.96	10	Logical thinking	0.594	0.73
3	Critical thinking	0.692	0.86	11	Analytic integrity	0.584	0.72
4	Impartial procedures and methodology	0.673	0.83	12	Personal ethics	0.577	0.71
5	Non-bias	0.639	0.79	13	Higher quality product	0.576	0.71
6	Quality control	0.635	0.78	14	Analysis	0.574	0.71
7	Professional and personal integrity	0.633	0.78	15	Comprehensive examination	0.566	0.70
8	Individual competency	0.632	0.78	16	Speak truth to power	0.562	0.69

Table 3. List of the top 10% of concepts based on their semantic similarity to the aggregated map collection

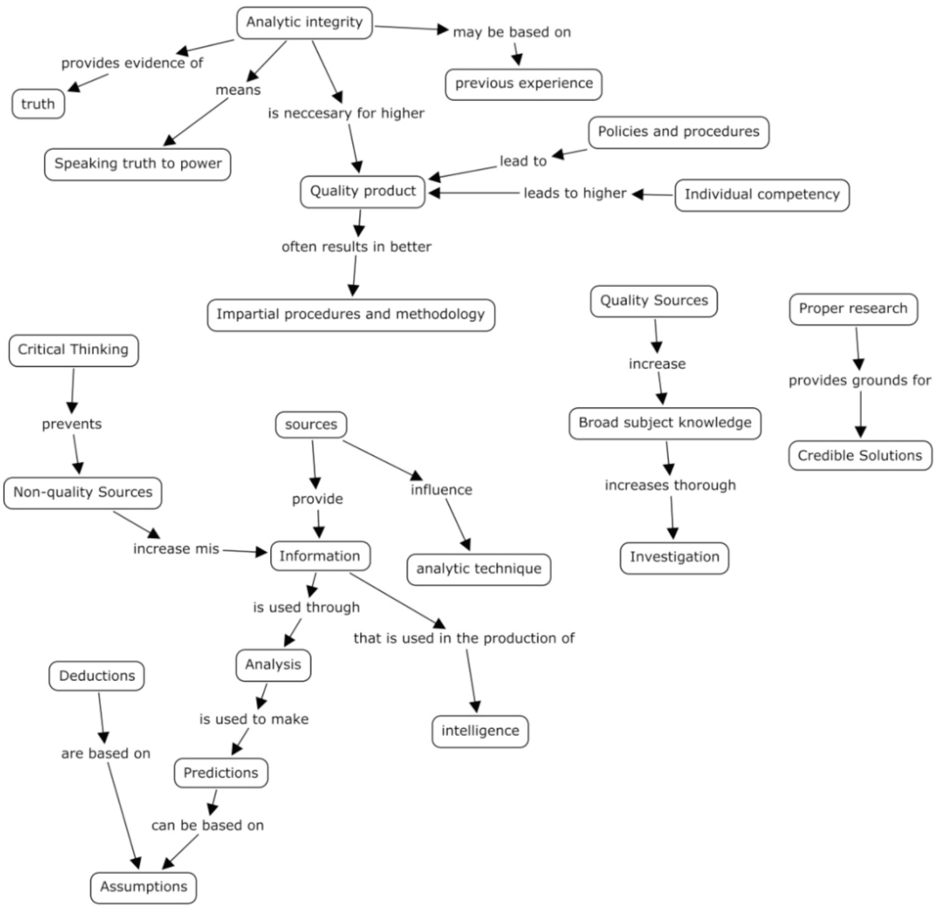

Figure 2. A CMap representation of the top 10% of propositions based on their semantic similarity to the aggregated map collection

Semantic analysis, such as LSA, can also facilitate CMap structural analysis. Most of the structural analyses of CMaps ignore semantic information carried by the linking phrases, treating all propositions as equal connections (and often ignoring their directionality). The requirement of labeling all concept connections is one of the distinguishing features of CMapping. Linking phrases carry information and differentiate among propositions. Structural analysis of CMaps requires methods that are able to take this information into account. One potential solution to this problem is to differentiate among propositions in a map based on their semantic centrality (as measured by a cosine between a proposition vector and a map vector). Weights could be assigned to links in a map network based on the propositions' semantic centrality, which would allow transforming a graph of a map from binary into a valued network. The integration of semantic and structural analyses of CMaps is an area that deserves further investigation.

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AUTOMATED CONCEPT MAP GENERATION FROM SERVICE-ORIENTED ARCHITECTURE ARTIFACTS

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Abstract. This article contains a description of the first phase of a two-phase project in computer program understanding for Service-oriented Architecture (SOA) composite applications. The first phase, which is described here, pertains to development of CARET, a prototype software tool that automates the process of generating concept maps that pertain to the structure of composite applications. CARET produces triples describing the relationships of entities contained in WSDL, BPEL, and XML Schema files. The triples can be imported into CmapTools, where they are automatically rendered into a concept map. The tool is programmatically extensible to capture any relationships of interest in such systems. In the second phase, to be reported in future work, the concept maps created in this fashion will be augmented with knowledge elicited from experts in the software system being modeled.

1 Introduction

Well-structured concept maps provide clear concise representations of conceptual knowledge. Although the vast majority of work on concept map creation pertains to those created by humans, some studies contain descriptions of machine-generated maps. This article describes work on the first part of a two-part process of automatically generating concept maps that identify and visualize relationships in complex artifacts of Service-oriented Architecture (SOA) composite applications and then augmenting these concept maps with domain knowledge of the software elicited from human experts. The end goal of the work is to foster understanding of SOA applications through these constructed knowledge models. This paper reports results on the first phase (automated concept map generation) of this process.

This work is motivated by the rapidly increasing use of Web Services and SOA to tie together heterogeneous networked software systems. The exceptional complexity of the documents that specify and orchestrate SOA applications makes these software systems difficult to understand. Separate XML specifications are used to describe Web service interfaces (WSDL), data types (XML Schema), and composite application processes (BPEL). Understanding how all the pieces fit together is a significant challenge for software maintainers. It is, however, feasible to extract {concept → linking phrase → concept} triples from these documents that explicitly summarize important relationships among them. These triples can be imported into a tool such as CmapTools (Cañas et al, 2004) in order to represent the relationships they convey as concept maps.

The remainder of this article contains a description of a system for the automated generation of concept maps from XML documents (WSDLs, XML Schemas, and BPELs) that describe composite applications executing in a Service-oriented Architecture. Following a review of relevant literature on the automated generation of concept maps and on conceptual models of composite applications residing in Service- oriented Architectures, the paper presents a description of CARET: Composite Application Reverse Engineering Tool. After a basic discussion of the way in which the tool is used, a case study pertaining to a medium-sized composite application is presented. The case study includes a description of a concept map that was automatically generated with CARET and populated with accompanying resources. The paper concludes with an analysis of the benefits and drawbacks of the approach, and a description of future work.

2 Automated Generation of Concept Maps

RDF and OWL are Semantic Web markup languages that are difficult for humans to understand. Eskridge and Hayes (2006) describe a plug-in to CmapTools named COE that allows the automatic generation of concept maps from RDF and OWL ontologies and OWL/RDF ontologies from concept maps. The goal of their work is to foster human understanding of these complex artifacts while retaining the formal properties of the descriptions. For this reason, the set of linking phrases is constrained to those in the OWL and RDF vocabularies. Graudina and Grundspenkis (2008) also described a tool that supported this task. Their contribution was identifying a general algorithm for the transformation of ontologies in any format into concept maps.

Richardson, Goertzel, and Fox (2006) have developed a tool named Relex that produces concept maps from text. The system they produced creates graphs of semantic primitives (Wierzbicka, 2006) extracted from syntactic dependencies. Relex requires domain-specific vocabularies, necessitating a lexicon of relevant terms. The work they performed was in the area of electronic theses and dissertations pertaining to computer science, which involves inherently large documents.

Work has also been done on the automated transformation of concept maps into other formalisms. For example, Gomez, Diaz-Agudo, and Gonzalez-Calero (2004) describe the transformation of concept maps into description logics. Leake, Maguitman, and Reichherzer (2004) describe the extraction of concepts from concept maps and the transformation of those concepts into queries that can be executed by a Web-based search engine. Cabral and Goncalves (2006) describe software that transforms concept maps into SCORM-compliant learning objects, and represented in another XML vocabulary.

Although not directly related to the automatic generation of concept maps, the idea of building understandings with "expert skeleton" concept maps put forth by Novak and Cañas (2004) is also relevant to the current work and briefly discussed here. Novak and Cañas state that expert skeleton maps provide a strong foundation for learning and that they create a context in which additional concepts and propositions may be added. This principle applies regardless of whether the concept maps are generated by humans or by automated means. Ideas in the work on expert skeleton maps are relevant to knowledge modeling for the understanding of SOA, the topic of the next section.

3 Knowledge Modeling for the Reverse Engineering of Software

Canfora, Di Penta, and Cerulo (2011) claim that "Radical innovations are needed to cope with new and emerging software development scenarios and new system architectures (p. 151)." They cite Chikofsky and Cross' (1990) seminal work which defined the problem of reverse engineering software as the creation of representations of the structure and function of software that are useful to humans from available software "artifacts." The word artifact was meant to include internal and external documentation of source and target code, as well as the code itself.

As suggested by Canfora, Di Penta, and Cerulo, a primary goal of reverse engineering is the creation of architectural models of software that support specific maintenance tasks. The prevailing approach to this end relies upon the evaluation of source code and documentation. The literature includes descriptions of a number of tools and methods that serve this goal. What is less clear in the literature is how to perform this task on the complex artifacts comprising SOA applications and how to incorporate less tangible conceptual knowledge that might provide significant insights into the software, including design rationale or undocumented features.

A substantial body of work exists on the idea of knowledge capture, preservation and sharing through the creation of knowledge models based upon the elicited conceptual knowledge of experts (Ford, Cañas, and Coffey, 1993; Cañas et al, 1996; Coffey, et. al., 2003). One approach involves interactive elicitation of concept maps (Novak and Gowin, 1984) which are concise representations of propositional knowledge. Propositions are triples involving two concepts and a linking phrase that describes the relationship between the concepts:

```
<concept> <linkingPhrase> <concept>
```

For instance, *"automobiles are powered by engines"* is a proposition comprised of the concepts "automobiles" and "engines" and the linking phrase "are powered by." Hierarchically structured groups of concept maps can be populated with other electronic resources to form conceptual or knowledge models (eg: Coffey, Hoffman, and Novak, 2010) pertaining to some body of knowledge.

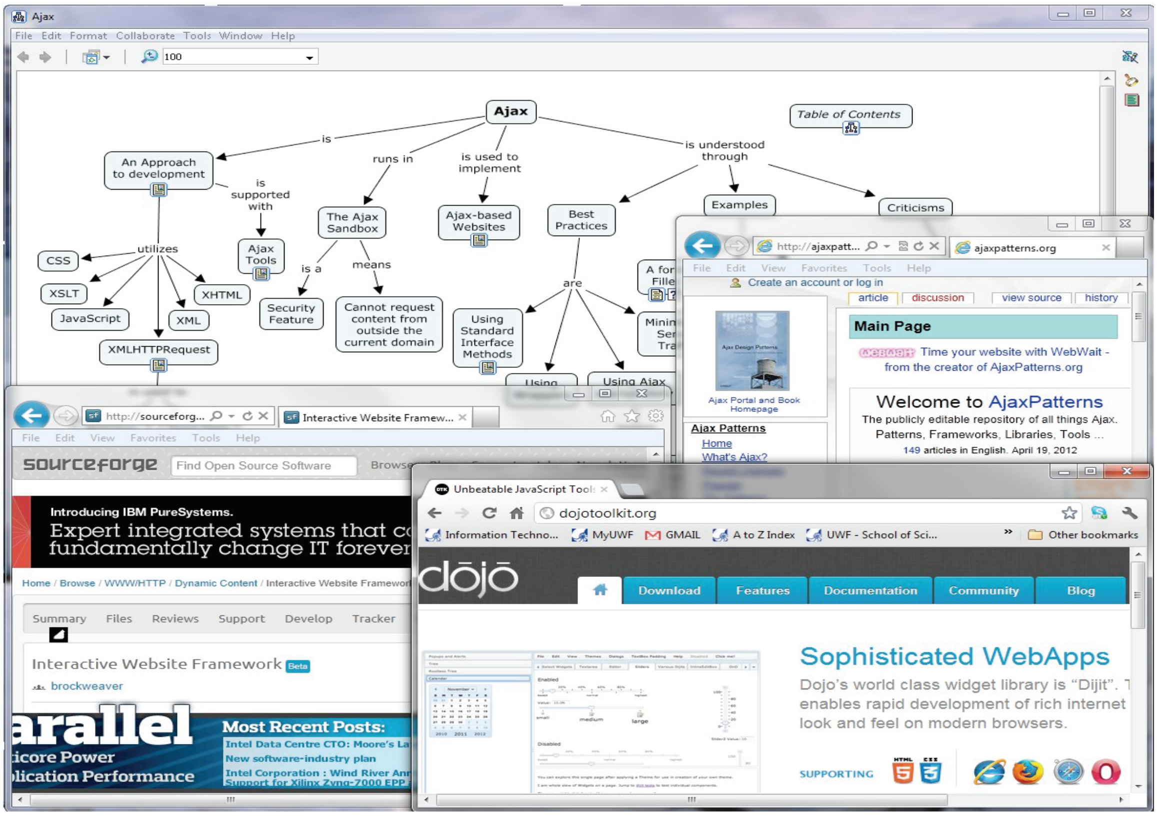

Figure 1. A Knowledge Model with concept map and related resources.

Figure 1 contains an illustration of components of a Web-based knowledge model that pertains to AJAX (Asynchronous JavaScript and XML, a group of technologies used to create interactive websites). The top-most window is a concept map that has been enhanced with links indicated by the icons below the concepts (the rounded rectangles in the maps) in some of the nodes. The icons provide access to pull-down menus that afford navigation to associated electronic resources. Figure 1 might arise from a scenario in which the user first navigated into the AJAX concept map from a more general concept map, perhaps on the subject of the JavaScript programming language. From the AJAX map, the user clicked on a link pertaining to AJAX tools to access the dojo Toolkit website, an “Interactive Website Framework” form Source Forge, and a page that pertains to AJAX design patterns. Knowledge models such as this one have been created in numerous knowledge domains (Coffey, et al. (2003); Coffey, Hoffman, & Novak, (2010)).

A fundamental purpose of CARET is to automate the creation of concept maps that provide a basic structure for the creation of knowledge models pertaining to SOA composite applications. CARET evaluates named entities described in BPEL, WSDL, and XML Schema files for a specific SOA composite application and provides input for a program that creates concept maps from triples. CARET produces all information needed to produce a hierarchically-structured “skeleton knowledge model,” a structured representation of several skeleton concept maps. These concept maps may be elaborated with elicited expert knowledge, and augmented with additional electronic resources including the original WSDL, BPEL and XML Schema files that were abstracted to form the maps. The elicited expert knowledge helps to address the issue of identifying design rationale and other important but non-obvious knowledge pertaining to the software.

4 Overview of Service-Oriented Architectures and Maintenance Problems

Service-oriented Architectures offer the prospect of creating multi-platform software out of heterogeneous services executing on the Internet. A composite application is typically comprised of several service components that may be internal or external to the organization constructing it. Each service component has interface descriptions that facilitate interoperability among the set of services in a SOA composite application. The descriptions follow a set of standard languages for building and deploying Web Services including Web Services Description Language (WSDL) for service interfaces, XML Schema Definition (XSD) for service data types, SOAP for message formatting, HTTP for message exchange, and Business Process Execution Language (BPEL) for service orchestration code. Together, service descriptions, code, and execution hardware form a complex system of systems that is difficult to comprehend.

Any maintenance task on such a composite system requires an in-depth understanding of its service components, the operations they perform, and the data they exchange. This includes knowledge of the service descriptions and the dependencies among the services within the composite. CARETs goal is to provide maintainers with a high-level description of service components, their operations and dependencies for a selected composite application.

5 CARET

CARET, Composite Application Reverse Engineering Tool, is a tool for the semi-automated creation of knowledge models of composite applications. CARET is based upon a SAX parser for XML files that allows it to react to individual elements and attributes that are of interest to the parser, without having to build a DOM tree in RAM. This feature ensures that the processing of large files, typical of those encountered in SOA systems, will be feasible.

When the current version of CARET executes, it processes the contents of a folder that contains files describing composite applications: the BPELs, WSDLs, and XML Schemas. These files will have been gathered into the target folder by other software that is currently in development and that preserves the locations of the original files. The user can select to process an entire composite application comprised of BPELs, WSDLs, and XML Schemas, the BPEL and WSDL components only, or WSDL and XML Schema components only. This feature enables the user to generate a more focused or a comprehensive view depending upon the kinds of information that is currently of interest. Additionally, the user can choose to create a single global concept map of the entire application, or to generate separate descriptions corresponding to individual BPELs, WSDLs, or XSDs that will ultimately become more detailed parts of the conceptual model. Figure 2 contains a graphic of the current interface to CARET.

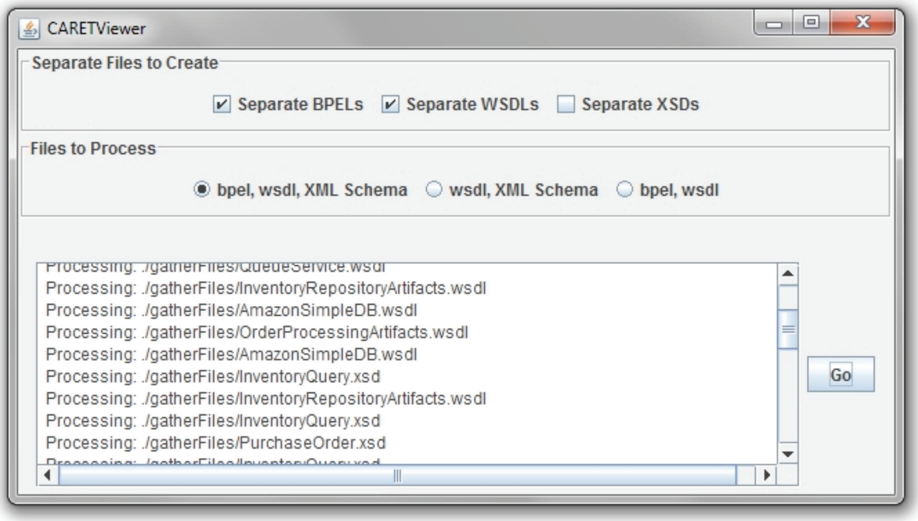

Figure 2. The interface to CARET.

When the program starts it analyzes the available BPEL or WSDL files, depending on the choice made in the "Files to Process" portion of the dialog. If the user has chosen to analyze BPEL files, dependencies based upon receive-reply and invoke operations are noted. These dependencies enable the system to infer the main and subordinate processes, to record the individual operations that are invoked, received, or replied to, and to link together references to them in BPELs and WSDLs. This set is recorded so that operations described in the WSDLs that are not used in the current composite are excluded from the current conceptual model. If the user has chosen to analyze WSDLs and XML Schemas only, the system makes note of the operations in the WSDLs and their links to local or XML Schema-based data definitions. In this case, all operations defined in the WSDLs are documented.

As the BPEL pre-processing proceeds, all referenced WSDL files are dynamically added to a list of files to be processed. As they are processed, following the scanning of the BPELs, their internal and external data declarations are analyzed. Any XML Schema files that are referenced in the WSDLs are added to a dynamically generated list of files to process. CARET is comprised of three SAX parsers, one for BPEL files, one for WSDL files, and one for XML Schemas. This division creates a context that allows for localization of operations specific to one type of file, even in the event that the operation is processing an element name that means different things in different contexts. It also allows for relatively simple programmatic extension of the parsers as other features of interest are identified for inclusion in the models to be generated. The output of CARET is a set of triples typically of the form illustrated in Table 1.

Concept	***Link***	***Concept***
`<filename>`	`<linkingPhrase>`	`<object>`
`<object>`	`<linkingPhrase>`	`<filename>`

Table 1: CARET Triple Representation**.**

In the triple representation, `<object>` might be another file, an operation name, a data element, or other item of interest. The `<linkingPhrase>` includes items such `as "is defined in," "has invoke operation," "has receive operation,"` etc. The triples are tab-delimited which allows them to be imported into CmapTools which is used to create the conceptual model. For example the triple:

`SMSFamilyModeling.wsdl→defines operation→BoundryUpdate`

is of the first format indicating that the file named `SMSFamilyModeling.wsdl` defines an operation named `BoundaryUpdate`. In this case, the object is a method rather than data or something else.

CARET produces as output one or more files of triples. If no separate file output is specified in the interface, a single file of triples relating features of some combination of the BPELs, WSDLs and XML Schemas (as specified in the "Files to Process" part of the CARET dialog) is created. If the user has additionally selected to output individual WSDL files or other files, separate files of triples are produced that allow for the creation of a hierarchical model with a single concept map at the root of the hierarchy, and additional, more detailed concept maps that can be linked to it.

The single item at the top of the hierarchy is a global view and additional items at lower levels comprise additional details of the WSDLs and XSDs in the composite application. All of the components the user specifies are available for import into CmapTools. The user can pick and choose which to include in the skeleton knowledge model. Once one or more triple files have been loaded into CmapTools, many capabilities are available that enable the user to tailor the model to current needs.

The individual files of triples are manually imported into CmapTools where they can be arranged in any manner that the user wishes. An "auto-layout" feature is available that creates alternative arrangements of the graphical depictions. The model is editable and can be enhanced with other electronic resources or with knowledge of the artifacts that participants in the process might know. A mature body of literature exists regarding the process of eliciting conceptual knowledge from an expert with concept maps. CmapTools provides a simple-to-use mechanism to create links among the graphical depictions of program structure, and the actual files to which the nodes in the map relate. The files that have been analyzed can be associated with their representations in the conceptual model by a simple drag-and-drop process to create a comprehensive knowledge model.

6 A Case Study

A case study in the use of CARET is described in this section. It is based upon a "Web Auto Parts" composite application comprised of two BPEL files, five WSDL files, and two XML Schema files (Wilde, Coffey, Reichherzer and White, 2012). Web Auto Parts is a hypothetical startup online automobile parts store which uses Business Process Execution Language to orchestrate services provided by commercial vendors such as Amazon. In this study, the full BPEL composite application is recovered. The Web Auto Parts application is comprised of the files depicted in Table 2.

`OrderProcessing.bpel`	`OrderProcessingArtifacts.wsdl`
`PurchaseOrder.xsd`	`QueueService.wsdl`
`TaxDataBasic5.wsdl`	`InventoryRepository.bpel`
`InventoryRepositoryArtifacts.wsdl`	`InventoryQuery.xsd`
`AmazonSimpleDB.wsdl`	

Table 2: Resource files of the Web Auto Parts composite application.

These files comprise a composite application that allows the user to request a check on availability of a selection of items with Amazon, to form an order, compute tax and shipping charges for the order, and to receive a reply regarding success or failure to complete the transaction. The composite application is comprised of a combination of both internal and external services. No global view of the composite application was available. The triples for the concept map in Figure 3 were generated automatically by the process described in the previous section.

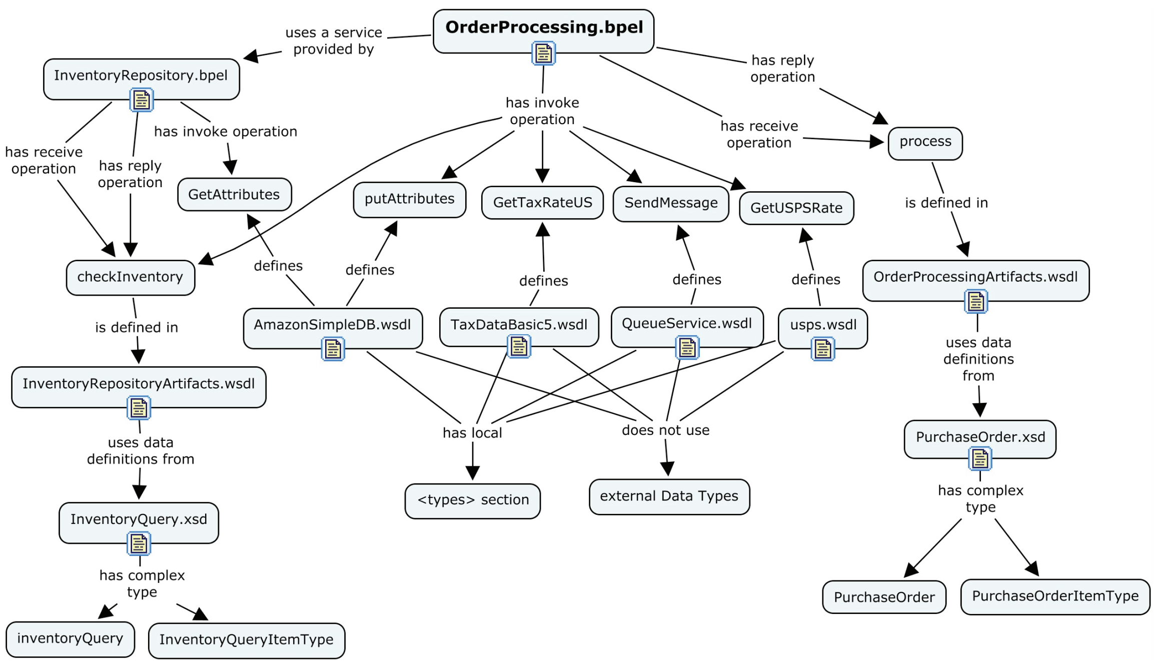

Figure 3. A Conceptual Model of the Web Auto Parts Composite Application.

As can be seen in Figure 3, the `OrderProcessing` BPEL (the main method in the composite application) has an invoke operation on the **`CheckInventory`** service and the `InventoryRepository` BPEL has `receive` and `reply` operations on the same service. Making explicit caller-callee relationships such as this one is an important abstraction afforded by CARET. It can also be readily seen that the `OrderProcessing` composite application utilizes four other services, `putAttributes`, `GetTaxRateUS`, `SendMessage`, and `GetUSPSRate`. The WSDLs in which these services are defined and the locations of their data structures are all made evident by the generated concept map. Also, as can be seen in Figure 3, the actual BPEL, WSDL, and XSD files have been made available as linked documents (indicated by the icons under the appropriate nodes in the concept map).

In the current case study, a total of 43 operations (individual Web Services) were made available through the five included WSDLs. Of that total, seven services were utilized in the Web Auto Parts Composite Application. CARET filtered out references to irrelevant services - those that were not utilized in the current composite application. The seven services that were invoked may be viewed across the middle of Figure 3. If the BPEL utilized different services, CARET would generate a different conceptual model for that composite application, even though it was based upon the same WSDLs and XML Schemas.

7 Conclusions

This article contains a description of CARET, a prototype tool that detects items of interest to maintainers who are trying to understand the structure of SOA-based composite applications. CARET is used to process artifacts of BPEL and WSDL-based composite applications to produce triples that can be imported into CmapTools. CmapTools automatically renders them in one or more concept maps. The concept maps can be ordered hierarchically from more general to more detailed to form what has been called a knowledge model of the software system. These knowledge models may be augmented with the original files that were processed by CARET, any other documentation pertaining to the system, and additional conceptual knowledge elicited from people who are knowledgeable in the workings of the system.

One of the compelling ideas in this approach is the capability to provide a minimal, comprehensible overview of a complex system using a set of machine representations that describe it. The approach of combining structural knowledge of a composite application that can be generated automatically from the processing of input that CARET performs with expert human knowledge of the system provides greater support for system understanding than can be garnered from standard reverse-engineering tools. The modeling of heterogeneous artifacts is supported in a way that has been shown to be intuitive to people trying to answer questions pertaining to a domain of knowledge (Carnot et al, 2001).

Future work includes empirical exploration of additional conceptual relationships that are of value to maintainers of SOA-based systems. These relationships can be captured by extending the SAX parser upon which the system is based. Encoding a characterization of individual triples and storage in a database will afford the capability to construct varying views of the various components of a composite application dynamically. Future work will also address the benefits of augmenting the knowledge model with elicited expert knowledge.

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CHALLENGES IN CROSS-CULTURAL PHD SUPERVISION: MAPPING TO FACILITATE DIALOGUE

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Abstract. This research used concept mapping and interview techniques to track changes in knowledge and understanding amongst students and their supervisors in the course of full-time research towards a PhD. The work measures *both* cognitive change in the specific subjects that are the topic for research *and* in the understanding of the process of PhD level research and supervision. The data shows the challenges for students and supervisors from different ethnic, cultural and academic backgrounds and traditions with a focus on how this impacts the PhD research process and development. Working cross-culturally, and often in a setting different from either the student or the supervisor's background and training, can lead to a lack of common language and understanding for the development of a pedagogically-oriented supervisory relationship. Documenting change in knowledge and understanding among PhD students and their supervisors is key to understanding what the joint processes of research and of supervision entail (Brew, 2003), and here we focus on the challenges of working across cultural, ethnic and diverse academic backgrounds, for both supervisors and students. The approach comprises detailed longitudinal case study analysis rather than any broad inferential comparison.

1 Background

Curzon-Hobson (2002) develops and defends a notion of trust in higher learning, and examines the pedagogical challenges of its pursuit within the sphere of higher education. It is argued that the experience of trust between teachers and students is a necessary foundation for a critical, dialogical learning environment, yet it is an endeavour that can be endangered by poor communication and misunderstanding, common when working in cross-cultural environments. Little research explores how cultural differences impact the research project and supervision process, despite the importance of communication and collaboration skills in PhD education (Phillips & Pugh, 2005).

Much research on PhD supervision is decontextualised and universalises the supervision process—across types of enquiry, disciplines, countries and individual characteristics. There is a notion that supervision can be analysed separately from the rest of the PhD. Rather, we see supervision as inherently part of the thesis development and completing a PhD, and managing the supervisor and student relationship, with the associated aspects of identity that arise. However, this can particularly challenging when supervisors and students come from different cultural backgrounds, particularly in regards to national origin, educational background and training and language differences. In this paper we use concept mapping to explore the role that these differences play in the intellectual approach to and conceptual understanding of a PhD. We further argue that concept mapping allows for visualisation of complex notions of what a PhD is about and what it is for, providing opportunities for communication, discussion and learning within the supervisory relationship.

2 Internationalisation

Globally there is focus on competition within the internationalisation agenda, (Marginson, 2006), although there are critiques of the marketisation of internationalisation (De Vita & Case, 2003; Kehm & Teichler, 2007; Mok, 2003). Alternative perspectives on internationalisation identify how it can be used as a vehicle to support diversity, access and equity for all learners. To this end, the lenses of interculturalism and inclusion help to identify a precise tension between internationalisation being part of a global capitalist agenda, or being a means to move towards "global understanding" (Teichler, 2004).

Within the dynamic landscape of higher education, internationalisation is often used to gesture to diversity. However, this diversity is itself maintained within strict discursive limits. As the 'international student' emerges as an increasingly familiar archetype within UK Higher Education (and beyond), there is a concern that, at an apparent moment of recognition, significant swathes of an international student population are occluded. However, internationalisation can be used to recognise wider indices of diversity (Banks, 2002) and learning and development opportunities for both staff and students.

3 Mutual learning

Conceptual change is an approach in which prior conceptions of teaching and learning are modified and changed to a notion of facilitating student learning that is required before specific student-centred strategies can be eventually adopted (Ho, Watkins & Kelly, 2001). Lecturers are often hesitant to embrace and adopt new teaching practices (Gibbs, 1995; Trigwell, 1995), although the conceptual change approach is developed for both teachers and students (Biggs, 1989; Gow & Kember, 1993; Ramsden, 1992). This approach requires opening conversational dialogue between students and supervisors in the context of the PhD.

Baker, Jensen and Kolb (2005) define conversational learning as "a process whereby learners construct new meaning and transform their collective experiences into knowledge through their conversations" (p. 412). Conversational learning suggests that learners are constructing meaning among themselves as well as within themselves and that learners transform their collective experiences—both tacit and explicit—into knowledge.

Academic staff must believe in the pedagogical process to safely encourage students to join the new approach to learning. Success and failure for a teacher in this course depend on one's own ability to create and hold safe dialogical space for students, to create a sense of dignity in their learning process, and to nudge students when they demonstrate curiosity or an emerging interest in topics. Cunliffe (2002) recommends reconstructing learning as a reflective/reflexive dialogue in which participants connect tacit knowing and explicit knowledge. An in-depth picture of the patterns that are evident in the ways multiple forms of identity of PhD students and their supervisors and how they work together over time increases our understanding of PhD supervision. This study uses theoretical frameworks from intersectionality and methodological approaches from concept mapping to analyse conceptual change amongst PhD students and their supervisors.

4 Theoretical approach

By drawing on intersectionality research (Berger & Guidroz, 2009; Jones, 2009) which considers multiple forms of identity, a broader conceptualisation of international students and staff becomes available. This reflects the university as a highly complex locus of multiple and intersecting spheres of 'difference'. An intersectionality-based research design engages with a more nuanced conceptualisation of identity and experience to recognise: race/ethnicity, gender, sexual orientation, socio-economic status, nationality, ethnic group, dis/ability, religion, and geographic region (Banks, 2002; Tatum, 2003). This speaks to the need to diversify the research on internationalisation (Renn, 2010) and doctoral education and explores the complexity that arises when multiple dimensions of social life and categories of analysis are included.

This more inclusive approach to identity is not common in postgraduate education, particularly for students and staff, whose unique identities raise challenges in the context of learning. Indices of identity are constantly shifting, but this dynamism is relevant particularly in the intimate supervisory relationship, requiring a sophisticated response that can be hard to maintain in the face of market-led educational policy where competitiveness, completion rates and measurable outcomes present significant challenges.

Practically, many staff and students are concerned about misconceptions and stereotyping, but find these issues difficult to discuss because of their political, personal and sensitive nature. This can lead to tensions in the teaching, learning and research environment and can negatively impact on the student learning experience. This speaks to gaps in our knowledge of how universities frame their understanding of identity, how academics construct/co-construct meanings of inclusive practice and the conditions that actually make a difference for diverse groups of staff and students. Issues of identity are pertinent in the close relationship of a PhD, particularly how such issues impact on approaches to communication, learning and understanding.

5 Methodology

The identification of mutual conceptual development and understanding requires a research design that enables the lived experience of the supervisory process to be explored over time. The method chosen also needs to be congruent with our epistemological position, which relates to the legitimacy of generating data about how PhD students and their supervisors work together by talking interactively with them. The approach most suited to this position is qualitative, utilising what Charmaz (2001) calls "multiple sequential interviews"; this type of interviewing "charts a person's path through a process" and creates the opportunity for a "nuanced understanding of that process" (p. 682).

Concept mapping (*sensu* Novak, 2010) is a method of graphic organisation. Its considerable utility stems from its origins within the human constructivist epistemology and it is now widely reported in the literature for use in the sharing of individual knowledge and understanding. The concept mapping work of Novak and others has been used in studies of learning (Kinchin, 2001); measurement of learning quality (Hay, 2007); assessment (Edmondson, 2000); cognitive typology (Hay & Kinchin, 2006; Kinchin *et al*, 2000); and learning style (Kinchin, 2004; 2011).

5.1 *Study design*

In this study interviews were conducted with students and supervisors separately so that the research did not interfere with the supervisory process. In-depth, semi-structured interviews were done with the students at four-monthly intervals utilising a grounded theory approach. Interview transcripts and interviewee-constructed concept maps provided structure for the data: facilitating analysis within cases and across cases. This also helps to identify a route through the developing narrative. Data collection and analysis occurred at each stage, and enabled each interview to draw upon the experiences of the participant to inform theory generation relating to changes in content and processes over time (see Figure 1). Participants were briefed on concept mapping techniques, and the maps below reflect those created. The interviews explored two complementary lines of enquiry:

1. Topic – looking at the content of the academic area under investigation within the PhD.
2. Process – looking at the conceptions held of the research process and of the PhD as an entity.

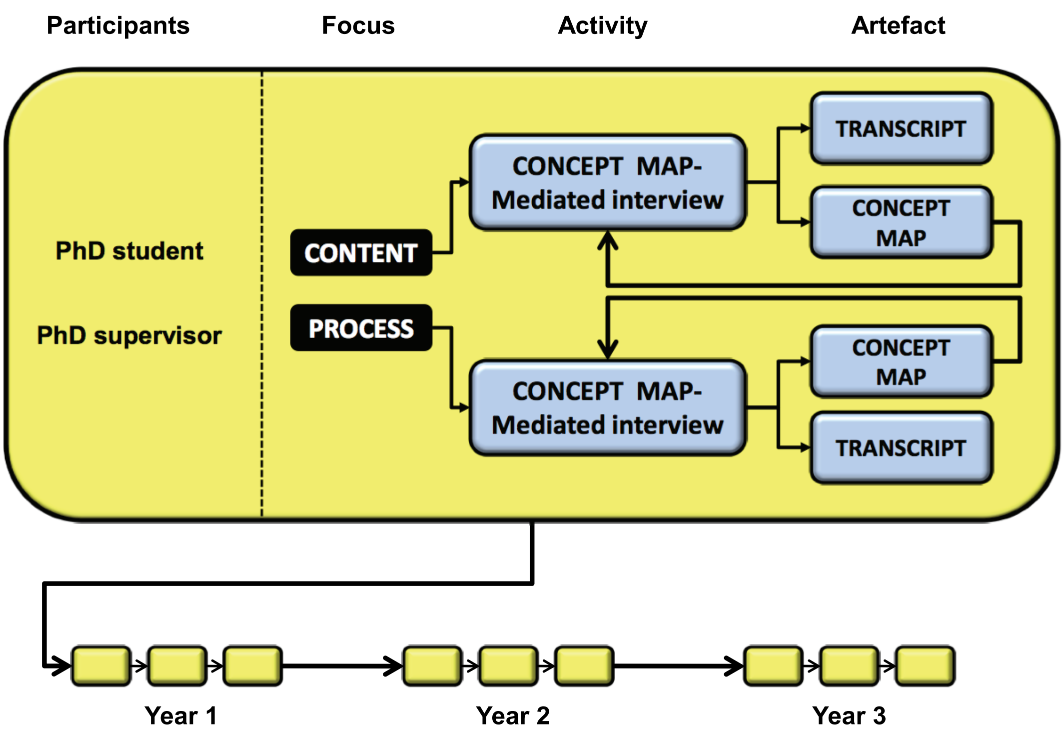

Figure 1. Concept map of the study design.

5.2 *Participants*

This process has generated a large volume of data that is drawn upon to inform the discussions here, although space permits the representation of only four concept maps from the total of 123 unique maps, collected over 88 interviews during the four years of the study. The pairs come from biological science, clinical science fields, and humanities. All are from a research university in the UK. However eight out of eleven participants in this study were from overseas and had previously studied or worked outside the UK. In all of the pairs, there were differing countries of national origin and academic training, cultural background and first language. There were further differences that arose in regards to gender, religion, relationship status and international visa status.

Rather than focus on specific issues that arose, this study explores the role that cross-cultural differences played in the mutual learning, conceptual development and progress in the PhD between supervisors and students.

6 Findings

The maps that are shown are from two different pairs of students and supervisors. These maps were selected as they are generally representative of themes that emerged from the study. The first set of maps (see Figure 2) covers the topic of the PhD, from supervisor and student Pair 'A', in biological sciences. As the map on the left shows, the supervisor has a much broader conception of the PhD, focusing more on the process rather than the end-product (Kandiko & Kinchin, 2012). The supervisor map places the student's project in the wider research area and details numerous experiments and techniques to explore the topic. The student map, on the right, shows a much more linear, and functional, conception of the PhD (Kinchin & Kandiko, 2012).

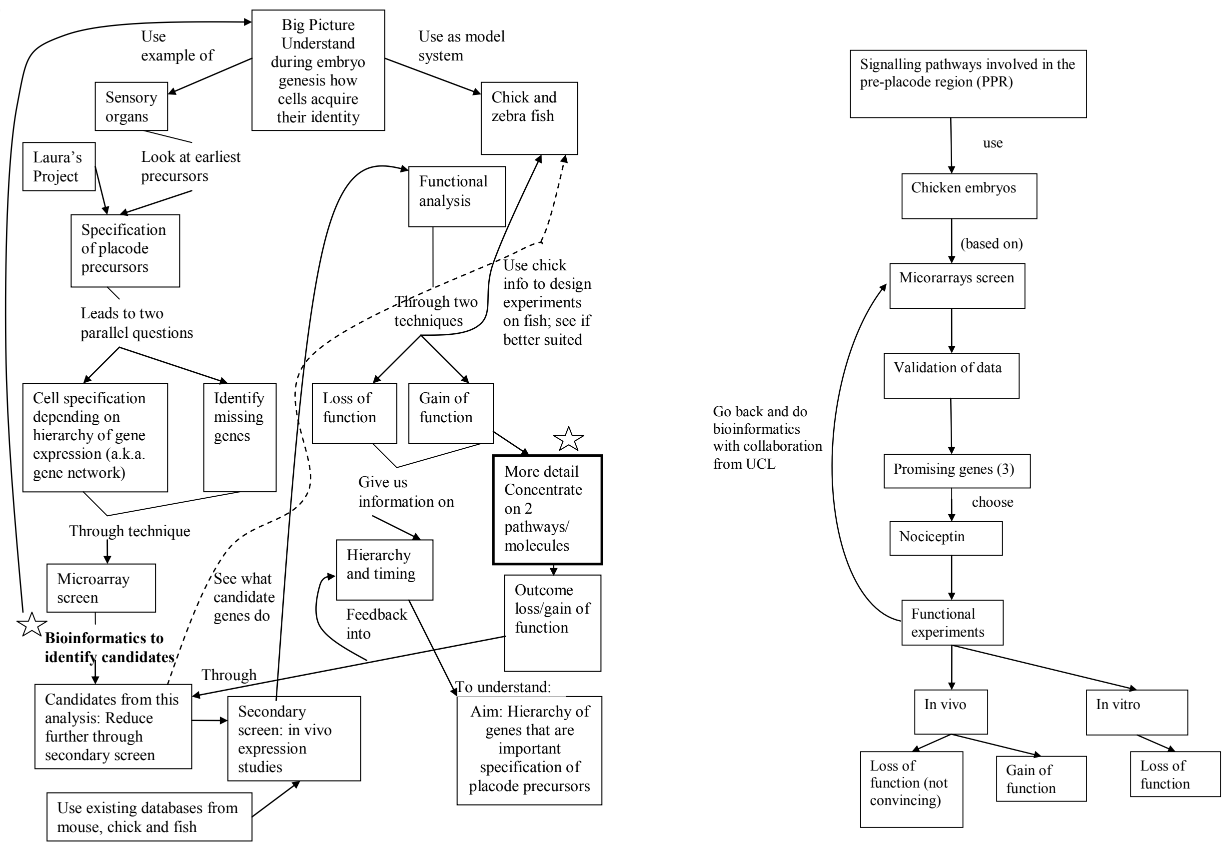

Figure 2. Pair A on the PhD topic, with the supervisor map on the left and the student map on the right.

The student and supervisor had different cultural and educational backgrounds compared to the other, and neither was from nor with prior education in the UK. As noted in the interview data, the student and supervisor's discussions often focused on the day-to-day work the student needed to complete. The supervisor's wider conception of the PhD was not clearly articulated to the student. Rather, the student had more of a 'checklist approach' to what needed to get done to complete the thesis. It seemed that when the supervisor attempted to discuss the research area more broadly, the student felt that time was being taken away from the work she needed to complete. Opportunities to work on other projects in the lab were seen by the supervisor as developmental and the student as time-consuming and doing other researchers and students' work.

Further communication challenges arose when the supervisor asked the student about how the student was doing, as an opening to discussion about the student's progress and direction, which the student interpreted as the supervisor 'wanting to be her friend'. This gap seemed to be related to different cultural approaches to how a PhD student enters the 'community of colleagues' that operates within the lab setting. As this is often a tacit process, it is difficult to manage in any supervisory relationship, but is particularly challenging when students and supervisors have different backgrounds and assumptions about a PhD and the relations between academics and students.

The next two maps, from a different supervisor and student, Pair 'B', are about the PhD as a process. The supervisor's map (see Figure 3) covers what he termed an 'aspirational PhD', noting that many students would not 'reach the furthest levels' and develop into star scientists and academics, but would still complete a PhD. Most of the concepts in the supervisor's map relate to learning and personal academic development. There are outputs on the map, but they are positioned as outcomes of the process of learning and discovery. The supervisor only made one map of the PhD-as-process, stating that over the course of his career, what he put down is what he thinks a PhD should be, and he works to get the students to develop as much as they can. Over four years he felt the map adequately represented his notion of the process of a PhD.

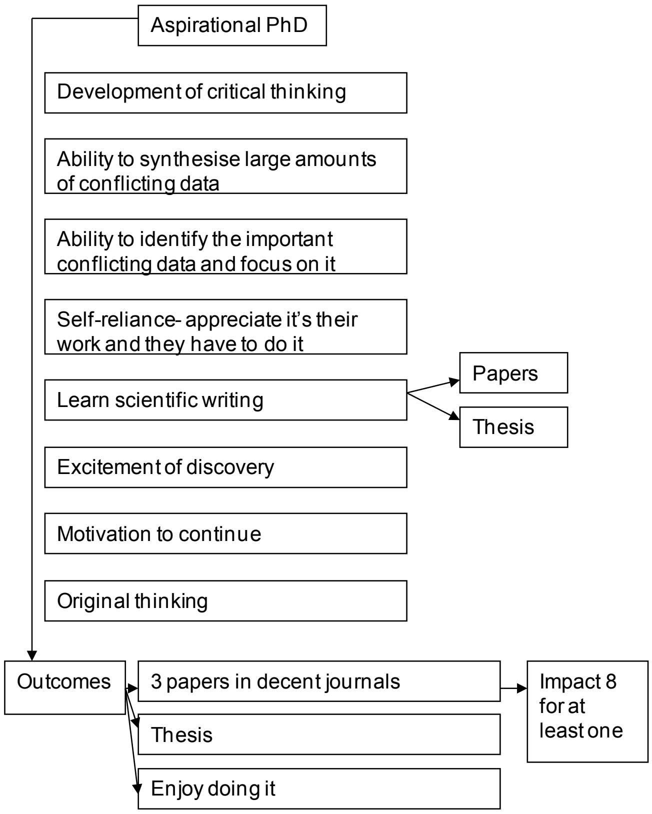

Figure 3. Pair B, supervisor map on the PhD process.

The student's map of the PhD process (see Figure 4), like the student map in Figure 2, takes a functional approach. In fact, as the student developed the map over time, she would tick off the boxes of activities she had completed. Whereas the supervisor map in Figure 3 concentrates on learning, the student map focuses on 'doing'. The student often remarked that she did not know why she doing certain tasks, or how different lab tasks were helping her PhD progress. There was more of an 'individualistic' approach to the PhD, which is in particular contrast to the group-orientation of most major academic research-oriented laboratories.

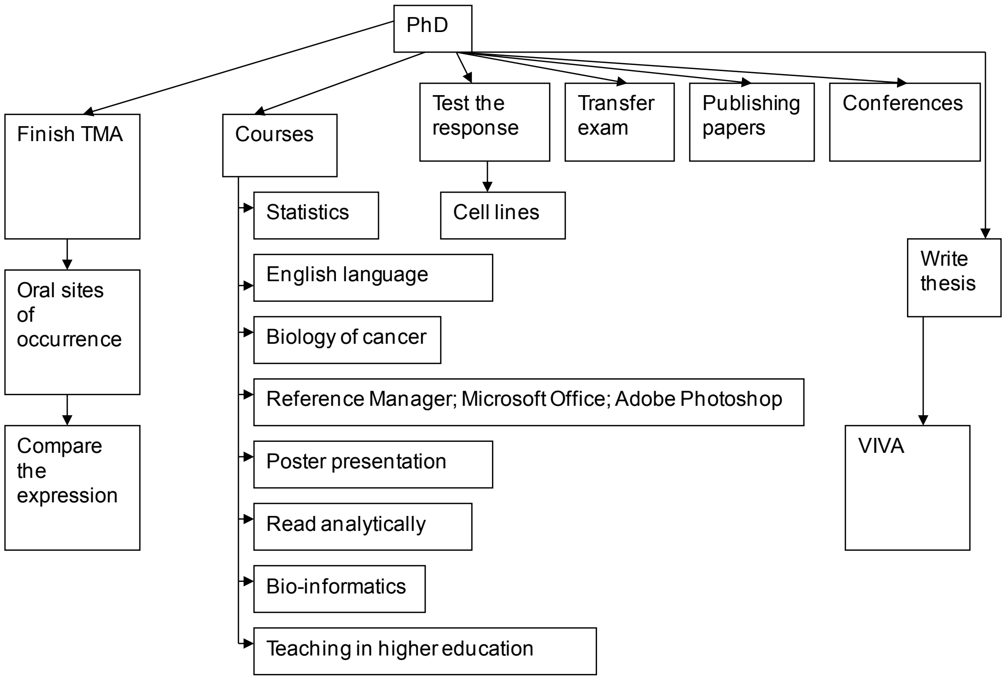

Figure 4. Pair B, student map on the PhD process.

7 Discussion

The student and supervisor are in constant dialogue, although the case studies in this research indicate that a great deal of misinterpretation occurs in this process. The challenges of supervision in a cross-cultural environment emerge in three main ways: the understanding of topic, the understanding of process and the role of the thesis. A longitudinal study allows for a deep insight into the supervisory process over time and how these challenges impact and affect both students and supervisors.

The lack of shared communication and understanding seemed to cause tension in the relationship of both reported pairs of students and supervisors. With a different supervisory pair in the study, the supervisor and student chose to share their maps with each other after each interview. They did not do this to make the maps the same, but each of their maps functioned as a point of departure for conversation about progress and development in the PhD, and each of their roles in the development of the research. That pair had a much more open communication pattern, and both described the maps as useful for synthesising complex notions about the PhD, which were difficult to describe when coming from different educational and cultural backgrounds.

Concept mapping during the PhD supervision process can be used as a tool, amongst many, which facilitates communication, dialogue and understanding. In an environment which is very diverse, in terms of both students and supervisors, concept mapping can provide a platform for initiating conversation about the purpose, process and product of the PhD. As Chang and Astin (1997) noted, a diversity-sensitive curriculum can lead to both academic achievement and growth of the students' personalities.

As seen in the Figures above, several of the maps stray from the traditional rules of concept mapping. This may reflect the developing nature of the ideas and the lack of a finished mental image of the PhD. We chose to report on the maps as the interviewees constructed them, as this more accurately reflects their understanding of the PhD. In other research, academics were able to construct formal concept maps reflecting back on a finished PhD, which may indicate the difficulty in mapping a work-in-progress compared to a finished product.

8 Summary

This study positions concept mapping as a pedagogical tool for diverse students, which can function as a framework for greater understanding and inclusion. Such frameworks can also link in with wider student support services, and with staff development opportunities. This approach also provides students, researchers and supervisors with capabilities and skills necessary in the modern global workforce.

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CO-REGULACIÓN Y FUNCIÓN COMUNICATIVA DE LOS INTERCAMBIOS EN EL APRENDIZAJE COLABORATIVO CON MAPAS CONCEPTUALES

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Abstract. En este trabajo se analizan los efectos de una ayuda (listado de conceptos clave), tanto en la calidad de los mapas conceptuales elaborados colaborativamente en una tarea de comprensión lectora de un texto expositivo como en los procesos de co-regulación y los intercambios comunicativos que despliegan estudiantes universitarios esta tarea. Además, de describir estos procesos e intercambios comunicativos para la co-regulación, se examina su influencia en el rendimiento alcanzado en la tarea colaborativa. Participaron en el estudio 18 estudiantes universitarios agrupados en 6 triadas. Cada triada fue asignada a una de las dos condiciones: elaboración colaborativa de un mapa conceptual con apoyo (listado de conceptos clave) y sin apoyo. Se controló que no existieran diferencias significativas previas entre los grupos respecto a comprensión lectora, estrategias de regulación de la comprensión lectora y conocimientos previos en el dominio específico y en la elaboración de mapas conceptuales. Se examinó la calidad de los mapas conceptuales grupales, utilizando con adaptaciones el procedimiento propuesto por Novak y Gowin (1984) y se valoró a través de un autoinforme el nivel de colaboración percibido por cada integrante de los equipos. Asimismo, se analizaron de manera cualitativa los procesos de co-regulación y las funciones comunicativas de los intercambios que pusieron en juego los estudiantes durante el trabajo colaborativo. El análisis cuantitativo de los resultados muestra la existencia de efectos significativos de la ayuda respecto a la calidad de los mapas colaborativos. No obstante, los estudiantes de la condición sin apoyo valoraron de manera significativamente superior los niveles de colaboración y participación alcanzados en sus equipos. En el análisis cualitativo, se observó en ambas condiciones el predominio de enunciados y episodios de tipo cognitivo relacionados con los contenidos de la tarea, resultando muy baja la existencia de episodios regulativos relacionados con la colaboración en la tarea. En las consideraciones finales se señala la conveniencia de incluir apoyos específicos dirigidos a promover la co-regulación del aprendizaje colaborativo con mapas conceptuales.

1 Introducción

Los mapas conceptuales ofrecen, en principio, un abanico de posibilidades para promover el aprendizaje colaborativo -tanto en entornos presenciales cara a cara como en ambientes en línea basados en el empleo de sistemas digitales- ya que generarían mayores oportunidades para que los estudiantes puedan explicitar y transferir sus propios conocimientos e interactuar con otros integrantes del equipo, discutiendo e intercambiando ideas (Gao et al., 2007; van Boxtel et al., 2000). Por ejemplo, los mapas conceptuales colaborativos favorecerían en los estudiantes no sólo la activación de sus conocimientos previos y la construcción de conocimientos de manera conjunta, a partir del intercambio de ideas y la negociación de significados (Cañas y Novak, 2005; Stayonova y Kommers, 2002; van Boxtel et al., 2000), sino que también promoverían el desarrollo de procesos más complejos de tipo metacognitivo relacionados con la regulación del propio aprendizaje (Chularut y DeBacker, 2003). Además, incentivaría a los estudiantes a desplegar habilidades de comunicación, estimulando su curiosidad y sus recursos motivacionales (Tifi y Lombardi, 2010).

La construcción colaborativa de un mapa conceptual requiere que dos o más aprendices desplieguen y coordinen de manera sostenida sus esfuerzos para aprender y construir conocimientos. Sin embargo, esta tarea puede no resultar sencilla. Los aprendices, en particular los novatos en la elaboración de mapas conceptuales, pueden experimentar sobrecarga cognitiva (Reader y Hammond, 1994; Chang et al., 2002); y, por consiguiente, se les dificultaría aprovechar las potencialidades de los mapas conceptuales. En el caso de tareas de comprensión, los aprendices no sólo necesitan poner en juego los procesos cognitivos, metacognitivos y motivacionales asociados a la comprensión lectora y a la elaboración de mapas conceptuales, sino también se ven movidos a desplegar una serie de procesos de co-regulación, es decir, procesos dirigidos a regular la tarea conjunta y la estructura de colaboración (Salonen et al., 2005; Volet et al. 2009).

Concretamente, el propósito de este trabajo es analizar los efectos de una ayuda (listado de conceptos clave) en la calidad de los mapas conceptuales elaborados colaborativamente en una tarea de comprensión lectora de un texto expositivo y en los procesos de co-regulación y los intercambios comunicativos que ponen en juego estudiantes universitarios en dicha tarea. Además, de describir estos procesos e intercambios comunicativos para la co-regulación, se examina su influencia en el rendimiento alcanzado en la tarea colaborativa. En primer lugar, se presentan los antecedentes teóricos y empíricos del estudio; en segundo lugar, se describe la metodología seguida y se da cuenta de los resultados obtenidos. Por último, se señalan algunas implicaciones para el empleo instruccional de los mapas conceptuales colaborativos.

2 Mapas conceptuales colaborativos en la comprensión de textos expositivos

Weinstein y Mayer (1986) han señalado que los mapas conceptuales constituirían un tipo de herramienta muy apropiada para promover la comprensión de un texto, debido a que especialmente facilitaría en los lectores la organización de las ideas. Cuando un aprendiz elabora un mapa conceptual, durante la lectura de un texto expositivo, necesita poner en juego e integrar procesos "bottom-up", es decir, abajo hacia arriba, junto con procesos "top-down", de arriba hacia abajo. Por ejemplo, tal como señalan Liu et al. (2010), se requiere -una vez que se ha captado el significado de palabras y proposiciones- identificar la idea principal del texto, a partir de la cual se establecen enlaces con otras proposiciones, organizándolas de manera jerárquica para construir una idea global del texto. A la par, la construcción de un mapa conceptual demanda activar los esquemas previos de conocimiento y establecer nuevos enlaces inferenciales que van más allá de lo que el texto dice. De esta manera, en la tarea de mapping el aprendiz va revisando las relaciones entre los conceptos, a la vez que recuerda y organiza la información que presenta el texto, integrándola con sus conocimientos previos. En tal sentido, siguiendo a Hilbert y Renkl (2008), los mapas conceptuales, como estrategia para la comprensión y el aprendizaje a partir de textos, permitirían cubrir cuatro funciones clave: a) una función de elaboración: que posibilitaría relacionar los conocimientos previos con la nueva información del texto para determinar las ideas principales y sus relaciones con otras ideas; b) una función de reducción: que permitiría identificar y retener las ideas centrales que configuran el esquema global del texto; c) una función de coherencia: al respecto, el mapa conceptual favorecería la construcción de una estructura coherente del texto, a la vez que sería útil para identificar las rupturas en la coherencia textual; y, por último, estrechamente relacionado con lo anterior, d) una función metacognitiva: ya que favorecería la detección y reparación de los sesgos y lagunas que pudieran aparecer en el propio proceso de comprensión.

Como es bien sabido, el aprendizaje colaborativo implica una estructura de intercambios en la que el aprendiz se ve inducido a asumir un alto nivel de responsabilidad (Dillenbourg, 1999). Ahora bien, la construcción colaborativa de un mapa conceptual, requiere que los estudiantes interactúen entre sí para construir significados compartidos a partir de un texto. Los mapas conceptuales podrían facilitar la verbalización, la comunicación y la negociación de las ideas que los estudiantes vayan construyendo en su propio proceso de comprensión. Por ejemplo, las conversaciones durante la construcción colaborativa de los mapas conceptuales, podrían representar momentos significativos para el aprendizaje, promoviendo la comprensión a través de discusiones en las que se ponen de manifiesto diferentes ideas y puntos de vista.

En tal sentido, Van Boxtel et al. (2002) han señalado que el uso de los mapas conceptuales colaborativos induciría a los estudiantes a implicarse en dos clases de acciones, que son centrales para la comprensión: a) acciones elaborativas y, b) acciones de negociación de significados. En primer lugar, los mapas conceptuales colaborativos ofrecen variadas posibilidades para generar interacciones que promuevan la elaboración del conocimiento. Por ejemplo, incrementaría la cantidad de información que se comparte, presentándola visualmente, de manera concreta y sintética. La construcción colaborativa del mapa conceptual fuerza a que los estudiantes identifiquen los conceptos presentados en el texto, intercambien los significados que atribuyen a estos conceptos y expliciten las relaciones existentes entre dichas ideas. Posibilitan, además que los estudiantes verbalicen y discutan lo que van comprendiendo, teniendo mayores oportunidades para poner a prueba los significados construidos y para identificar los posibles sesgos que pudieran aparecer en este proceso de comprensión.

En segundo lugar, siguiendo a van Boxtel et al. (2002), los mapas conceptuales colaborativos suscitarían condiciones adecuadas para que aparezcan acciones de negociación del conocimiento. Al llevar a cabo esta tarea, los estudiantes en sus interacciones generan preguntan y respuestas, resuelven desacuerdos y co-construyen significados. Además, es posible que aparezcan discusiones y conflictos que demanden a los estudiantes respuestas explícitas y justificaciones de sus propios puntos de vista (van Boxtel, et al., 2000). Junto a ello, se requiere que los estudiantes ejecuten acciones coordinadas, para las cuales deben crear significados compartidos de la tarea y seleccionar los procedimientos y estrategias que consideren más adecuadas para colaborar. En las acciones de negociación los estudiantes, no sólo se ven forzados a reflexionar y elaborar su propio conocimiento, sino también necesitan considerar, integrar y elaborar el conocimiento de sus compañeros de equipo.

2.1 La investigación sobre mapas conceptuales colaborativos

La investigación sobre los mapas conceptuales colaborativos ha encontrado resultados que confirman las posibilidades y ventajas de los mapas conceptuales, no sólo respecto a otra clase de tareas de aprendizaje colaborativo (elaborar resúmenes, escribir ensayos, confeccionar un póster) sino también a la construcción individual de mapas conceptuales. Sin embargo, también existen algunos estudios que han encontrado resultados discrepantes en relación a los efectos positivos de los mapas colaborativos en el aprendizaje (para una revisión, Basque y Lavoie, 2006; Gao, et al., 2007; Nesbitt y Adesope, 2006). Por consiguiente, podría pensarse que la utilización colaborativa de mapas conceptuales por sí sola no garantiza que se promuevan niveles altos de aprendizaje. Tal como señala Nesbitt y Adesope (2006), las potenciales ventajas de los mapas conceptuales colaborativos están estrechamente relacionadas, tanto con el tipo y la calidad de interacciones y la estructura colaborativa en que se enmarca la utilización de los mapas conceptuales colaborativos, como también con las características de la tarea y el sistema de apoyos que se proporcione.

En efecto, por una parte, variados estudios han encontrado que el rendimiento que alcanzan los grupos en tareas colaborativas con mapas conceptuales está estrechamente relacionado con los niveles y las características de los intercambios en estos grupos. Así, por ejemplo, Carter (1998) describió que los estudiantes no prestan atención a los comentarios de sus colegas y no capitalizan las diferentes oportunidades que la tarea proporciona para la construcción de significados. Los estudiantes recurrían por lo general a la memorización y no generaban discusiones sobres las ideas, teniendo dificultades para establecer las relaciones jerárquicas que el mapa conceptual demanda. Junto a ello, Chiu et al. (2000) encontraron que en entornos colaborativos en línea, a mayor cantidad de interacción -sobre todo de interacciones complejas, tales como proporcionar explicaciones e intercambiar ideas sobre un producto- los estudiantes alcanzaron un rendimiento más alto en tareas colaborativas con mapas conceptuales sobre temas de informática. Además, van Boxtel et al. (1997; 2000) encontraron resultados que correlacionan la frecuencia de episodios elaborativos -en los que los estudiantes se implican en discusiones donde tienen que expresar sus puntos de vista sobre conceptos de electricidad- con un mayor nivel de aprendizaje de estos conceptos.

Por otra parte, respecto a las características del contexto colaborativo y de los apoyos que se proporcionan en tareas colaborativas con mapas conceptuales, la investigación empírica es aún incipiente. Algunos estudios han indagado acerca de la configuración de los grupos de trabajo. Por ejemplo, Kinchin et al. (2005) obtuvieron resultados que muestran que los grupos colaborativos heterogéneos posibilitan que los estudiantes proporcionen diferentes puntos de vista, lo que beneficia un trabajo más efectivo en la construcción colaborativa de mapas conceptuales. Asimismo, Haugwitz et al. (2010) encontraron que estudiantes con habilidades cognitivas superiores al promedio alcanzan un mayor rendimiento en una tarea colaborativa de elaboración de resúmenes, utilizando mapas conceptuales, si trabajan en grupos heterogéneos donde interactúan con estudiantes con bajo nivel de habilidades cognitivas. En relación a los apoyos, algunos estudios empíricos han comprobado que incluir andamiajes para acompañar la tarea de elaboración de mapas conceptuales (por ejemplo, proporcionar a los aprendices conceptos clave y algunos enlaces relevantes, como en el estudio de Chang et al., 2001) contribuyen a materializar las ventajas de los mapas conceptuales, pero estas ayudas sólo han sido puestas a prueba en la construcción individual de mapas conceptuales.

No obstante, la calidad de la interacción y los efectos de los andamiajes en el trabajo colaborativo podrían estar modulados por factores individuales, tales como el nivel de conocimientos previos de dominio específico y, muy especialmente, por los recursos metacognitivos con que cuenten los aprendices. Estos procesos metacognitivos resultan críticos no sólo para la autorregulación del aprendizaje sino también para la co-regulación del aprendizaje cuando se trabaja de manera colaborativa en pequeños grupos (Hacker et al., 2009), ya que constituyen uno de los principales mecanismos que nos permiten establecer metas, monitorear y supervisar nuestras acciones y valorar si nos ha sido posible alcanzar dichas metas.

En efecto, en el caso del aprendizaje colaborativo, además de la propia autorregulación de su proceso de aprendizaje, los estudiantes deben intervenir con la intención de regular el proceso de construcción conjunta de significados y también para gestionar las estructuras de colaboración (Beishuizen et al., 2004). A estos procesos alude la idea de co-regulación. Sin embargo, no queda del todo claro cómo en los entornos colaborativos los estudiantes ponen en juego sus procesos de autorregulación y co-regulación del aprendizaje, tal como refiere el meta-análisis realizado por Dignath et al. (2008).

Se hace necesario, por consiguiente, contar con mayor evidencia empírica acerca de los efectos que producirían los apoyos, como el de proporcionar un listado de conceptos clave, y la manera en que los procesos de co-regulación se despliegan en una tarea de construcción colaborativa de mapas conceptuales. En este estudio se identifican y caracterizan dichos procesos co-regulatorios y los intercambios comunicativos que despliegan estudiantes universitarios cuando construyen colaborativamente un mapa conceptual en una tarea de comprensión lectora de un texto expositivo. Además, se examina la influencia de dichos procesos e intercambios en la calidad de los mapas conceptuales, y se analizan los efectos de una ayuda instruccional (listado de conceptos clave) en estos procesos y en el rendimiento que alcanzaron los equipos en la mencionada tarea. Los participantes fueron agrupados en 6 equipos de tres integrantes. Cada triada fue asignada a una de las dos condiciones: elaboración colaborativa de un mapa conceptual con apoyo (listado de conceptos clave) y sin apoyo. Se controló que no existieran diferencias significativas previas entre los grupos respecto a comprensión lectora, estrategias de regulación de la comprensión lectora y conocimientos previos en el dominio específico y en la elaboración de mapas conceptuales. Se examinó la calidad de los mapas conceptuales grupales y se valoró a través de un autoinforme el nivel de colaboración percibida por cada integrante de los equipos. Asimismo, se analizaron de manera cualitativa los procesos de co-regulación y las funciones comunicativas de los intercambios que pusieron en juego los estudiantes durante el trabajo colaborativo.

3 Metodología

3.1 Participantes

Los participantes fueron 18 estudiantes universitarios mexicanos que cursan primeros años de carreras afines a las Ciencias Sociales (14 mujeres y 4 varones). La edad media de los participantes fue de 21 años. Se agruparon en 6 triadas, cada una de la cuales fue asignada a una de las dos siguientes condiciones: a) mapas conceptuales colaborativos con apoyo (listado de conceptos clave), b) mapas conceptuales colaborativos sin apoyo. Los participantes fueron instruidos previamente en la elaboración de mapas conceptuales, en dos sesiones grupales (gran grupo) de 20 minutos cada una. La participación de los estudiantes fue voluntaria y como bonificación recibieron créditos en sus asignaturas.

3.2 Procedimiento

El estudio se llevó a cabo en tres sesiones. En las dos primeras sesiones (40 minutos cada una de ellas), los estudiantes recibieron instrucciones sobre la elaboración de mapas conceptuales y se aplicaron los instrumentos para controlar variables pre-test. En la primera sesión se explicaron las notas distintivas del mapa conceptual, presentándose su técnica de elaboración; además, se discutieron algunas de sus aplicaciones y fundamentos psicopedagógicos y se comentó sobre su relevancia de utilizar esta herramienta en el ámbito universitario (Aguilar Tamayo, 2004). Además, se aplicaron las pruebas de comprensión lectora y de regulación de estrategias de lectura. En la segunda sesión se llevó a cabo una práctica de modelado para la elaboración de mapas conceptuales, sobre contenidos de la vida cotidiana, utilizando lápiz y papel. En esta sesión se administró el cuestionario de conocimientos previos de dominio específico. En la tercera sesión 60 minutos se realizó la sesión de aprendizaje colaborativo. Al inicio se presentaron los objetivos y las instrucciones para efectuar la tarea. Posteriormente, los grupos contaron con 40 minutos para elaborar mapa conceptual colaborativo y, finalmente, los participantes respondieron el cuestionario de autovaloración de la colaboración en los equipos. Los estudiantes elaboraron los mapas conceptuales con pluma digital (Smartpen Livescribe) que recogió también los intercambios verbales durante la tarea. Posteriormente, estos mapas conceptuales fueron pasados a CmapTools V. 5 [Aplicación Informática] (IHMC, 2009) y se transcribieron los intercambios verbales.

3.3 Materiales

El material de aprendizaje consistió en un texto expositivo de 9 páginas (alrededor de 3,900 palabras) sobre el tema “La dimensión cultural de Internet” de Manuel Castells (2002). Este texto utiliza un vocabulario sencillo y presenta una serie de marcadores textuales que favorecería la construcción de su esquema global. Para la condición mapas colaborativos con apoyo se proporcionó a los equipos un listado de 30 conceptos clave que aparecen en el texto. Estos conceptos se presentaron de manera desordenada en el listado.

Para valorar las habilidades de comprensión lectora de los estudiantes se emplearon dos tareas. Por un lado, se aplicó la Batería Multimedia de Comprensión (versión abreviada) de Gernsbacher y Varner (1988), adaptada por Díez y Fernández (1997) que permite valorar los niveles de comprensión lectora. En esta prueba se pide a los alumnos que lean un texto informatizado “El regalo más preciado” y que, luego de la lectura, contesten ocho ítems con formato de pregunta de elección múltiple con cinco opciones de respuesta acerca del contenido presentado en ese texto. La prueba seleccionada de la batería multimedia controla el tiempo de presentación del texto, manteniéndolo constante, y también establece un tiempo uniforme (20 segundos) para responder cada uno de los ítems de evaluación. Cada pregunta acertada es contabilizada con un punto hasta alcanzar un máximo de ocho. Además, se administró una tarea de comprensión lectora de un texto expositivo corto y sencillo (111 palabras), en la que se solicita a los estudiantes que después de haber leído el texto durante 120 segundos, señalen las tres ideas principales de los tres párrafos que consta el texto y la idea global de dicho texto. El puntaje máximo de esta tarea es seis.

Para la valoración de estrategias de regulación de la lectura, se empleó la *Escala de Evaluación de la Autorregulación del Aprendizaje a partir de Textos* —ARATEX— (Solano et al., 2005). Consta de 23 ítems y la valoración se lleva a cabo a través una escala Likert, con cinco alternativas de respuesta, en relación con la frecuencia con la que realizan o no la actividad que se describe en el ítem (1= nunca; 5= siempre). La estructura factorial de la escala es de cinco dimensiones interrelacionadas entre sí: e*strategias de regulación de la cognición* (dimensión cognitiva, con 6 ítems), e*strategias de regulación de la motivación* (dimensión motivacional, con 5 ítems), *estrategias de regulación de gestión de recursos* (dimensión de gestión de recursos o de apoyo, con 6 ítems), *estrategias de regulación de la metacognición* (dimensión evaluativa, con 4 ítems), y *estrategias de regulación del contexto* (dimensión contexto, con 2 ítems). La escala aporta información sobre la situación real en la que se encuentran los alumnos universitarios en relación con su eficacia a la hora de regular su proceso de comprensión y aprendizaje. Por ejemplo, "Cuando termino el texto, compruebo si lo he comprendido todo bien".

El nivel de conocimientos previos de dominio específico fue examinado por medio de un cuestionario con 6 preguntas. Tres de ellas exigen recuperación de información (por ejemplo, ¿Qué es la sociedad del conocimiento?) y las tres restantes requieren de una mayor elaboración inferencial (por ejemplo, ¿Qué notas distintivas de la sociedad del conocimiento considera que no están presentes, de manera generalizada, en el contexto mexicano?). El puntaje máximo que los estudiantes pueden obtener en ambos grupos de preguntas es de 6 puntos.

La calidad de los mapas conceptuales fue valorada siguiendo el sistema de puntuación utilizado por Liu (2011), a partir de la propuesta de Novak y Gowin, (1984). Se otorgó puntajes de acuerdo a: número de conceptos relevantes (1 punto por cada concepto significativo); número de niveles jerárquicos (5 puntos por nivel de jerarquía válido); número de enlaces cruzados (10 puntos por enlace cruzado válido); número de ejemplos (1 punto por cada ejemplo correcto). Además, se introdujo una adaptación, ya que se tuvo en cuenta el número de enlaces correctamente etiquetados (2 puntos por enlace correcto) (Hillbert y Renkl, 2009; Rafferty y Fleschner, 1993).

Para calificar el nivel de colaboración percibido por los participantes, se utilizó el Cuestionario de Colaboración elaborado por Chan y Chan (2011), y desarrollado siguiendo la noción de construcción colaborativa del conocimiento que plantea Scardamalia y Bereiter (2006). Este cuestionario comprende 12 ítems, valorados de acuerdo a una escala Likert de 5 puntos. Los diferentes ítems reflejan los 12 principios del aprendizaje colaborativo propuestos por Scardamalia y Bereiter (2006), de acuerdo a la experiencia de colaboración que tuvieron los estudiantes en sus respectivos equipos. Por ejemplo: "Nuestros puntos de vista y conocimientos pudieron ampliarse gracias al trabajo con los demás".

Los intercambios verbales de los participantes dentro de cada equipo fueron codificadas de acuerdo con un sistema de análisis, adaptado a partir de la propuesta de Manlove et al. (2005, 2006), que integra, a su vez, algunos componentes del análisis de la colaboración desarrollado por Van Boxtel et al. (2000). Cada producción de los estudiantes fue segmentada en enunciados (unidades mínimas de sentido), es decir, en cada idea completa o frase completa gramaticalmente y comprensible por sí misma, con una función comunicativa específica. A su vez, cada una de estas unidades mínimas de sentido fueron codificadas de acuerdo a sus funciones en el diálogo, en las siguientes categorías: - *cognitivos*: cuando hacen referencia a aspectos relacionados con los contenidos de la tarea de aprendizaje; - *regulativos*: en este caso aluden a la planificación, monitoreo y evaluación de la tarea de aprendizaje y a la colaboración en la tarea; - *afectivos*: en los que se señalan emociones y sentimientos vinculados con la tarea de aprendizaje y el ambiente colaborativo; - *procedimentales*: correspondientes a aspectos operacionales del manejo de la herramienta mapas conceptuales; - *irrelevantes*: cuando los estudiantes manifiestan alguna otra idea ajena a la tarea de aprendizaje, la colaboración y los mapas conceptuales.

Estos enunciados pueden ser integrados, tal como lo propone Van Boxtel et al. (2000), en unidades mayores denominadas episodios, es decir, una secuencia de expresiones que resultan significativas respecto a un contenido determinado. Los episodios pueden ser codificados de acuerdo al tipo de enunciados que los componen en cognitivos, regulatorios, afectivos o procedimentales. Manlove et al. (2005) establecen también una distinción en los episodios regulativos, ya que pueden referirse a: a) la *regulación de la tarea de aprendizaje*, cuando se trata de conversaciones que aluden a la planeación, el monitoreo de los progresos en la comprensión y a su evaluación; o bien a: b) la *regulación de la colaboración* (co-regulatorios), cuando los intercambios se refieren a la estructura colaborativa de la tarea, por ejemplo, división de tareas, organización de los intercambios y acuerdos respecto a los turnos de participación.

Para el análisis de datos se ha trabajado con un nivel de significación estadística de $p < 0.05$ y en dicho análisis se utilizó el programa informático Statistical Package for Social Science (SPSS) versión 15.0 para Windows. Para el análisis cualitativo se empleó el programa AtlasTi.

4 Resultados

Para el análisis de resultados se compararon entre sí las dos condiciones, empleando la prueba no paramétrica *U* de Mann-Whitney.

Respecto a las variables de control, no se encontraron diferencias significativas entre las dos condiciones consideradas para este estudio (grupos de mapas colaborativos con apoyo y sin apoyo del listado de conceptos clave) en ninguna de las medidas de comprensión lectora, estrategias de regulación del aprendizaje con texto ni en el nivel de conocimientos previos de dominio específico.

Los resultados obtenidos en las variables cuantitativas postest: autovaloración de la colaboración y calidad de los mapas conceptuales se presentan en la siguiente Tabla 1.

	Colaboración		**Mapa conceptual**											
			N° de conceptos		**N° de enlaces válidos**		**N° de enlaces cruzados**		**N° de jerarquías**		**N° de ejemplos**		**Puntajes totales (Novak y Gowin, 1984)**	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Grupos con apoyo n = 3	3.86	.42	30.00	9.04	13.33	5.76	.66	.50	4.6	1.3	2.33	.50	89.00	29.78
Grupos sin apoyo n = 3	4.11	.16	19.33	3.50	8.66	1.00	.00	.00	4.00	.86	.66	.50	57.33	9.96

Tabla 1: Medias de los puntajes obtenidos por los grupos en las dos condiciones (con y sin apoyo) en autovaloración de la colaboración en el equipo y calidad del mapa conceptual colaborativo

En el análisis estadístico (test no paramétrica U de Mann-Whitney) se encontraron diferencias significativas en las dos variables postest: calidad de mapa conceptual colaborativo y autovaloración de la colaboración. Por un lado, la condición con apoyo del listado de conceptos clave promovió mapas conceptuales de mayor calidad que la condición sin apoyo (*U* de Mann-Whitney= 9,00; *Z*= -2,81; *p*=,005). En tal sentido, estos mapas resultaron superiores en los siguientes aspectos: número de conceptos válidos (U de Mann-Whitney= 4,50; Z= -3,26; p=,001); número de enlaces válidos (U de Mann-Whitney= 13,50; Z= -2,48; p=,013); número de enlaces cruzados correctos (U de Mann-Whitney= 13,50; Z= -2,91; p=,004) y número de ejemplos (U de Mann-Whitney=,00; Z= -3,72; p=,00).

Sin embargo, por otro lado, los estudiantes que trabajaron colaborativamente sin el apoyo del listado de conceptos clave valoraron significativamente de manera más alta el nivel de colaboración alcanzado en sus equipos, en comparación a los estudiantes de la condición con apoyo (U de Mann-Whitney= 16,00; Z= -2,18; p=,029).

Respecto al análisis cualitativo de los intercambios durante la tarea de colaboración, los principales resultados hacen referencia a: a) en ambas condiciones predominaron enunciados de tipo cognitivo (73 y 67 % del total, con y sin apoyo respectivamente); b) se registraron enunciados regulativos en un 22 % (con apoyo) y en un 26 % (sin apoyo); c) en la condición sin el apoyo del listado de conceptos clave, se observaron enunciados irrelevantes y afectivo-motivacionales (6 %). En relación a los episodios regulativos, se puede consignar que en ambas condiciones correspondieron en su gran mayoría a episodios regulativos relacionados con la tarea. No obstante, en la condición con apoyo predominaron contenidos que aludían a los momentos de monitoreo y evaluación, mientras que en la condición sin apoyo aparecieron contenidos referidos también al momento de planificación de la tarea. Asimismo, fueron escasos los episodios vinculados a la regulación de la colaboración en la tarea con mapas conceptuales. Solamente se registraron dos episodios en la condición sin ayuda y otro episodio en los grupos que trabajaron con el listado de palabras clave.

5 Consideraciones finales

Los resultados encontrados en este estudio muestran los efectos positivos de proporcionar un listado de palabras clave como apoyo para la construcción colaborativa de mapas conceptuales en una tarea de comprensión de un texto expositivo. Esta ayuda resultó significativa en relación a la calidad de los mapas conceptuales que se elaboraron colaborativamente. En buena medida estos datos siguen la línea de evidencias recogidas en trabajos como el de Chang et al. (2001) que señalan la importancia de incluir ayudas que permitan afrontar las altas demandas cognitivas que supone la construcción colaborativa de mapas conceptuales. Sin embargo, la ayuda de listado de conceptos clave no generó los mismos efectos respecto a los niveles de colaboración e intercambio comunicativo en los grupos. Podría pensarse, por tanto, que esta clase de ayuda focaliza la interacción grupal en términos de los intercambios cognitivos y regulativos a nivel de contenidos de la tarea, limitando otros tipos de intercambios, en especial los de índole co-regulativo. Empero, en ambas condiciones fueron escasos los episodios relacionados con la regulación de la colaboración en la tarea. Por consiguiente, sería conveniente desarrollar apoyos específicos para favorecer el despliegue de estos procesos vinculados con la gestión de las estructuras de colaboración en el trabajo grupal.

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COMPULSORY CONCEPT AS INSTRUCTIONAL STRATEGY TO IDENTIFY LIMITED OR INAPPROPRIATE PROPOSITIONAL HIERARCHIES IN CONCEPT MAPS

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Abstract. Concept maps (Cmaps) are powerful graphical organizers that have been used over the last four decades for educational and corporative purposes. Verification of the benefits of using Cmaps to represent and share our ideas depends on the mapper's skills and the general understanding that Cmaps are more than simple diagrams or charts. When these conditions are met, concept mapping is likely to promote changes in teaching, learning, and assessing students. Limited or Inappropriate Propositional Hierarchies (LIPHs), as proposed by Novak, refer to conceptual errors that may occur even when students choose to learn meaningfully. One educational challenge posed in everyday classrooms is convincing students to choose meaningful rather than rote learning. High-quality instructor feedback during the learning process plays a critical role to keep students committed to learning meaningfully throughout the course. This paper presents the use of compulsory concepts (CCs) to make explicit students' LIPHs in Cmaps. Propositions involving the CC(s) can externalize naive messages (limited propositional hierarchies) or conceptual mistakes (inappropriate propositional hierarchies). In both cases, the identification of LIPHs is straightforward and accomplished by checking, at-a-glace, neighbor (NCs) and supplementary (SCs) concepts in the propositional network. Therefore, the use of CC(s) increases the probability of a mapmaker to externalize his or her LIPHs. Making LIPHs visible can help instructors provide precise feedback to students throughout the learning process. We believe this strategy can foster pedagogic resonance between the instructor and students and allow a suitable social interaction to promote the choice to learn meaningfully.

1 Introduction

Concept mapping is a well-established technique for graphical representation of information and knowledge, which makes explicit description of mental models possible. Since its introduction in 1972, concept maps (Cmaps) have often been used for educational and corporate purposes and have changed the way we manage knowledge and information (Coffey et al., 2003; Hoffman et al., 2006; Moon et al., 2011; Nesbit & Adesope, 2006; Novak, 2010). The verification of the benefits of using Cmaps to represent and share our ideas depends on one's skills as a mapper and understanding that Cmaps are more than simple diagrams or charts (Correia, 2012). When these conditions are met, concept mapping is likely to promote changes in teaching, learning, and assessing students (Novak, 2002; 2005).

Cmaps present some unique features that make them more powerful than other graphic organizers: propositions (P), focal question (FQ), recursive revision (RR), and hierarchy (H).

- Propositions (P) are formed by two concepts that are connected through a linking phrase (initial concept + linking phrase + final concept). Reading direction is usually indicated by an arrow. Good propositions have a high degree of semantic clarity and readers can understand clearly the mappers' ideas.
- Focal Question (FQ) is the ultimate goal of the Cmap. It is the critical parameter to drive the selection of the most relevant concepts and linking phrases. The FQ must be addressed by the propositional network from which the readers obtain the mapper's answer.
- Recursive Revision (RR) reflects the dynamic nature of knowledge and information. In other words, Cmaps are never finished and they can be improved over time. It must be stressed that the "right" answer is no longer available; on the contrary, it must be continuously pursued.
- Hierarchy (H) is the fine-tuning of the network structure of the Cmap. The spatial organization of concepts depends on their inclusiveness and the most inclusive concepts must be read first. This hierarchy structure supports understanding through progressive differentiation of concepts (Ausubel, 2000).

Assimilation Theory of Meaningful Learning and Retention refers to the description of the learning process on a continuum between two extremes, called meaningful and rote learning (Ausubel, 2000; Mayer, 2002). The distinction between these extremes is characterized by how new information relates to the relevant aspects within the existing cognitive structure of each learner. In meaningful learning, relationships are established in non-arbitrary and non-literal ways; this process requires more cognitive effort to relate the individual's prior knowledge to the new information. On the other hand, these relationships are established arbitrarily and literally in rote learning and do not require the individual to check the effect of prior knowledge on the new information (Ausubel, 2000; Novak 2010). Meaningful learning is more demanding than rote learning and students must make an effort to learn in this way. Instructor feedback is critical to avoid students shifting from meaningful to rote learning. Finally, meaningful learning depends on the idiosyncrasies of each person (*e.g.*, prior knowledge, experiences, self-efficacy, values, and control beliefs), the instructional strategies used, and learners' intrinsic desire to find meaning (Ausubel, 2000; Novak, 2010; Pintrich, Marx & Boyle, 1993).

Meaningful learning does not imply the absence of conceptual mistakes (Novak, 2002; Novak & Musonda, 1991). On the contrary, the literature refers to them as misconceptions, alternative conceptions, naive notions, and pre-scientific notions. Novak (2002) proposed Limited or Inappropriate Propositional Hierarchies (LIPHs) to refer to these types of conceptual errors. The identification of LIPHs in Cmaps is straightforward as the lack of semantic clarity of some propositions may reveal the presence of mistakes or limited understanding. For example, poorly chosen linking phrases constrain the accuracy of messages embedded in the propositional network. Novak (2002) proposed LIPHs as suitable starting points to foster meaningful learning. Therefore, instructors can consider LIPHs to intentionally plan and revise upcoming learning activities to continue to foster meaningful learning.

LIPHs can be the result of meaningful learning and changing them is a difficult task. Students must gradually revise the relevant structures of their own knowledge and build new propositions over time while trying to gain a deeper understanding of the mapped topic. For instance, students must create new meaning from the instructor's comments about their original Cmaps to gain awareness of the propositions that need to be revised. If students choose to use rote rather than meaningful learning to overcome their LIPHs, the resultant knowledge will not be appropriately retrieved after long period and will not be used in contexts that are different than the one used during the learning process.

One educational challenge posed in everyday classrooms is convincing students to choose meaningful rather than rote learning. High-quality instructor feedback during the learning process plays a critical role to keeping students committed to learning meaningfully throughout the course. The achievement of pedagogic resonance (Kinchin, Lygo-Baker & Hay, 2008) and the development of self-regulative skills (White & Frederiksen, 1998) are desirable side effects in supporting meaningful learning. For these reasons, we believe that there is a need for a procedure that allows rapid identification of LIPHs in Cmaps.

2 Research goal

The aim of this paper is to propose the use of compulsory concepts (CCs) to make explicit students' Limited or Inappropriate Propositional Hierarchies (LIPHs) in Cmaps.

3 The role of compulsory concept(s) in concept mapping

The instructional strategy underlying this study is to ask learners to use one or multiple compulsory concepts (CCs) to prepare their Cmaps. This task involves analysis (breaking material into its constituent parts and detecting how the parts relate to one another and to the overall structure or purpose), evaluation (making judgments based on criteria and standards), and creation (putting elements together to form a novel, coherent whole or an original product). These tasks are sophisticated cognitive processes, as described by Bloom's revised taxonomy of educational objectives (Krathwohl, 2002).

The selection of CC is critical to allow students to expose the limits of their understanding of the subject. Some criteria to choosing CC include:

- Selection of threshold concepts (Meyer and Land, 2005, p.373) that may be transformative (occasioning a significant shift in the perception of a subject), irreversible (unlikely to be forgotten, or unlearned only through considerable effort), and integrative (exposing the previously hidden interrelatedness of something).
- In-depth discussion of the CC during learning activities in classroom.
- Usefulness of the CC to address the focal question appropriately.

Concepts in a Cmap can be classified, according to their location from the CC(s), before reading the propositional network. Specifically, all concepts that are directly connected to CC(s) are classified as neighbor concepts (NCs); supplementary concepts (SCs) are not directly linked to CC(s) (see Figure 1). This at-a-glance check allows to analyze the relevance that mappers conferred to the CC(s) by counting the propositions from or to CC(s).

The relevance of the CC(s) to address the focal question is predictable from the number of propositions from or to CC(s). Many propositions are a sign of high relevance (Figures 1a and 1c), whereas few propositions could indicate a student's difficulty in connecting the CC(s) to his or her own conceptual knowledge (Figures 1b and 1d). Curiously, the number of propositions from or to CC(s) is not a good indicator of students' understanding of the mapped topic. In some cases, students may choose to follow the exam instructions without any concern for the usefulness of the propositions they create. The expected result is a Cmap with many (but meaningless) propositions from or to CC(s). Despite using the CC(s), the bureaucratic approach that is adopted by some students is easily detected (Cicuto & Correia, 2012).

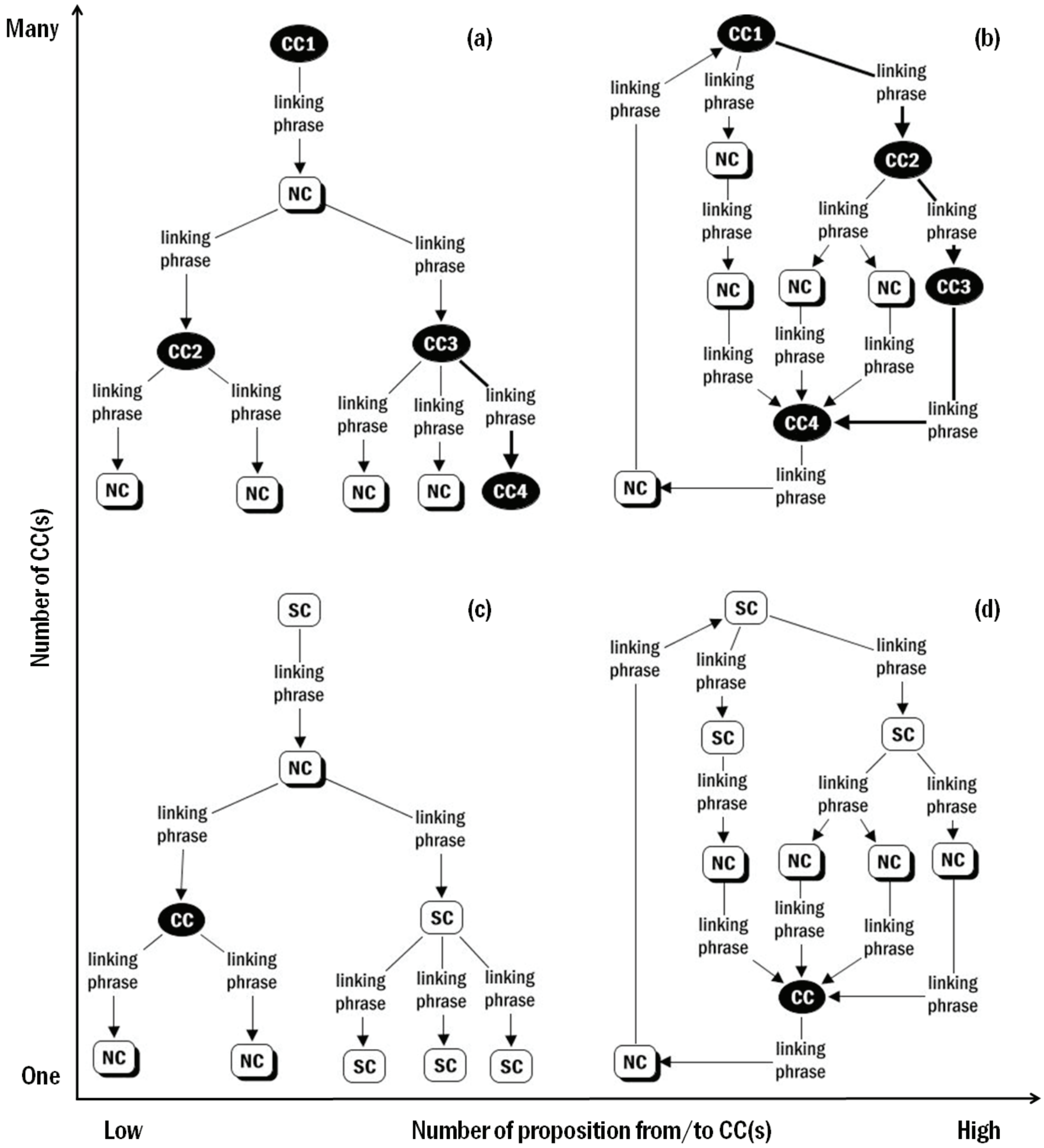


Figure 1. Classification of concepts according to the CCs (black circles): neighbor concepts (NCs, shadowed boxes) are directly linked to the CCs, whereas supplementary concepts (SCs, white boxes) are not. Some patterns can be identified at-a-glance: Cmap with multiple CCs and few propositions from or to them (Figure 1a), multiple CCs and many propositions from or to them (Figure 1b), one CC and few propositions from or to it (Figure 1c), and one CC and many propositions from or to it (Figure 1d). Thicker lines show CC-CC propositions in Figures 1a and 1b.

Propositions CC-CC and CC-NC can be considered to evaluate the occurrence of progressive differentiation (Figures 1a and 1c) or integrative reconciliation (Figures 1b and 1d). In the former, inclusive concepts present in the student's cognitive structure subsume the newer information. Frequently, beginners on the mapped topic prefer to express their knowledge using this approach. Integrative reconciliation (Figures 1b and 1d) is typically applied by experts on the topic. This approach reflects a deeper understanding of the concepts involved by identifying patterns among less inclusive concepts to other concepts (called as superordinates). The rapid analysis of the structure of Cmaps, when CC(s) are required, allows for classification into two groups according to the amount of integrative reconciliation. The pedagogic resonance (Kinchin, Lygo-Baker & Hay, 2008) between the instructor's conceptual knowledge and the students' Cmaps can take place and increase the precision of the instructor's feedback throughout the learning process.

4 Compulsory concept(s) to identify Limited or Inappropriate Propositional Hierarchies

We hypothesize that the use of CC(s) increases the difficulty of making a Cmap because the CC(s) is not chosen by the map-makers themselves. Consequently, the mapper must find appropriate NCs and linking phrases to express how the CC(s) can be included into the propositional network. This task seems more difficult than establishing propositions using only concepts selected by the author of a Cmap.

It is possible that the CC(s) will not be familiar to some students who studied the topic without considering its threshold concept(s) appropriately (Meyer & Land, 2005). In this case, the externalization of LIPHs, due to the CC(s), is likely to occur while students try to use this concept(s) without a clear comprehension about its meaning(s). On the other hand, when the map-makers choose all concepts themselves (there is no CC to be used), the externalization of LIPHs is less probable because the students will prefer to use only familiar concepts and avoid the risk of exposing their conceptual gaps. Therefore, it is more difficult for instructors to identify LIPHs from students' Cmaps and plan further activities to fostering meaningful learning. Our hypothetical generalization can be summarized as follows: propositions involving the CC(s) can externalize naive messages (limited propositional hierarchies) or conceptual mistakes (inappropriate propositional hierarchies). In both cases, the identification of LIPHs is straightforward by checking, at-a-glace, the neighbor (NCs) and supplementary (SCs) concepts in the propositional network. Therefore, the use of CC(s) increases the probability of a map-maker to externalize his or her LIPHs. The comparative evaluation of students under the same instructional conditions and the precise feedback provided by the instructor are critical in the support meaningful learning. Specifically, these can be achieved in everyday classrooms using CC(s), Cmaps, and the proposed procedure to make a rapid evaluation of learning progress.

Figure 2 illustrates Cmaps prepared by the authors to represent the most common patterns identified using CC during a Natural Sciences course (Correia et al., 2010), offered at School of Arts, Sciences, and Humanities (University of São Paulo). Our intention is to present how LIPHs are externalized in Cmaps that contain one or multiple CCs. The Cmaps represented in Figures 2a and 2b show two types of propositions: CC-CC (thicker lines) and CC-NC. The former proposition is only formed when multiple CCs are selected by the instructor, whereas the latter is found with one or multiple CCs.

Figures 2a and 2b allow a close evaluation of CC-CC and CC-NC propositions, which may increase the chance of LIPHs externalization. The CCs for these Cmaps include environment, technology, science, and climate change. This selection aims to confirm the relationships involving science, technology, and society (STS approach), which are critical aspects to promoting scientific literacy (Bybee, McCrae, & Laurie, 2009; Correia et al., 2010; Millar, 2006; Osborne, 1997, 2012; Santos, 2009). Figure 2a illustrates only one CC-CC proposition (climate change – is studied by → science). This proposition has semantic clarity and is correct considering the message expressed. On the other hand, the CC-NC propositions in Figure 2a present limitations or conceptual mistakes. The propositions that involve technology, economic development, and climate change (technology – and → economic development; economic development – with → climate change) were classified as limited (L) because their semantic clarity is hindered by the lack of verbs in the linking phrases. Inappropriate propositions (containing conceptual mistakes) can be found from the concept climate change (climate change – minimizes → clean development; climate change – minimizes → alternative energy use). The verb used in the linking phrases confirms the lack of understanding about climate change and the differentiated concepts (clean development and alternative energy use).

The remarkable feature of the Cmap presented in Figure 2b is the sequence of CC-CC propositions: technology – can minimize → climate change; climate change – is studied by → science; and science – and → environment. This sequence of propositions using only CCs requires a good understand of the topic. Moreover, the student must be confident in expressing his or her ideas, which can be another indicator of he or she understands the topic. This type of Cmap reveals confident students who take a chance to make something special. The price they could pay is externalizing LIPHs, as seen in the last proposition (science – and → environment). However, the instructor's feedback should recognize the mappers' effort to go beyond a naive subject description. The limitation should be identified without compromising the net evaluation of the Cmap (low grades for this mistake may be not justifiable). The deeper understanding shown in Figure 2b can be supported with the use of “environment” as a concept to promote integrative reconciliation. The Figure 2a shows a less complex Cmap that is based only in progressive differentiation.

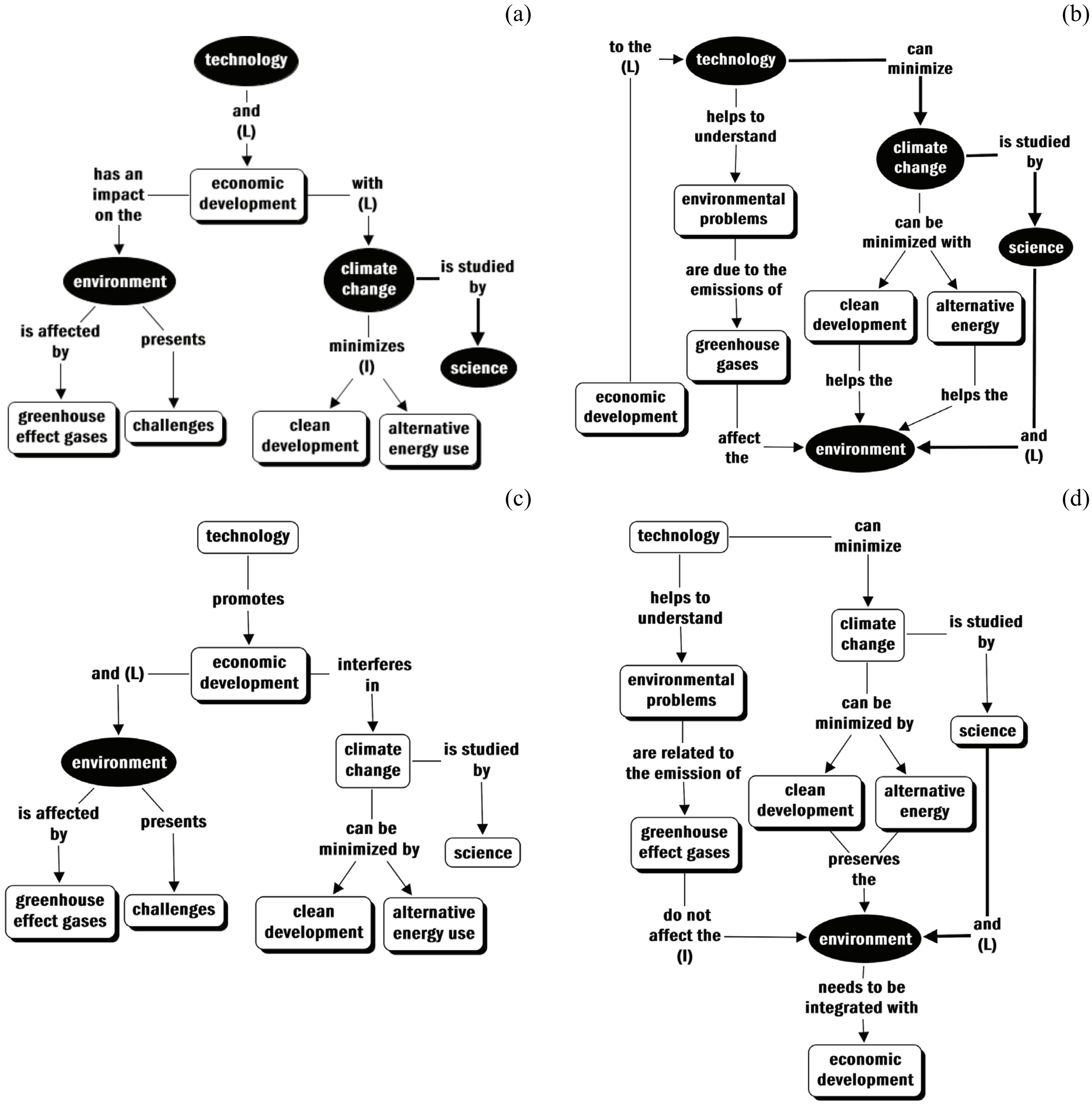
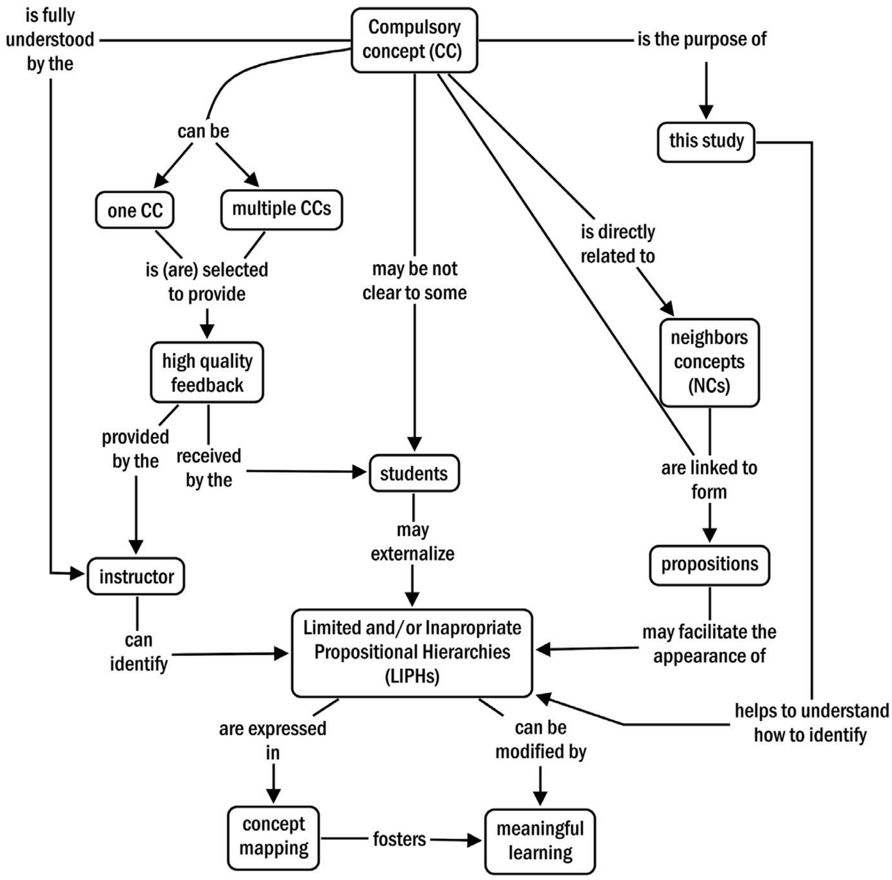


Figure 2. Illustrative Cmaps made by the authors to highlight typical patterns from our experience using CC(s) to identify LIPHs. Classification of concepts, according to the CCs (black circles): neighbor concepts (NCs, shadowed boxes) are directly linked to the CCs, whereas supplementary concepts (SCs, white boxes) are not. Limited and inappropriate propositions are indicated using L and I, respectively. Thicker lines show CC-CC propositions (Figures 2a and 2b).

Figures 2c and 2d present Cmaps that contain one CC (environment). Therefore, only CC-NC propositions are available to foster the externalization of LIPHs. Both Cmaps have one limited (L) proposition (economic development – and → environment in Figure 2c, and science – and → environment in Figure 2d); whereas the Cmap in Figure 2d includes an inappropriate proposition (greenhouse effect gases – do not affect the → environment). The latter shows a conceptual mistake, while the former is not clear enough to allow this type of judgment. The comparison among the two allows differentiating, at-a-glance, limited and inappropriate propositional hierarchies in Cmaps (Novak, 2002).

The overall analysis of the four Cmaps presented in Figure 2 supports the use of one or multiple CCs to foster the externalization of LIPHs. Making LIPHs visible can help instructors provide precise feedback to the students throughout the learning process, thus, making the learning progress even more visible (Hay, Kinchin, & Lygo-Baker, 2008). We believe this strategy fosters pedagogic resonance between the instructor and students (Kinchin, Lygo-Baker & Hay, 2008) and allows a suitable social interaction to promote the choice to learn meaningfully.

5 Summary



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CONCEPT MAP-BASED KNOWLEDGE ASSESSMENT TASKS AND THEIR SCORING CRITERIA: AN OVERVIEW

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Abstract. Concept map is a graphical representation of its creator's knowledge structure, and it can be used as a tool for knowledge assessment. Even when considering only three factors – whether the structure, linking phrases and concept labels are given – there is a wide range of possible concept map-based tasks. Tasks with different demands allow assessing different aspects of knowledge, and thus, various sets of criteria are used for their assessment. Scoring of some of these criteria is easy to automate (e.g. count of concepts or propositions), but also more elaborate criteria are used that are more difficult to assess automatically (e.g. proposition's depth of explanation). This paper represents the results of a literature study on usage of concept map-based tasks for knowledge assessment purposes and criteria used to score them.

1 Introduction

Human memory is an interrelated system, and learning process is described as an alteration of this system by adding new knowledge pieces and/or modifying the structure to accommodate newly learned knowledge. Knowledge assessment allows measuring the outcomes of learning and determines whether the educational process has been successful. As knowledge structure cannot be observed directly, various indirect methods are used instead. Concept maps (CM) are one of such methods.

CM is a graphical tool for representing knowledge structure in a form of a graph whose nodes represent concepts, and arcs between nodes correspond to interrelations between them. Linking phrases on the arcs describe the semantics of a connection. Two concepts and a relationship between them form a proposition. None of the concepts can be explained without referring to its relation to other concepts (Ruiz-Primo & Shavelson, 1996), so the proposition is the smallest unit of meaning in CMs. The more knowledge one holds in the domain, the more interconnected the responding knowledge structure is. Concept maps can have hierarchical segments with cross-links between these segments or a net-like structure where other kinds of relationships dominate.

Since 1970's, when Concept maps (CM) were introduced as a pedagogical tool (Novak & Cañas, 2006), researchers have experimented with a wide range of CM-based tasks to test their suitability for knowledge assessment purposes. According to Ruiz-Primo & Shavelson (1996), a CM-based task consists of three main parts: task demands, task constraints and task content structures. Task demands define what a student has to do to complete the task: construct a CM, fill in missing elements in a CM structure, rate the relatedness of concept pairs etc. Task constraints (directedness of the task) refer to the limitations that a student has to follow while solving a task. For example, a student may be asked to use only the concept labels and linking phrases given in a list or define them himself/herself. Task content structure refers to the nature of the subject domain to be mapped. There are hierarchical domains, e.g. taxonomy of live beings, and also cyclic, net-like, and chain-like domains.

This paper documents a literature review about most frequently used kinds of CM-based tasks and criteria that can be used to score these tasks. The rest of the paper is organized as follows. In the next section types of CM-based tasks are described. The third section describes three classes of the most frequently used criteria for scoring these tasks. The paper ends with conclusions.

2 Concept map-based tasks

Different kinds of CM-based tasks serve different purposes. In (Ruiz-Primo, Schultz & Shavelson, 2001) it is said that high-directed tasks impose different cognitive demands on students than low-directed tasks. High-directed tasks where a student has little freedom to express his/her knowledge structure are more likely to misinterpret the student's knowledge structure. High-directed tasks are useful for activating the student's knowledge, while low-directed ones enable students to represent their knowledge structure more precisely (Gouli, Gogoulou & Grigoriadou, 2003). At the same time, low-directed tasks demand more content knowledge (Ruiz-Primo,M.A et al., 2001); thus, these tasks may appear too challenging for students with less competency. There is no one most appropriate task for all assessment purposes, as there is no best scoring method that would be appropriate for all kinds of CM-based tasks and would reflect all aspects of knowledge structure.

Range of CM-based tasks is wide. In (Shavelson, Lang & Lewin, 1994) it is stated that there is no less than 128 diverse types of tasks. Even wider set – 739 tasks – can be found by varying these factors: there can be given complete (C), or partial (P) CM structure, or it can be not given at all (E), complete (C), partial (P) or empty (E) sets of concepts and linking phrases in the list or in the CM structure and there can also be included distractors – misleading concepts and linking phrases. Some of these factors are mutually dependent (see Fig.1). For example, if all concepts are given in the list, then there can be no concepts in the structure.

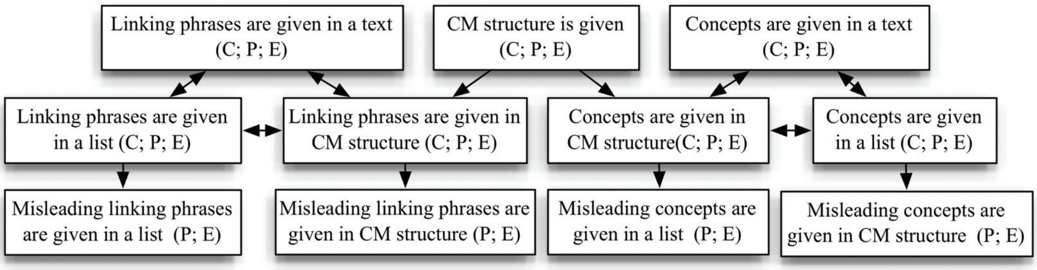

Figure 1. Factors that comprise a CM-based task and their interdependence

	Factors	Task (source)
1	(C; C; C; E; C; E; C)	**Fill-in-the-lines** (Ruiz-Primo et al., 2001; Shavelson, Ruiz-Primo & Wiley, 2005). **Relationships list completion** (Gouli, et al., 2004).
2	(C; C; E; C; C; C; E)	**Fill-in-the-Nodes** (Ruiz-Primo et al., 2001; Shavelson, Ruiz-Primo& Wiley, 2005); **Concept list completion** (Gouli, et al., 2004); **CM task** (Anohina-Naumeca, Grundspenkis, Strautmane, 2011).
3	(C; C; E; C; C; P; P)	**Select-and-fill-in** (Schau, 1999; Schau, 1997); **CM task** (Anohina-Naumeca, Grundspenkis, Strautmane, 2011).
4	(E; C+D; C+D; E; C+D; C+D; E)	**CM Task** (Taricani & Clariana, 2006; Koul, Clariana & Salehi, 2005; Hsu & Hsieh, 2005).
5	(E; C; C; E; C; C; E)	**S mapping technique** (Yin et al., 2005; Schaal, Bogner& Girwidz, 2010); **Concept-relationship lists construction** (Gouli, et al., 2004), **Construct-by-self** (Chang, Sung & Chen, 2001) **CM Task** (Herl, Baker & Niemi, 1996; Chang et al., 2005; Schaal, 2008; da Rocha, da Costa & Favero, 2008; Klein et al., 2002; Schacter et al., 1997; Fatemeh, Ahmad & Mohammad, 2011; O'Neil, Chuang & Chung, 2004; Sims-Knight et al., 2004; Anderson & Huang, 1989; Osmundson et al., 1999; Hoeft et al., 2003; Anohina-Naumeca, Grundspenkis, Strautmane, 2011).
6	(E; E; E; E; C; C; E)	**Construct-a-map with a list of concepts provided** (Plummer, 2008); **C mapping technique** (Yin et al., 2005); **Construct-a-map from scratch** (Ruiz-Primo et al., 2001; Shavelson, Ruiz-Primo, Wiley, 2005). **Concept-list construction** (Gouli, Gogoulou & Grigoriadou, 2003; Gouli, et al., 2004), **Pre-selected term maps** (Oliver, 2008); **CM task** (Schreiber & Abbeg, 1991; Rice, Ryan & Samson, 1998; Mls, 2006; Asan, 2007; Cathcart et al., 2010; McClure, Sonak & Suen, 1999; McPhan, 2008; Bolte, 1997; Nakiboglu & Ertem, 2010; Gerstner & Bogner, 2009; Roberts & Moriarty, 1996; Kankkunen, 2001; Luckie, Harrison & Ebert-May, 2011; Ruiz-Primo, Shavelson & Schultz, 1997; Lapp, Nyman & Berry, 2010; Markow & Lonning, 1998; Austin & Shore, 1995; Erduran-Avci, Unlu & Yagbasan, 2009; Adamczyk & Willson, 1996; Barenholz & Tamir, 1992; Luckie, Harrison & Ebert-May, 2004; Anohina-Naumeca, Grundspenkis, Strautmane, 2011);.
7	(E; E; E; E; E; E; E)	**Construct-a-map from scratch** (Ingec, 2009); **Free-construction task** (Gouli, Gogoulou & Grigoriadou, 2003; Gouli, et al., 2004), **Open-ended maps** (Oliver, 2008). **Map-generation task** (Hauser, Nückles & Renkl, 2006); **"Free range" CM task** (McLay & Brown, 2003); **CM Task** (Pearsall, Skipper, & Mintzes, 1997; West et al., 2002; Çakmak, 2010; Ozdemir, 2005; Gregoriades, Pampaka, & Michail, 2009; Kankkunen, 2001; Walker & King, 2002; Freeman & Urbaczewski, 2002; Stoddart et al., 2000; Borda et al., 2009; Turns, Atman & Adams, 2000; Beatty, 2000; West et al., 2002; Blackwell, & Williams, 2007; Fatemeh, Ahmad& Mohammad, 2011; Lavigne, 2005; Besterfield-Sacre, et al., 2004; Sanders et al., 2008; BouJaoude & Attieh, 2003; McKeown, 2009.

Table 1: Most frequently used types of concept map-based tasks

However, in reality a lot less variety of tasks is used. Reviewing literature, 23 types of tasks were found; here only seven more frequently used ones are mentioned (see Table 1). The first three of them are fill-in-the-map tasks, while remaining four are construct-a-map tasks. For this survey only those papers were selected that describe evaluation criteria used for scoring CM and where student fills or generates CM himself/herself instead of deriving the CM from student's response in some other form (e.g. text or concept relatedness assessments).

In the table factors that comprise a task are represented in such form: (<Structure>; <Relations given>; <Relations in the list>, <Relations in the structure>, <Concepts given>, <Concepts in the list>, <Concepts in the structure>). The first factor can have one of three values: "C" – complete; "P" – partial or "E" – empty. Other six factors can have three mentioned values and also "C+D" – complete, contains distractors. The table also contains different names that researchers have used to denote these tasks; sometimes the same name is used for different tasks (e.g. construct-a-map from scratch).

As can be seen from the table, construct-a-map tasks are used more frequently than fill-in-the-map tasks. Around 85% of summarized reports document the usage of a construct-a-map task alone or it's comparison to one or several different tasks. It is due to their ability to elicit more information about student's knowledge structure, which is also one of the main reasons for interest in using CMs as a knowledge assessment tool.

3 Concept map assessment criteria

An assessment is a combination of a task, response format and scoring system (Ruiz-Primo, & Shavelson, 1996). Scoring system in CM-based assessment usually employs a combination of several criteria because different criteria measure different aspects of knowledge represented by a CM (e.g. number of propositions reflect the volume of the knowledge, number of hierarchy levels – the depth of knowledge, etc.) There is a plethora of criteria used to assess CM-based tasks. It is possible to measure various aspects of a CM as well as its creation process (Yin et al., 2005). The choice of criteria depends on the aim of assessment – if it is an additional or the only technique used for evaluation of knowledge. The choice depends also on the characteristics of a domain where knowledge is to be measured and mode of assessment (manual or automated).

In the following subsections criteria that are used for certain kinds of CM-based tasks and their level of automation are described. Criteria are divided in three groups: (a) criteria that measure CM components, such as number of concepts, levels of hierarchy etc., (b) criteria that describe the structure as a whole such as correspondence to certain patterns, diameter of the graph etc., (c) other criteria. Tables in subsections 3.1, 3.2, and 3.3 contain references only to some of the sources where usage of a certain criteria is mentioned.

3.1 CM component measures

CM component measures include criteria that measure the quantity and quality of distinct elements of CM (see table 2). These include criteria of one of the most frequently used assessment schemes, proposed by Novak and Gowin (Novak & Gowin, 1984) – number of propositions, hierarchy levels, examples and cross links. The mode of assessment used in each source is denoted by the letter A (automated), M (manual), SA (semi automated) or U (not mentioned).

Criteria	Example of usage	Task
Number of concepts	Schaal, 2008[A]; Kankkunen, 2001[M]; Oliver, 2008[M]	5; 6; 7
Completeness of concepts used	Gouli et al., 2004[A]; Gouli, Gogoulou & Grigoriadou, 2003[A]; Rice, Ryan & Samson, 1998[M]; Koul, Clariana & Salehi, 2005[M]	1; 2; 4; 5; 6; 7
Quality of concept labels	Çakmak, 2010[M]; Stoddart et al., 2000[M]	7
Number or propositions	Schreiber & Abbeg, 1991[M]; Nakiboglu & Ertem, 2010[M]; Borda et al., 2009[M]; Koul, Clariana & Salehi, 2005[A]	4; 5; 6; 7
Completeness of relationships	Gouli et al., 2004[A]; Gouli, Gogoulou & Grigoriadou, 2003[A]; Walker & King, 2002[U] Koul, Clariana & Salehi, 2005[M]	1; 2; 4; 5; 6; 7
Proposition correctness**	Anohina-Naumeca, Grundspenkis & Strautmane, 2011[A]; da Rocha, da Costa & Favero, 2008[A]	2; 3; 5; 6
Proposition correctness*	Schaal, 2008[A]Gouli et al., 2004[A]; Fatemeh, Ahmad & Mohammad, 2011[A]; McClure, Sonak & Suen, 1999[M]; Luckie, Harrison & Ebert-May, 2011[A]; Taricani & Clariana, 2006[SA];	1; 2; 4; 5; 6; 7
Proposition quality (correctness, validity)	Yin et al., 2005[M]; Ruiz-Primo et al., 2001[M]; Ruiz-Primo, Shavelson & Schultz, 1997[M]; West et al., 2002[M]; Stoddart et al., 2000[A]	1; 2; 5; 6; 7
Proposition's depth of	Stoddart et al., 2000[M]	7

explanation		
Correct propositions that are not present in expert's CM	Anohina-Naumeca, Grundspenkis & Strautmane, 2011[M]; da Rocha, da Costa & Favero, 2008[A]; Cathcart et al., 2010[M]	2; 3; 5; 6
Proposition similarity to expert's CM	Osmundson et al., 1999[A]; Oliver, 2008[M]	5
Proposition correspondence to a category of relations	Herl, Baker & Niemi, 1996[M]; Schacter et al., 1997[A]	5
Proposition relevance	Klein et al., 2002[A]; Kankkunen, 2001[M]	5; 6
Correct places of concepts and relations	Chang, Sung & Chen, 2001[A]; Schau, 1999[M]	3; 5
Number of levels of hierarchy	Luckie, Harrison & Ebert-May, 2004[A]; Gouli, Gogoulou & Grigoriadou, 2003[A]; Hsu & Hsieh, 2005[M]	4; 6; 7
Concepts per level	Beatty, 2000[M]	7
Quality of hierarchy	Roberts & Moriarty, 1996[M]; Turns, Atma & Adams, 2000[M]	6; 7
Frequency of branching	Pearsall, Skipper & Mintzes, 1997[M]; Borda et al., 2009[M]	7
Number of cross-links	Osmundson et al., 1999[A]; Luckie, Harrison & Ebert-May, 2004[A]; Gouli, Gogoulou & Grigoriadou, 2003[A]; Hsu & Hsieh, 2005[M]	4; 5; 6; 7
Number of strands (major themes)	Schreiber & Abbeg, 1991[M]; Oliver, 2008[M]	6; 7
Number of examples	Nakiboglu & Ertem, 2010[M]Kankkunen, 2001[M]; Hsu & Hsieh, 2005[M]	4; 6; 7

* In comparison to expert's CM
** In comparison to expert's CM and its derivations

Table 2: CM scoring criteria that measure CM components

As can be seen from the last column in this table, fill-in-the-map tasks are mostly assessed by the number of concepts and relationships and the quality of propositions they comprise. It is meaningful to assess such criteria as levels of hierarchy, number of strands and cross-links and examples only for construct-a-map tasks because they actually describe the quality of a student's created structure. There are also two criteria that are meaningful only for tasks where the student generates concept labels and linking phrases by himself/herself, namely, the quality of concept labels and the proposition's depth of explanation. The assessment of propositions correctness criterion in various sources is related to all or a subset of such proposition components as linking phrase, direction of the arc, propositions weight (importance) and concepts linked. Some authors use only two levels of correctness while others consider also partially correct propositions. About 40% of sources report automated assessment of criteria that belong to this group. However there are some currently manually assessed criteria that could be easily automated (e.g. concepts per level and frequency of branching).

Criteria	Example of usage	Task
Convergence with expert's CM	Ruiz-Primo et al., 2001[M]; Ruiz-Primo, Shavelson & Schultz, 1997[M]; BouJaoude & Attieh, 2003[M]	1; 2; 6; 7
Salience	Ruiz-Primo et al., 2001[M]; Ruiz-Primo, Shavelson & Schultz, 1997[M]; BouJaoude & Attieh, 2003[M]	1; 2; 6; 7
Goldsmith's closeness index	Chang et al., 2005[A]	5
Similarity to experts' CM	Chang et al., 2005[A]; Schaal, 2008[A]; McKeown, 2009[A]	5; 7
Diameter of a graph	Sanders et al., 2008[U]	7
Maximum degree of concept	Sanders et al., 2008[U]	7
Spanning tree of the map	McKeown, 2009[A]	7
Number of hierarchical segments	Besterfield-Sacre et al., 2004[M]	7
Ruggedness (unconnected parts)	Schaal, 2008[A]; Koul, Clariana & Salehi, 2005[A]; Austin & Shore, 1995[M]	5; 6
Spatial distance	Mls, 2006[M]; Taricani & Clariana, 2006[A]	4; 6
Graph connectivity	Austin & Shore, 1995[M]	6
Correspondence to structural patterns	Yin et al., 2005[M]; Nakiboglu & Ertem, 2010[M]; BouJaoude & Attieh, 2003[M]; Koul, Clariana & Salehi, 2005[M];	4; 5; 6; 7
Hierarchiness	Ruiz-Primo, Shavelson & Schultz, 1997[M]	6
Domain-specific subpatterns	Sims-Knight et al., 2004[M]	5
Richness of relationships	Lapp, Nyman & Berry, 2010[M]; McKeown, 2009[A]	6; 7
Holistic score of overall quality	Luckie, Harrison & Ebert-May, 2011[M]; Gregoriades, Pampaka & Michail, 2009[M]; Besterfield-Sacre et al., 2004[M]	6; 7

Table 3: CM scoring criteria that measure CM structure parameters

3.2 CM structure measures

Criteria of this group are most frequently used for construct-a-map tasks because it is meaningful to measure various aspects of a structure only then when the student has created this structure. The first four criteria are evaluated by comparing the student's CM to the expert's CM, but others measure graph characteristics.

This class of criteria mostly strives to evaluate the interconnectedness of the student's CM, because as a result of learning knowledge structure becomes more and more interconnected (Ruiz-Primo, & Shavelson, 1996). The expert's generated CMs are characterized by a small number of concepts compared to a number of relationships between them (Novak, & Cañas, 2006). Correspondence to structural patterns also aims at assessing the complexity of a structure by comparing students' created constructs to linear, spoke-like, tree-like, net-like and other patterns.

Only about one third of sources report automated assessment of criteria of this group, because when used for construct-a-map tasks where linking phrases must be generated by the student (tasks 6 and 7) part of them involves analysing semantics of the relationships (e.g. salience and convergence with expert's CM). Correspondence to the various subpatterns is one of the most widely used criteria of this group because it reveals an important characteristic of a knowledge structure as different patterns correspond to different levels of understanding. Still it is complicated to evaluate it automatically because student's CM can contain structures that are inexact matches to the structural patterns.

3.3 Other CM measures

Aside from the scoring CM elements and structure, the process of completing the task can also be measured by inspecting the student's actions log or amount of help used. In computer-based knowledge assessment systems, such as IKAS (Anohina-Naumeca, Grundspenkis & Strautmane, 2011) data, for evaluation of these criteria can be easily gathered automatically. The advancement of computing technologies also allows including more information in a CM such as notes, Web links, digital library resources and images (Oliver, 2008). This additional information also characterizes the student's understanding about the topic, so appropriate evaluation criteria must be included in the scoring system.

Criteria	Example of usage	Task
Amount of help used	Anohina-Naumeca, Grundspenkis & Strautmane, 2011[A]	2; 3; 5; 6
Relevance of attached web document	Schacter et al., 1997[SA]; Oliver, 2008[M]	5; 7
Students actions log	Schacter et al., 1997[SA]	5
Errors, missing elements, used distractors	Gouli et al., 2004[A]; Kankkunen, 2001[M]; Luckie, Harrison & Ebert-May, 2011[A]; Rice, Ryan & Samson, 1998[M]	1; 2; 5; 6; 7
Temporal proximity of creating propositions	Lapp, Nyman & Berry, 2010[M]	6

Table 4: Other CM scoring criteria

4 Conclusions

Although there exist so many variations of CM-based tasks, an CM-based knowledge assessment system does not need to include them all to be useful in various stages of the learning process. It is sufficient if it has a few high-directed tasks for assessment in early stages of learning and some of the low-directed ones for elicitation of deep understanding.

Current computing technologies allow including more criteria in the scoring system without burdening the teacher with a complex computations. Thus an automated CM-based knowledge assessment system has a potential for regular knowledge assessment even for large groups of students. There is still a need for an CM-based knowledge assessment system that could perform the assessment automatically with a little intervention by the teacher. It is crucial for those tasks where student generates linking phrases and/or concept labels because the student can use different words to express correct knowledge than the teacher does. Currently analysis of propositions in such tasks usually is performed manually although there are some attempts to automate it.

As scoring CM components and scoring CM structure reveals different aspects of a knowledge structure, a comprehensive scoring mechanism should use a combination of criteria belonging to both of these groups. Especially in cases where the score of the CM is used as a measure of learning success.

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CONCEPT MAPPING AND ENVIRONMENT AS CONNECTION

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Abstract. What is environment? We follow recent scholarly literature in approaching environment as connection, not as some category of reality, and consider pedagogical implications via concept mapping. Concept maps potentially offer a visually explicit means of representing and analyzing the hybrid connections between actors that define environmental issues. We explore the utility of concept mapping as pioneered by Joseph Novak and others via the CmapTools application, in which concept maps (cmaps) consist of concepts (boxes or nouns) connected by propositions (arrows or verbs); both can include linked resources, and the resultant cmap can be collaboratively edited and shared online. We evaluate concept mapping in the context of a sophomore-level environmental methods course taught annually at Lewis & Clark College. The course includes a variety of concept mapping exercises designed for students to reflect on their environmental perspectives, synthesize course material, and explore a proposed topic for environmental research. These exercises were evaluated in fall 2010 using self-reports, assessment rubrics, and open-ended student responses. Results showed that higher-achieving students generally found concept mapping more demanding and attained more sophisticated understandings of connections. This suggests that concept mapping helps facilitate the intellectual struggle that characterizes engaged learning; yet in a larger sense, the study illustrates challenges in cultivating new approaches to environment among undergraduate students.

1 Environment as connection

1.1 The environment of ESS

As an interdiscipline, environmental studies and sciences (ESS) gathers a tremendous diversity of contributing fields, ranging from history and philosophy to economics and chemistry to sociology and ecology. What is shared across this broad spectrum is the term “environment.” But what is environment, and how shall practitioners of ESS develop approaches to learning so that their students effectively grasp and communicate this common thread?

In this paper, we approach ESS from the premise of environment as connection, not a category. This approach is more etymologically true to the root of environment as, roughly, that which surrounds (Proctor 2009), and potentially affords fuller and more novel explorations of environmental issues by our students without importing too much baggage associated with concepts of nature. To us, the connections that comprise environment are not so much between some overgeneralized “human” and “nonhuman” or “natural” realms as between all the specific actors— lizards, laws, ocean currents, spiritual movements, structural adjustments—that come into relation in the context of what we have received as environmental issues, whether relatively longstanding (e.g., water pollution, wilderness) or more recent (e.g., endocrine disruption, environmental justice). There is no clear line separating environmental issues from other issues, which our definition of environment affirms; but there is plenty of good work to be done by practitioners of ESS to shed greater scholarly light on the issues we have inherited, primarily by elucidating the connections that matter in tracing issue-related problems and solutions.

1.2 Reframing environmental research

Approaching environment as connection demands new analytical methodologies, as it generally approaches environmental problems and solutions more with a fine-tipped felt pen than a foot-wide paint roller. Gone—if the above critiques of environment are at all valid—are the easy truths of listening to nature, going green, or caring for the earth. There are no *a priori* problems and villains, no *a priori* solutions and heroes. What replaces these shortcuts is educationally rich: a more open-ended focus on connecting the details that matter in a given environmental issue; a valorization of curiosity and careful research; and a sense that there is still much of value to be contributed by the current and future ESS community.

Approaching environment as connection and not just a category of nonhuman stuff also challenges notions of cause and effect fundamental to our understanding of environmental issues. Far too often, the nonhuman realm has been understood as a passive recipient of human injury, thus leading to the curious conclusion (sometimes celebrated in “green” product advertisements) that the ideal human impact is to have none at all.[1] If, however, environmental reality is understood as fundamentally entangled, notions of cause and effect become

[1] See e.g. noimpactproject.org.

more complex and interesting, and environmental solutions encompass change—or resistance to change—in a host of related human and nonhuman actors. Ultimately, ESS research can remind us that though—as Barry Commoner reminded us (1971)—everything is indeed connected to everything else, some connections are more significant, some are better understood, some are more tractable to change…in short, certain connections matter more than others. Discovering, explaining, and elucidating these special connections becomes the value added to contemporary discourse on environmental issues via ESS scholarship.

2 Connecting via concept mapping

2.1 Concept mapping and related approaches

With the advent of web2.0 interactive tools, a host of possibilities arises for ESS instructors interested in helping their students explore environmental connections. Some of these offer web-based simulation: one example is climateinteractive.org, an online climate simulation community serving users ranging from high school to government. Another class of web2.0 social bookmarking tools (e.g., Digg, StumbleUpon, Delicious, Diigo) provides for readily connecting online resources by allowing users to store, aggregate, share, rate, and comment on anything they find online.

A final class of web2.0 interactive tools deserves greater attention, as it very closely resembles concept mapping: this is what is generally known as mind mapping. Mind maps are hierarchical, generally starting with a core idea in the center of the map, then branching in treelike fashion out to subcategories. In this regard, mind maps reproduce a typical text outline structure, and in fact text outlines can be exported for visual display as mind maps. A wide variety of desktop and online mind mapping tools is currently available,[2] some of which allow for online collaboration and presentation. Some (not all) mind mapping tools allow for resources (hyperlinks, documents, notes, etc.) to be added to components, and some (not all) allow for nonhierarchical connections to be drawn between components. For all, however, the user interface is optimized for tree-like hierarchical entry of elements at either a parallel level in the hierarchical structure, or a lower level.

Concept mapping is similar in many ways to the more ubiquitous mind mapping, with one crucial difference: concept maps are not necessarily hierarchical in structure. The difference proves fundamental when one wishes to use these tools to help students explore connections. If ESS were approached as a *multi*discipline, hierarchical mapping may in many ways be sufficient, as each contributing field (and related system, e.g., hydrology or politics or culture) could be viewed as offering its relatively distinct perspective on an environmental issue. Approached as a mind map, an environmental issue would be the core idea, then each contributing field would define a first-level subcategory, with its attendant details under that subcategory. All contributing fields would be related in the context of this environmental issue, but only contingently so: there would be no significant connections outside of this root-level connection to the issue.

In approaching environment as connection, however, hybrids and heterogeneity tend to be the norm, where surprising and persistent entanglements of politics and climate, or culture and charismatic species, or economics and energy, challenge any hope of separating constituent processes. This, to the *inter*disciplinary ESS practitioner, is the reality to be analyzed, with connections that are often more necessary than contingent: the current climate system, or state of charismatic megafauna, or rate of alternative energy development, are necessarily entangled with issues of politics, culture, and economics. These relations are, for the most part, nonhierarchical, as the overall set of interactions is more of a diffuse network than a hierarchy. This is why, no matter what sort of tool or pedagogical approach is employed, care must be taken to allow for nonhierarchical as well as hierarchical relations in mapping out connections in ESS. In a similar vein, Kinchin (2001) argues that appreciation of nonhierarchical connections—what he calls a “net” concept map—generally suggests a more complex student understanding of biological processes than simple hierarchies, which he calls a “spoke” concept map.

Though the above suggests that concept mapping was developed as an alternative to hierarchical mind mapping, the most commonly cited origins of these two approaches suggest otherwise. Mind mapping is generally attributed to the work of educational consultant Tony Buzan dating from the 1970s,[3] whereas concept mapping is attributed to Joseph Novak dating from the same period (Novak and Cañas 2008), and in much of his work Novak recommends building concept maps hierarchically—by which he appears to mean a flow of

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[2] See for instance www.mindmeister.com, www.mindnode.com, www.mindomo.com, www.thinkbuzan.com.
[3] See www.thinkbuzan.com.

ideas from general to specific, though not necessarily a strict tree-like hierarchy as in mind mapping.[4] Yet CmapTools,[5] the concept mapping tool Novak helped develop and the one we have utilized at Lewis & Clark College, can be deployed to build any sort of diagram, so we do not necessarily follow Novak's recommendation, especially in what we call process concept maps below.

As elaborated by Novak and others, concept mapping has strong roots in educational theory and is regularly deployed in classrooms worldwide.[6] Novak originally designed concept mapping as a means of evaluating student achievement in the sciences. He was strongly influenced by the work of psychologist David Ausubel, whose theory of cognitive learning proposes that students do not simply assimilate new information, but rather connect and integrate it into their pre-existing mental structure (Ausubel 1963). Novak aspired for concept mapping to facilitate Ausubel's notion that truly meaningful learning occurs when students are motivated, clearly comprehend root concepts, and find meaning and relevance in the new material. According to this theory, education is not a cognitive, one-directional model of information assimilation, but rather the significance of the student's individual learning experience is critical to the learning process. Says Novak, "The central purpose of education is to empower learners to take charge of their own meaning making…involving thinking, feeling, and acting, and all three of these aspects must be integrated for significant new learning" (Novak 2010, 13). From an assessment perspective, this necessitates scoring concept maps for more than just "correctness," attending to each map's individual morphology (Kinchin 2001)—though others have attempted to create more generalized normative rubrics for "good" concept maps (Moon et al. 2011a).

2.2 Concept mapping and environmental studies at Lewis & Clark

Concept mapping has been applied in a variety of educational and corporate settings, including cases related to ESS such as national parks (O'Brien 2002), grassland management (White 2011), and ecosystem services (Yee et al. 2011). Given the flexibility of the concept mapping approach and its potential relevance to environmental analysis, the Environmental Studies (ENVS) Program at Lewis & Clark College introduced concept mapping into its curriculum as a visual tool to more clearly specify connections in environmental processes. To aid this approach, we have developed online documentation to guide students in use of the technology.[7]

Students use the CmapTools application to develop their concept maps (cmaps). We selected this application as it is freely available for a variety of platforms, well maintained, and easy for our students to learn. In CmapTools, concept maps consist of concepts (boxes or "nouns") and linking propositions (lines or "verbs" defining associations); CmapTools-based concept maps are thus designed not only as visualizations, but as structured textual descriptions of processes. One special CmapTools feature our students utilize involves its ability to associate concepts or propositions with resources such as documents, references, or websites, which are simply dragged onto the cmap; these resources, for instance, can be used to justify, or summarize the state of knowledge on, a connection. Another feature students use involves a CmapTools server, whereby they readily save and edit their cmaps in a cloud environment, providing opportunities for live collaboration. In addition, all cmaps saved on the server are immediately rendered into viewable images for web visualization. thus affords a means of reinforcing an approach to environment as connection, and offers a social learning approach for students to work together and compare their efforts.

When we originally introduced concept mapping into our ENVS Program, we gave students a great deal of latitude in how to use it. Their early forays proved useful toward refining our pedagogical approach, as in many ways this laissez-faire approach promoted as much frustration and muddled thinking as clarity in analysis among students. Two challenges arose in particular: first, students tended toward inclusion of overly broad concepts and propositions, such as identifying "population growth," "climate change," or "capitalism" as key drivers of environmental processes. Concepts or propositions at this level of generality may be helpful for preliminary work, but typically do not afford the more nuanced understandings we seek among our students. Second, students would generally include a large number of concepts and propositions, such that their resultant concept maps complexified rather than clarified environmental processes.

We eventually realized that overly broad concept map elements, and overly complex concept maps, are understandable and useful in early stages of student thinking about an environmental process, yet devised a

[4] The hierarchical nature of Novak-inspired concept maps also seems to be interpreted differently by those who have applied this approach in a variety of practical settings; see Moon et al. (2011b).
[5] See http://cmap.ihmc.us.
[6] As one estimate, the CmapTools server network includes over 150 publicly available servers distributed across the globe; see http://cmapdp.ihmc.us/servlet/HtmlViewServlet?viewhtml.
[7] See http://sge.lclark.edu/social-learning-tools/#Concept_Mapping.

contrasting later-stage approach built on actor-network theory (ANT) to address these limitations. ANT has been well documented elsewhere (e.g., Latour 2007; Law and Hassard 1999): as applied to environmental processes (e.g., Castree 2002), it reinforces a more hybrid and fluid notion of environment as unfolding connections. Actor-networks map readily onto our use of concept maps, and ANT theory addresses the two student challenges noted above, in that actors-networks are ideally specific and concrete, and given the implicit notion underlying actor-networks that some connections matter more than others. These ANT principles have led students to work toward concept maps—and thus understanding and communication of connections in environmental processes—that are clearer and more forceful. Our resultant approach to student concept mapping thus progresses in multiple phases, from relatively rough, general, and complicated initial concept maps to relatively refined, specific, and elegant concept maps including related resources.

We also have realized that concept maps can be applied toward two different sorts of needs. The first concerns clarification of ideas, which we call "perspectives" concept maps. Students create perspectives concept maps, for instance, to clarify ideas presented in a reading, or to draw together material learned in a class. The second concerns clarification of processes occurring in the world, which we call "process" concept maps. Process concept maps are designed in ANT fashion to represent networks of associations between a wide array of biological, technological, legal, and other actors. These initial and refined concept maps, and perspectives and process concept maps, were all implemented in the course we will analyze below.

3 Learning concept mapping at Lewis & Clark College

3.1 What we did

We conducted an evaluation of concept mapping during a semester-long sophomore-level environmental analysis course in fall 2010. The objectives of this course are to equip students with a wide array of methodological approaches for empirical and conceptual analysis of environmental issues, and to apply these tools to the process of doing environmental research, from formulating initial questions to documenting final results. Though students had previously been introduced to concept mapping in our freshman introductory course, this sophomore-level course explores it in much greater detail, and offers feedback to enable improvement in student use of the tool for environmental analysis.

In line with our general approach to teaching concept mapping introduced above, we developed three different types of concept mapping assignments in this course (see Table 1). The first builds on Novak's theory of learning summarized above via what we called a MyTFA assignment. In this assignment, students identified and connected their major thinking, feeling, and acting elements in the context of a chosen environmental issue, then compared their resultant concept maps in terms of areas of emphasis and overall coherence. This MyTFA assignment was repeated at the end of the course, and students compared their two MyTFA concept maps to see how their key thinking, feeling and/or acting elements had evolved over the semester. The second type of assignment was a unit synthesis concept map, designed to help students review, analyze, and make visual connections between topics, terminology, skills, or other material covered in main instructional unit in the course. Students began with an overview unit synthesis map incorporating a wide variety of brainstormed elements, then selected a small subset of elements to relate in a more detailed way. These two assignments illustrate the perspectives concept mapping approach introduced above, as the main objective was to relate ideas.

The third type of concept mapping assignment in our sophomore level environmental analysis course gets to much of the theory about environment and connection introduced above: we called it an ANT cmap, following actor-network theory. Students produced these (process) ANT cmaps in teams assembled around a proposed research topic located in one of six international sites our ENVS Program focuses on as part of its situated research approach.[8] They developed these ANT cmaps in two stages. First, after collecting and perusing resources (publications, organizational websites, data sources, etc.) for their research topics, they developed an initial ANT cmap and added these resources to the concept map. The objectives at this stage were for student teams to begin to visually identify connections as elaborated in the resources they had compiled, and to document these connections via the resources they added to their concept maps. In the second stage, following several weeks of additional focus on their research topics, they revised these initial ANT cmaps with the goal of preserving only the most important concepts, propositions, and related resources. As suggested above, the idea here was for students to use concept mapping to help them focus their research goals relative to the vast array of potentially relevant connections as elaborated in their initial ANT cmaps: as one possibility, they were

[8] See https://sge.lclark.edu/about-the-sge-initiative.

recommended to focus their proposed research on connections that are potentially significant but not yet well documented.

Type of Cmap	Cmap assignment	When conducted	Repetitions
Perspectives	MyTFA	At beginning and conclusion of course	2
Perspectives	Unit synthesis	At the end of each unit	4
Process	ANT	Initial and refined during situated research unit	2

Table 1: Cmapping assignments in ENVS 220

We conducted this study within the general framework of action research, which aims to improve student learning and educational performance through teacher inquiry. Action research aims to release educational research from the confines of academia and make it accessible to practitioners (Mills 2010). Out of a class of 35 total, 23 students elected to participate in an extended evaluation of concept mapping; the rest did the above assignments as well, but did not participate in evaluation activities. Following the action research model, we did not let this relatively small sample prevent us from trying to improve student learning, yet refrained from deploying certain analysis techniques (t-tests, ANOVA, factor analysis, etc.) that we would typically use in a formal assessment.

For these participating students, we conducted a pre-assessment including an entry quiz, a background interview, and compilation of past grades in environmental studies courses. From these data, we created an individual and collective baseline by which to evaluate student achievement in the course overall, and in their concept mapping skills.

All concept maps created by participants in our evaluation were assessed using a rubric examining concept map qualities as suggested above (e.g., level of specificity in named concepts and propositions), and feedback was given through online discussion forums and in class. After each concept mapping exercise, participants completed a self-assessment questionnaire which measured their impression of the mapping assignment, including its perceived technical and intellectual difficulty and learning value. At the completion of the course, concept map scores and self-assessments were analyzed longitudinally to determine whether there was overall improvement, whether changes occurred in attitudes toward the concept mapping process, and whether certain exercises proved more beneficial than others. The concept mapping exercises as well were evaluated via the rubric and self-assessment questionnaires. Self-assessment questionnaires were analyzed using descriptive statistics. Students were also assessed as to their overall achievement in the course, as measured through success on their final project (which included an ANT cmap), and their final grade.

3.2 What we learned

At the conclusion of the project, we analyzed our data, both qualitative and quantitative, to better understand the degree to which concept mapping facilitated student understanding of environment-as-connection. First, we assessed whether confounding variables were impacting the ability of students to engage with concept mapping as a learning tool. Students generally reported being comfortable with technical aspects of the concept mapping process, had sufficient time to complete assignments, and felt that assignment instructions were sufficiently clear; thus, these issues did not appear to skew our analysis.

Based on student self-reports, some positive effects of concept mapping emerged: concept mapping helped students "better understand the significance of actors and their relationships" and "better understand actor-network theory" (text in quotes from evaluation instrument), both critical in ameliorating broad, unwieldy cmaps and fuzzy articulation of environmental connections. Said one student, "This [ANT] cmap was very helpful in organizing all the different actors that were a part of this issue and what connections we need to focus on to address the influence of safaris in the Serengeti." Students reflected on the increased sophistication with which they grappled with environmental problems when revising their MyTFA cmaps. Said another student, "In my new cmap, I do not explicitly say that complete removal of oneself from the conventional agricultural system is an option. It may be possible, but in this class I have learned that there are many complex interactions going on at many different scales, and that elements of a system are so strongly interconnected that completely changing the system could be impossible." In general, most students reported that concept mapping improved their nonhierarchical thinking skills and increased their appreciation of environmentally significant actors as enmeshed in networks of relationships.

Student reports also indicated that concept mapping proved useful as a project design and research planning tool. As part of their collaboration process, it helped "clarify areas that need[ed] further research," "organize [my] ideas," "recognize gaps in [my] understanding," and "pare down or expand" their topic into one with an appropriately focused scope. Said one student, "Overall, this type of concept mapping is a good idea and has helped my group layout the specifics of our research question, along with determining what areas of research need more information and what areas we could focus on for collecting data." Interestingly, however, students did not report that the process helped much with explaining the environmental issue to others or clarifying possible solutions, pointing to a perceived limit to the usefulness of concept mapping in communication or policy contexts.

The above results suggest that concept mapping was not overly challenging technically, and proved helpful in attaining certain key learning objectives. Yet additional results indicate that some students struggled with reducing the scope and increasing the clarity of their cmaps. Despite the relative ease with which they took to the mechanics of concept mapping, they reported that the "intellectual material addressed" and "assembling the material into a concept map" were the most challenging parts of the concept mapping process. Said one student, "It was difficult to connect the frameworks [broad philosophical positions related to environment] to the theories [more specific explanatory notions for environmental problems] since the frameworks tend to deal with two ways of looking at one issue. While I was able to find connections, it was difficult to find the words to explain how they connected with arrows." However, not all students perceived this as negative: as one student stated, "I found it challenging to link class concepts and theories/frameworks with this particular set of tools. This was a good challenge, though, as it made me put statistics into context and think about how we use them." To the students, the challenges posed by the mechanics of concept mapping paled in comparison to the challenge of specifying, clarifying, and elucidating the relationships being mapped.

Most educational interventions aim to improve student comprehension and achievement. In this context, the sequence might go as such: students who create better concept maps would have a higher level of mastery over the material and subsequently achieve a higher course grade. However, based on the relationship between concept map quality (as scored via our rubric) and students' final grades, we surprisingly did not find evidence for this progression. While we did not find across-the-board grade improvement, we found that level of engagement moderated the benefit of using of cmaps. We deduced this via two proxies. First, certain students found the concept mapping process significantly more challenging than others, but these were not the low-achieving students. Rather, the students whose final course grades were *highest* reported being the most challenged by "the intellectual material [they] addressed" and "assembling that material into a concept map" ($r(21) = 0.44$ $p<0.05$ and $r(21) = 0.61$ $p<.01$). Second, students who completed more required assessments than others found the concept mapping process more useful in general ($r(21)= 0.45$, $p<0.05$). Apparently, those who were more invested in the course were more likely to follow instructions, thereby achieving more by reflecting on the cmapping process more systematically.

We thus found that concept mapping did not engender individual student improvement universally but rather benefitted the students who were engaged in the learning process. Our research showed that the end product—the actual *concept map*—was not the critical outcome, but instead the struggle that generated that map. This is consistent with the constructivist philosophy from which concept mapping emerged (Kinchin 2001). The degree to which students took the concept mapping process seriously may have differentiated them into high and low achieving groups. This indicates that students with an increased level of buy-in and are willing to engage with the nuance and hybridity of connections reap the rewards. It appears that intellectual struggle, and the subsequent reflection on that struggle, is what increased student achievement.

One possible alternative explanation for this differing level of engagement in concept mapping could invoke the literature on learning styles, based on the intuitive assumption that so-called "visual learners" may preferentially engage in visually-based activities such as concept mapping. One of the most widely used instruments is the VARK (visual, auditory, reading/writing, kinesthetic) learning styles survey (Fleming and Mills 1992). Despite critique (e.g., Cain and Dweck 1989; Dunn 1993; Hargreaves 2004), it has penetrated mainstream consciousness. A background survey we did using Fleming's 2010 VARK 7.0 instrument,[9] however, does not corroborate this intuition. In fact, we found that visual learners found concept mapping less useful overall ($r(21)= -0.434$, $p<0.05$), and were more challenged by the procedural aspects of concept mapping assignments, finding the instructions unclear ($r(21)= 0.434$, $p<0.05$) and feeling they lacked the time to complete the assignments ($r(21)= 0.455$, $p<0.05$). Visual learners were also less successful in the course overall: of the 25% of students who had the worst grades in the course, 33% identified as visual learners. Conversely,

[9] Taken from www.vark-learn.com/documents/The%20VARK%20Questionnaire.pdf.

none of the students who achieved the highest course grades identified as visual learners. We thus do not believe that learning style, at least as theorized in this manner, was the reason underlying differing levels of engagement with concept mapping.

Given the lack of across-the-board longitudinal student improvement in our assessment, it's worth contextualizing concept mapping within educational innovation generally. If adding an e-tool or teaching technique to a course unfailingly improved individual student grades, educational improvement would be simple. We must be cautious not to make technological innovations our beasts of burden, saddled with rectifying the messy complexity of learning and problem solving with, quite literally, the click of a button. Given the complexity of variables potentially influencing student achievement, it is not surprising that our rising tide of concept mapping did not lift all boats. Additionally, there are inherently confounding variables in a classroom research setting, not all of which we addressed: for instance, we lacked a control group and the final cmap assignment was done as a team. Further research could isolate and rectify these relatively simple issues. Even in terms of our significant findings, correlation is not causation. Are higher achieving students more likely *a priori* to go beyond the deceptive simplicity of concept mapping, and recognize the delicate hand needed to treat environment as connection? Are higher achieving students more likely to complete all class assignments, bear the fruit of those assignments, and gain the means to do better in the course? It may simply be that students who are high achieving engaged more fully with what the course asked of them, and were subsequently rewarded by their engagement. Should this be the case, a valid concern could be that educational innovations such as concept mapping may further stratify high achievers from low achievers, widening the gap between students who thrive with increasingly challenging demands and those who do not.

4 Next steps, better practices

4.1 Better concept mapping, better connecting

Our implementation of concept mapping at Lewis & Clark College suggests possibilities and guidelines for use in ESS instruction. For instance, both perspectives (e.g., MyTFA or unit synthesis) and process (e.g., ANT) cmaps can readily be applied to a wide range of existing ESS courses and topics. Additionally, having students do concept map exercises in stages (e.g., by comparing a MyTFA map at the beginning and end of the semester, or by incrementally reducing the number of key actors in an ANT cmap) helps students better appreciate the tool. Finally, given the flexibility of the CmapTools application, ESS instructors could apply it to a wide range of desired learning outcomes, as we have by using actor-network theory to inform a more specific representation of environmental connections.

In our experience, certain principles have worked better than others. We have found that committing fully to the approach has allowed us to integrate the exercises into our curriculum more authentically. By differentiating concept mapping into lesson-specific exercises, we avoided tacking concept mapping exercises on to pre-existing lessons, thereby diminishing their impact. Yet our efforts to encourage relatively simple, elegant cmaps have clashed with the desire among (mainly high-achieving) students to comprehensively map connections. This tension may be a good one, given the need in environmental studies to identify answers in a messy, interconnected world.

Ultimately, no matter how much effort is devoted to designing high-quality concept mapping exercises for students to discover and communicate environmental connections, more fundamental issues may hamper even the best efforts, as the effectiveness of concept mapping seems contingent on student motivation. While there is no simple recipe for increasing student engagement, awareness of the fundamental importance of student interest can assist instructors in designing appropriate classroom activities.

4.2 Challenges inherent in reframing environment

Our empirical results speak as well to a larger challenge found in and outside of the classroom. Approaching environment as connection requires new ways of thinking and analyzing in ESS, and some ESS scholars—including our students—will be more willing to do the novel work following from this approach than others. We found that concept mapping may serve, unintentionally, as a differentiator between more and less motivated students, between those who worked hard to appreciate, analyze, and communicate environmental connections via concept mapping and those who were less convinced of the purpose of concept mapping. For all the scholarly justification behind this approach, many students come to ESS looking for the more familiar approach of environment-as-nature. The importance of finding ways to motivate these students was suggested above, but the larger challenge may fall on the ESS community of scholars to offer compelling models to our students of appreciating, and analyzing, the heterogeneous web of connections that matter. We may best serve our students by taking to heart the insights revealed by approaches such as environment-as-connection and tools such as concept mapping, even if they lead our ESS field in new and uncharted directions.

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CONCEPT MAPPING AND TEXT WRITING AS LEARNING TOOLS IN PROBLEM-ORIENTED LEARNING

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Abstract. In two studies we investigated whether concept mapping or summary writing better support students while learning from authentic problems in the field of business. We interpret concept mapping and summary writing as elaboration tools aiming at helping students to understand new information, and to integrate it with prior knowledge. We hypothesize concept mapping to be superior to summary writing. Both studies had a pre-test and post-test design with two experimental groups (concept mapping and summary writing). In the first study, 26 students of a commercial high school (pre-university level) in their next to last year took part. In the second study 30 students aged 16-18 years from the pre-final year of pre-university education participated. Contrary to our expectations, in both studies the groups did not differ significantly in pre-test and post-test scores. However, the concept mapping condition seems to better support meaningful argumentation and elaboration of information.

1 Introduction

Students should be supported in acquiring complex knowledge in order to adequately understand and cope with complex problems, both in school and in daily life. While solving problems, students learn domain concepts, the discourse of the domain, and problem solving itself (Kneppers, 2007; Kneppers, Elshout-Mohr, Van Hout-Wolters, & Van Boxtel, 2007). However, in schools, learning almost exclusively takes place on an abstract level. In addition, students are often not encouraged or motivated to learn actively. Consequently, often rote learning instead of meaningful learning takes place (Novak & Cañas, 2008) and the application of concepts in daily life or in the workplace, and contextual reasoning will be difficult.

Against this background, authentic problems should be integral part of instruction. However, learning from authentic problems often leads to deficient results. Students have difficulty understanding main ideas and complex interrelationships of relevant topics. They are not able to develop a structured knowledge base. To avoid the obstacles mentioned, problem-oriented learning can be supported by using learning strategies, such as organization and elaboration strategies (Weinstein & Mayer, 1986). Organization helps structuring the contents to be learned. Elaborations go beyond the original problems because they are constructed by the learner independently. In the course of organization and elaboration, the learner activates his/her prior knowledge and combines it with given information. Thus, a rich knowledge base is generated which may result in better memory and better understanding of the learning material (Reder, 1980). Concept mapping and summary writing can be regarded as organization and elaboration tools.

Concept maps are two-dimensional structural representations of a topic consisting of nodes and labeled lines between the nodes. The nodes represent important concepts; the lines are relations between the concepts. The combination of two nodes and a labeled line in between is called a proposition. A proposition is a basic semantic unit which can be assessed true or false (Ruiz-Primo & Shavelson, 1996). In the process of concept mapping students translate information or knowledge into a visual format which displays the main ideas and their interrelations. As a prerequisite, students have to recognize the important concepts and decide about their interrelationships. Thus, concept maps help structure knowledge and information und by that aid meaningful learning (Novak & Cañas, 2008). This is an active and reflective process which leads to elaboration (Beyerbach & Smith, 1990).

Similar to concept maps, summaries have the function of consolidating information in a macrostructure (van Dijk, 1980). In the process of summary writing, students have to both select important and to omit irrelevant concepts, and they have to construct sentences which do not or not identically exist in the text (Christmann & Groeben, 1996). Thus, summary writing and concept mapping are active and reflective processes. The most important difference between the two strategies is the format. While concept maps represent information in a structured graphic, summaries represent information in a linear order. Concept maps are assumed to be advantageous for displaying all relations between concepts in an unequivocal manner. In contrast, summaries contain the relations between the main concepts in several sentences, and the universe of interrelationships as well as potential hierarchies might not be as clear as in the graphic (Nesbit & Adesope, 2006). The decisions about the information structure do not necessarily have to be as precise as in the concept map. Furthermore, the advantage of concept maps may be explained by the fact that the diagram format corresponds with the notion of knowledge as a semantic network (Dansereau et al., 1979). Thus, the similarity of knowledge and concept maps (as learning media/learning strategy) may support students in externalizing their cognitive structure and in using concept maps as learning aids.

In a couple of studies concept mapping proves to be an effective learning-from-text strategy. Amer (1994), for example, shows that both, translating a scientific text into a knowledge map and underlining important information in a scientific text is superior to just reading a text. However, no significant differences could be found between concept mapping and underlining. Further more, Nesbit and Adesope (2006) report in their meta-analysis that concept mapping only has a small advantage compared to other construction tasks like note taking or summary writing. Against this background the aim of our research is to investigate whether concept mapping or summary writing is more effective for promoting students' learning from authentic problems in the field of business. For that purpose, we conducted two studies using the same material, one focusing on individual concept mapping and one focusing on concept mapping of pairs.

2 Study 1: Concept Mapping vs. Summary Writing as Learning Tools in Problem-Oriented Learning of Individuals

2.1 Research Question and Hypothesis

Research Question: Does concept mapping lead to better learning results than summary writing while learning from authentic problem-oriented texts?

Hypothesis*:* Concept mapping is superior to summary writing.

2.2 Learning Material

We developed an authentic case (see Fig. 1) which should support students in learning different forms of financing. In addition, we provided the students with learning material consisting of data about the case and information necessary for solving the problem.

Taxi firm *Speedy Rite* is a one-mans' business. The owner, Mister Simons, is also the manager. The firm possesses 6 cabs. All cabs are from trademark Cicerro. Two of the cabs are 6 years old, two 4 years and two 2 years old. The economic working life of the cabs is 6 years, so two of the cabs have to be replaced. Until now Simons has bought all new cars by a bank loan. He is wondering, however, if it is wise to continue that habit now during the financial crisis. Besides, he is asking himself if the bank is willing to give him a loan again. Simons considers if he is better off leasing the cabs. But, unfortunately, he is not capable of deciding about which form of financing will best meet his needs. And, he does not understand the meaning of the two different forms of leasing – financial and operational – and the consequences they will have for his business.
Therefore, he is asking you for help. Figure out what is best for Simons: buying the cabs with a bank loan or leasing the cabs: financial or operational. The advice you will give Simons has to be reported in a clear manner.

Figure 1: Authentic Case

2.3 Method

2.3.1 Participants and intervention

A total of 26 students of a commercial high school (pre-university level) in their next to last year took part in the study during the school year 2010/2011. They were 18.4 years old on average. All students had prior knowledge about management but not about forms of financing. The students were randomly assigned to a control group or to one of two experimental groups, i.e. either concept mapping or summary writing. The students of the control group just studied the learning material and had to find a solution for the problem (see Fig. 1). They did not accomplish an additional learning strategy. The students of the two experimental groups had to work through the learning material and in addition construct a concept map (using paper & pencil) or write a summary on the relevant information. All groups spent the same time on task. As an aid every student of the experimental groups received a list of concepts. In addition, the students of the concept mapping groups received a list of relations. The concepts and relations were gained in a pre-study with a comparable group of students. The summary writing group was introduced to a summary writing technique PQ4R (Preview, Questions, Read, Reflect, Recite, and Review) (Thomas & Robinson, 1972). Four days before starting the study, we put the respective strategy across to the students by means of familiar topics.

2.3.2 Data Gathering

Before and after the treatment the students took a knowledge test consisting of tasks in short answer or essay format. Questions in multiple-choice format were not included. The pre-test consisted of 8 questions aimed at assessing the basic economic knowledge necessary to understand the task and to integrate information with prior knowledge. The students could reach 44 points at most. Cronbach's α was 0.62. The post-test consisted of 9 questions aiming at assessing retention and transfer of the specific information to be learned from the material, that is to say the forms of financing (see Fig. 1). The highest point score is 31. Cronbach's α was 0.61. In addition, we collected both the summaries and the concept maps in order to gather data about the quality of the learning process.

2.3.3 Data Analysis

The students' answers were analyzed using a qualitative content analysis procedure. This is a systematic, replicable technique for assigning words or phrases of a text to content categories based on explicit rules of coding. On the basis of the qualitative content analysis a test score was calculated for each student. To determine whether the differences in knowledge could be explained by prior knowledge or by the respective learning strategy (concept mapping or summary writing), Analyses of Covariance (ANCOVA) (controlled by pre-test score or controlled by the quality of concept maps/summaries) were carried out with post-test scores as dependent variable. In addition, we calculated Analyses of Variance (ANOVA) in order to control differences in pre-test and post-test knowledge between the groups and in order to control differences in quality of summaries and concept maps between the groups. In addition, we calculated correlations (Pearson) of pre-test scores, post-test scores, and quality.

To assess the quality of the summaries, we constructed an expert's summary based on the respective curriculum and textbook. The expert's summary represents the learning objective. We, then, divided the summary into 50 units of meaning, such as "leasing instalment depends on contract period" or "debtor has to have securities". The same procedure was applied to the students' summaries. We divided every summary into units of meaning. In case the student's unit of meaning matches the expert's unit of meaning we coded a "1", otherwise a "0". Consequently, the score of a student's summary could range between 0 and 50 points. In the same manner as for the summaries, we constructed an expert's concept map which consisted of 35 propositions. In order to determine the quality of the individual maps, we calculated the percentage of accordance between individual concept map and expert's concept map based on the propositions as unit of analysis. In case the student's proposition matches the expert's proposition we coded a "1", otherwise a "0". Consequently, the score of a student's concept map could range between 0 and 35 points. The higher the score, the closer the summary or the concept map comes to the learning objective.

2.4 Results

In terms of test scores, the concept mapping group had lowest prior knowledge (18 points), the control group scored second best in the pre-test (19.6 points), the summary group had the highest prior knowledge (20.9 points) (see table 1). In the post-test, the summary group scored best (17.6 points), followed by the concept mapping group (16.9 points) and finally by the control group (13.4 points). At large, the summary group outperformed the two other groups, but the difference between the summary group and the concept mapping group was smaller in the post-test than in the pre-test whereas the difference between summary group and control group increased from pre- to post-test. Based on the percentages, the concept mapping group had the highest increase in knowledge (see Tab. 1).

The ANCOVA (controlled by pre-test scores) showed that the groups did not differ significantly in their post-test scores ($F(2,22) = 2.392$; $p = .115$, $\eta^2 = .179$), but that the pre-test scores significantly influence the post-test scores ($F(1,23) = 11.579$; $p = .003$, $\eta^2 = .345$). Thus, the results in the post-test can be partly explained by the prior knowledge of the students, and not by the assignment to one of the experimental or the control group. Additional ANOVAs support the fact that the 3 groups did not differ significantly in pre-test scores ($F(2,23) = .460$; $p = .637$, $\eta^2 = .038$) or in post-test scores ($F(2,23) = 1.581$; $p = .227$, $\eta^2 = .121$).

The quality of the summaries is much better than the quality of the concept maps (see table 1). An ANOVA proved that the groups significantly differ in quality of maps and summaries ($F(1,19) = 19.256$; $p = .000$, $\eta^2 = .503$). The ANCOVA (controlled by quality of summaries/concept maps) showed a significant main factor group ($F(1,17) = 4.579$; $p = .047$, $\eta^2 = .212$), a not significant main factor quality ($F(1,17) = 1.624$; $p = .22$, $\eta^2 = .087$), and a significant interaction factor group*quality ($F(1,17) = 7.945$; $p = .012$, $\eta^2 = .319$). Because of the significant interaction effect it was not possible to calculate a saturated model. The complementary correlation analysis reveals that the quality of the maps correlates significantly and positively both with pretest-scores (r = .619, p = .032) and with post-test scores (r = .646, p = .023) whereas the quality of the summaries correlates negatively and not significantly with both pre-test (r = -.659, p = .054) and post-test scores (r = -.562, p = .115). This means that high pre-test scores go along with high quality of concept maps and high quality of concept maps with high post test scores and vice versa. In contrast, high pre-test scores go along with low quality of summaries, and low qualities of summaries go along with high quality of post-test scores.

	Cmap (N=12)		Summary (N=9)		Control (N=5)	
	Mean (in % of max. score)	(SD)	Mean (in % of max. score)	(SD)	Mean (in % of max. score)	(SD)
Pre-test	18 (40.9)	(8.5)	20.9 (47.5)	(4.5)	19.6 (44.5)	(4.9)
Post-test	16.9 (54.5)	(5.5)	17.6 (56.8)	(2.2)	13.4 (43.2)	(4.2)
Quality of Maps/Summaries (accordance with expert's version)	25.04%	14.2%	52%	13.45%		

Table 1: Results of Pre- and Post-Test: Means and (Standard Deviations); Quality of Maps and Summaries

3 Study 2: Concept Mapping vs. Summary Writing as Learning Tools in Problem-Oriented Learning of Teams

3.1 Introduction

This study differs in some way from the first study. The first study was comparing text writing and concept mapping for individual learning. However, many studies stated that collaboration is effective for learning. Chi (2004) and Roychoudhury (1993, 1994) conclude that concept mapping in collaboration can lead to effective discussions about concepts. That supports learning. Roth and Roychoudhury (1992) are seeing collaborative concept mapping as an activity that contributes to the development of the discursive practice. Concept mapping serves to force students to communicate in a scientific manner. Students become, as they call it, *members of a community of knowledge and practice.* They learn strategies to negotiate in the domain language and other usual communication forms in the domain. This type of interaction is described in literature as *explorative talk* (Mercer & Wegerif, 1999) and *construction and reconstruction* (Dekker & Elshout-Mohr, 1998). In a qualitative research study we wanted to find out if concept mapping results in more meaningful learning and better problem solving than summary writing.

Research Question:

Does concept mapping lead to better learning results than summary writing while learning from authentic problem-oriented texts? Can we explain the difference between the two conditions by a different learning process?

Hypothesis:

We expect that concept mapping as a tool for problem solving produces a more meaningful learning process than summary writing.

3.2 Method

3.2.1 Evaluation

In the second study we performed a qualitative experiment with two experimental conditions: the concept mapping condition and the writing condition. Students were working in pairs. They were randomly assigned to the two conditions. Pairs were formed by use of the 'middle group-method' (Pijls, Dekker, & Van Hout-Wolters, 2003). First the students were divided into four groups: high, high/middle, low/middle and low grade point averages, consecutively. Then, students from the group with the high grade points averages were teamed up with students from the high/middle group and students from the group with the lowest grade point averages were teamed up with students from the low/middle group. This method resulted in pairs that were heterogeneous but not extremely so.

Two pre-tests were administered to check whether or not the groups differ in prior knowledge. One measured the verbal ability of the students and one measured prior knowledge as precondition for the tasks. The post-test – that was different from the pre-task - measured what the students learned from the task.

3.2.2 Participants and instruction

Thirty students 16-18 years old from the pre-final year of pre-university education participated in the study. They were following a three years course - called *Management and Organization* beside other economic and general education. The students were in their second year. The subject chosen for the experiment – a loan from the bank for investment and leasing - had not been taught before. All students were experienced with word processing. The CmapTools program used in the experiment was trained in two lessons before.

The instructions and the tests were part of the regular schedule at school. The research period covered five lessons: in the first lesson we assigned a verbal ability test and the pre-test to the students. The instruction followed in the second, third and fourth lesson. In the fifth lesson the students took a post-test.

3.2.3 The Learning Material

We developed the context case (see Fig. 1) for both conditions. Problem solving requires not only domain knowledge but also problem solving strategies. Because we cannot expect the students to be capable of problem solving in this phase of their study, we structured the problem according to the sub processes of Jonassen (1997).

In the first lesson students in the concept mapping condition were asked to construct a concept map guided by the following questions: 1. What do you know already about the different financial resources? 2. Show in the concept map what you have to know about the taxi firm to be able to give an advice. 3. Report in the concept map what you want to learn about this subject.

The students should use all related concepts they know and they had to define the relations between them. First they had to do that individually with paper and Post-its^{TM}. After that they had to compare their work in pairs. Then, they got information about the topic and specifications about the taxi firm's business and had to construct one concept map together on the computer. They must reach consensus about the map. Consequently, they had to discuss. The writing condition had the same task, but they were asked to write a summary instead of making a concept map. Their learning material consisted of information about bank loan, financial lease, operational lease, a balance sheet and a profit-and-loss account balance of the firm. In the second lesson students were asked to write down the priorities of the firm for financing new cabs and based on that to make comparisons between the financial resources. Their writings served as a help for that. In the third lesson students had to write the advice for the taxi firm.

3.2.4 Tests

A verbal ability test was performed by the students, which measures the students' ability to identify synonyms and interrelationships between words. The pre-test consisted of 14 questions. Possible minimum and maximum scores were 0 and 24, consecutively. Cronbach's α was 0.72.

The post-test consisted of 14 questions. An example for the questions is as follows: "What does it mean for a firm when a financial resource has influence on the solvability?" Possible minimum and maximum were 0 and 31, consecutively. Cronbach's α was 0.71.

3.2.5 Coding

To analyze the *concept maps* of the students, we decided to use the CmapTools *(website: cmap.ihmc.us)* to pull out all propositions provided by the program for each concept map. Propositions have two key components, "concepts" and "linking words" (also referred to as "linking phrases"). The linking words are consecutively used to join two or more concepts there by forming propositions. We coded the concept maps on two categories, i. e. size and quality (Cañas, Bunch, & Reiska, 2010). Size describes how many propositions are in a concept map. More propositions given by students can mean more knowledge. We counted the complete propositions: consisting of two concepts and their relation. In some concept maps the students had not written the linking phrases between the two concepts, but they were included in the second concept. In these cases we adjusted the relationship. The quality of the concept maps is measured by rating the correctness of the propositions: 0 pts – The content displayed in the proposition is wrong, 1 pts – The proposition displays the main idea, but the wording used or the relation lacks correctness, 2 pts – The content, the relation and wording of the proposition are correctly used and displayed. In the end a total of valid propositions per concept map and a total of gained points were calculated in order to compare the concept maps.

We coded the *texts* of the writing condition in the following way: We aimed at creating a rating system comparable with the one of the concept maps. We looked for propositions in the text. We used a color coding scheme to identify the three different forms of financing (financial lease, operational lease and bank loan). Each rater applied this coding scheme separately to the texts. Afterwards, all texts were compared with each other in order to evaluate the content and validity. We counted the propositions and we rated them in the same way as we did with the concept maps.

We coded the *advices* students wrote for the taxi firm by counting the arguments they used. Double arguments we only counted one time. After that we assessed the used arguments, just (1 point) or not just (0 points)

3.2.6 Analyzing the observations

We have read and discussed the protocols of the work of the student pairs in the concept-map condition and the text condition. We decided to focus on the part of the protocols where the pairs had to compare their findings, got new information and had to make a concept map or text together. It was during this activity that the discussions in both conditions were very vivid in the sense that the key economical concepts were most intensely discussed. Yet we were curious if there was a difference in the quality of the discussions between the concept-map and the text condition. For that purpose we selected fragments in which a good insight or a wrong insight into the key concepts was shown. We analyzed these fragments with the codes based on the Process Model for Interaction and Insightful Learning, developed by Dekker and Elshout-Mohr (1998). In the Process Model key activities are discerned: to tell or *show* one's work, to *explain* one's work, to *justify* one's work and to *reconstruct* one's work. These key activities are crucial for insightful learning. Students can regulate the performance of these key activities by *asking* each other *to show* one's work, *asking to explain* one's work and *criticizing* one's work. We coded the presence of key and regulating activities in the fragments. To clarify this procedure we give an example of a short fragment of a discussion of a pair in the concept-map condition, Mat and Jim:

Mat: Well, for a company it is clear, because you have a fixed amount each month that will be paid for the price per mile.
Jim: But you don't know how many miles you will drive.
Mat: Yes, but here it says 'operational lease will take care that the constant price per mile will be guaranteed, because a fixed amount per month will be paid for the cars'.
Jim: OK, the other lease … a kind of rent buy. Economical risk is here with the taxi company.
Mat: Yes, that is a big difference. He is economic owner but actually not legal owner… He does not finance the car, but it is on his balance.

The insight is revealed in the last phrase of Mat where he *justifies* his solution. But it was triggered by the fact that he first *showed* his thinking and *explains* it and that Jim in reaction to that gives a specified *criticism*.

3.3 *Results*

The results on the pre-test showed that the two experimental groups did not differ in the beginning of the experiment. The t-test showed that the difference was not significant: $t = 1.14$, $df = 25$, $p = 0.265$. There was also no significant difference between the conditions in the post-test: $t = 0.637$, $df = 25$, $p = 0.53$. That means that the concept mapping condition is as good as the writing condition (see Tab. 2).

	Pre-test			Post-test		
	N	Mean	Std.-Dev.	N	Mean	Std.-Dev.
Concept mapping condition	14	10.68	4.29	14	9.68	3.68
Writing condition	13	8.84	4.04	13	8.75	5.23

Table 2: Results of Pre-Test and Post-Test

The advice to the firm that the pairs had to write had a remarkable result. In the figure 2 we see that there is not much difference between the two conditions concerning the amount of arguments (75-72), but the value of the arguments is much higher (52) in the concept condition compared to the writing condition (38).

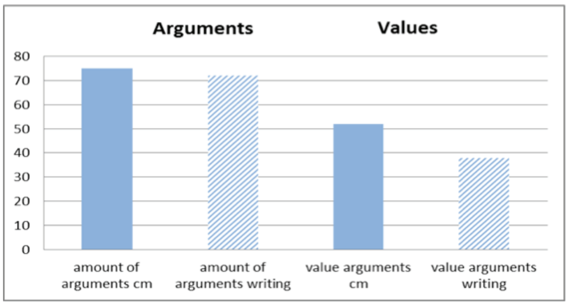

Figure 2: Amount and Value of Arguments

Concept mapping seems to be a good tool to stimulate the arguing between the students about the problem, so they are better prepared to give an advice. In the concept-map condition we found 52 fragments in which the students expressed a good insight of the key concepts and 13 fragments in which students expressed a wrong insight. In the text condition we found 39 fragments in which the students expressed a good insight and 29 in which the students expressed a wrong insight. So in the concept-map condition 80% of the fragments were positive, and in the text condition 57%. That is clearly a quality difference in favor of the concept-map condition.

Analyzing the fragments with the coding for the key activities revealed that in the concept-map condition 47% of all the key activities are explaining and justifying. In the text condition that is 28%. So the reasoning is much more evident in the concept-map condition than in the text condition.

4 Discussion

The learning strategies concept mapping and summary writing support the students' in problem-oriented learning. The groups using a strategy outperformed the control group using no additional strategy. Though the control group is very small in the first study and consequently not representative, the result is consistent with other studies according to which active involvement in knowledge construction, e.g. by the learning strategies such as concept mapping or summary writing, fosters learning. In addition, the results underline the meaning of learning strategies or learning tools.

However, the initial hypothesis in both studies has to be rejected. In both studies, the experimental groups did not differ significantly, neither in pre-test scores nor in post-test scores. Nevertheless, concept mapping seems to better stimulate both pair-arguing and individual reasoning about a topic. In the second study, the value of arguments in the concept mapping group is much better than the value of arguments in the experimental group. In the first study, though the quality of summaries is significantly better than the quality of maps, the concept mapping group gained ground in terms of test scores. In the post-test the concept mapping group is second best and there is no big difference between the summary group and the concept mapping group. In addition, the correlation analysis shows that the quality of the maps positively correlates with the test scores. The opposite is true for the summary group. Interestingly, high prior knowledge correlates with a low summary quality and high summary quality correlates with low post-test scores. We attribute these results to the fact that the specific summary writing technique (PQ4R) used in the first study may have misled the students to write off sentences from the original material without deep reasoning about the contents. Thus, the cognitive activity is reduced to the selection of sentences, not to knowledge construction. The more sentences they select, the higher the correspondence with the expert's solution and the higher the quality score. For a high quality score hints to not thinking about the contents it is no longer surprising that a high quality score corresponds with a low post-test score. In our case, a low quality of summaries presumably indicates a more critical selection process of information and thus more reasoning. In contrast to summary writing, the concept mapping condition forced reasoning at any rate, be it that the students had to transform text into maps and/or to negotiate with others. Thus, for learning and instruction we are in favour of concept mapping independent of the individual or pair condition. Admittedly, the post-test scores can be mainly explained by prior knowledge.

The fact that the experimental groups did not differ significantly and that the positive effects of concept mapping did not fully work through may be attributed to the comparatively new format for knowledge explication which is required by concept mapping. The students may not be familiar enough with the technique so that they cannot apply it confidently. Instead, the students may much more be used to summary writing. Thus concept mapping is more time consuming and causes more extraneous cognitive load (Sweller, 1988) compared to summary writing. Continuous training in concept mapping previous to the study might have led to other results.

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CONCEPT MAPPING AND VEE HEURISTICS: A MODEL OF TEACHING AND LEARNING IN HIGHER EDUCATION

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Abstract. This paper will present a model of teaching and learning in Higher Education through the integrated use of Vee Heuristics and Concept Mapping. This research will suggest that when using Concept Maps, Vee Heuristics and an awareness of how students prefer to learn, learners will go through a metacognitive learning process which will eventually lead to meaningful learning. Using the productions of University students, this study traces the effect of a learner's mental operations on the learner's use of Vee Heuristics and Concept Mapping as the learner embeds and retrieves new and scaffolded knowledge. The data collected reveals the powerful effect which this combination of learning tools yielded on student achievement and transformation.

1 Introduction

We are living in a world which is changing relentlessly at a breathtaking rate. In order to address these rapid changes, Malta is at the moment going through a wide-ranging reform in education. It is calling for a paradigm shift from a situation where teachers are disseminators of information and students are passive recipients to a scenario where teachers facilitate and empower students to become active lifelong learners by equipping them with the necessary tools to embark upon a meta-learning journey leading to success. We are, however, facing a huge dilemma; a dilemma mirrored in Fullan (1993:3) *"On the one hand, schools are expected to engage in continuous renewal, and change expectations are constantly swirling around them. On the other hand, the way teachers are trained, the way schools are organised, the way the educational hierarchy operates, and the way political decision makers treat educators results in a system that is more likely to retain the status quo."*

Prevalent literature (Moon 2010, Fullan 1993) suggests that one way of bringing change within an educational system is through teacher education. According to UNESCO *"teacher education institutions serve as key change agents in transforming education and society."* Nonetheless, having pursued the Bachelor of Education course besides recently mentoring student teachers during their teaching practice, I have observed that often, after a four year course at University, student teachers end up teaching the way they were taught therefore reproducing the status quo in our educational system. This situation is apparently not novel or unique to Malta (Hartman, 2001). One of the reasons for this perpetuation may be because student teachers are adopting ineffective and inappropriate learning practices during their training and *"thus, existing misconceptions about learning are perpetuated through automatic adoption"* (Gamache 2002:279). Another reason could be that teachers are not aware of developments in pedagogical tools which now vary from those they encountered while they themselves were being taught and educators need the tools to engage in change productivity (Fullan, 1993). However, if the 'new' teachers are not going through a change themselves how shall this change be brought about in our educational system? If four years of Higher Education are not producing reflective and innovative teachers, how can we expect teachers to change their vision towards teaching and learning? How can we expect the change many stake holders are calling for in our educational system to take place? If educators are to be agents for meaningful change, then this must be initiated in initial teacher education (Senge, 1990).

This study will investigate and present a model of the integrated use of Concept Maps and Vee Heuristics, paired with an awareness of the students' own learning processes, in teaching and learning in Higher Education. The implication is that students are encouraged to go through a process of reflection and to embark on a journey of transformative learning. Mezirow & Taylor assert that to promote transformative learning, education should be a practice *"predicated on the idea that students are seriously challenged to assess their value system and worldview and are subsequently changed by the experience"* (Quinnan, 1997:42 in Mezirow & Taylor 2009:3). Similarly, Gamache believes *"that what struggling university students need are practical, specific activities that will lead them toward an alternative conceptual framework within which they can **re-create themselves as active learners.*** [My emphasis] *Rather than just absorbing theory, students actually engage it through a process of active self-reflection and self-direction"* (Gamache, 2002:291).

Gow & Kember suggest that *"Tertiary education must challenge students enough to develop their powers of independent reasoning. Teachers*[Teacher trainers- my addition] *need to develop in their students an academic approach to their study, that is, an interest in what is learnt for its own sake and an active attempt to understand what is being studied"* (Gow & Kember,1990:320). Learning meaningfully is crucial within any educational sector, let alone in Higher Education. Kinchin (2001) identified ***dialogue*** as a fundamental contributing component to meaningful learning. Similarly, Richards (2007) reveals that ***student/teacher interaction*** is an important factor affecting the level of learning. And not just in primary and secondary education. Ramsden (2003) suggests that separating learning and teaching within Higher Education is a false myth: Various authors propose that in order for students to become agents of their own learning they need metacognitive strategies (Gamache, 2002; Bruer, 1993). Active self-reflection and self-direction are two kinds of metacognition (Gage & Berliner, 1998).

With this in mind, Concept Maps and Vee Heuristics will be explored in this study as two tools which a wide body of theoretical evidence is confirming as being intrinsically metacognitive. (Vanhear, 2008). Concept Maps and Vee Heuristics will be presented as two entirely innovative tools to our educational system, which, without any pretensions to being a quick fix, sure tool, can definitely serve as a stepping stone to challenging the prevailing transmission model of education. Using them in initial teacher training will hopefully lead to the use of these tools in our school classrooms.

2 Research Question and Methodology

The path that this study pursues is not to seek absolute truths or promote the pedagogical tools as sure quick fix learning tools but rather to shed light upon a pedagogical process which captures personal structures of knowledge and their development so as to generate meaningful learning. This study will also explore whether the use of these tools could lead to enhancing student/teacher interaction which goes on within the context of Higher Education. The main focus question will therefore revolve around the question ***"In what ways can teacher-student interaction influence meaningful learning?"***

Using students' productions from the Bachelor of Education course at the University of Malta, this study traces the effect of learners' mental operations on the learners' use of Concept Mapping and Vee Heuristics as the learners embed and retrieve new and scaffolded knowledge. By analysing productions constructed by the students before and after the learning programme, as explained hereunder heading 4, this study will reveal a tangible transformation in the ideas held by students about a specific issue which is: *What is Education for Sustainable Development?* This question will be the vehicle through which data will be collected so that the learning development of the students can be observed and recorded.

The nature of this study calls for a qualitative research since qualitative researchers *"often espouse a commitment to demonstrating the viability of truly alternative educational approaches"* (Schulman in Jaeger 1997:18). In line with one of Dewey's principles about educational research, this research is experimental and conducted within a natural setting. Furthermore, *"If we can create and sustain a particular instructional innovation in a real school, we have demonstrated the possibility that it can exist"* (Schulman in Jaeger 1997:19).

In this scenario, the tradition which best suits this qualitative research is Action Research. Corey argues that action research *"is a process in which practitioners study problems scientifically so that they can evaluate, improve and steer decision-making and practice"* (Corey, 1953, as cited in Cohen, Manion & Morrison 2000:227). Action research allows educators to systematically and empirically address topics and issues that affect teaching and learning in the classroom. McNiff regards action research *"as an approach to education that encourages teachers to be aware of their own practice, to be critical of it and to be prepared to change it"* (McNiff, 1992 in Rearick & Feldman 1999:345).

An in-depth study of specific case studies is one of the overwhelming approaches in Action Research. The productions of case stories show how researchers improved their own learning and situations for the benefit of themselves and others. They provide undeniable evidence that Action Research is a form of learning that has insightful implications for the future society and that it could lead to transformation (Mcniff, Lomax & Whitehead, 1996).

In this light, Action Research can also be called a form of self-reflective practice. It is also concerned with '*praxis'* – the process of reflection and action, with the aim to emancipate; *"the claim is made that action research is strongly empowering and emancipatory in that it gives practitioners a 'voice'"* (Cohen, Manion & Morrison 2000:30). Moreover, since Action Research is built upon collaboration between the professional researcher and the local stake holder, it integrates praxis with theory (Denzin & Lincoln, 2005).

3 Merging metacognitive tools for use in Higher Education

Learning is about change and changing oneself (Ramsden, 2003; Zull, 2002). Higher Education must nowadays highlight the quality of education and not just certification. Learning should be about *"changing the ways in which learners understand, or experience, or conceptualise the world around them"* (Ramsden, 2003:6). This research is intended to clarify the mechanisms by which Concept Maps and Vee Heuristics support meaningful learning. It will also raise awareness of how students' mental processes work most effectively leading to conceptual transformation for both the teacher and the student. These two tools merged together present a process of praxis which is *"an activity that combines theory and practice, thought and action for emancipatory ends"* (Kincheloe, 2005:22).

More importantly, these two metacognitive tools lay open what is going on in the learners' mental processes so as to empower them to embark upon a meta-learning journey. Consequently, it is anticipated that they will be better equipped and trained in decision making, reflective and problem solving skills (Ramsden, 2003; Biggs & Tang, 2009 Novak & Gowin, 1984; Gamache, 2002). Furthermore, these two tools do not occur in a vacuum but they build on the learner's prior knowledge (Novak & Gowin, 1984). They take into consideration the diverse and personal experiences therefore making learning more meaningful. This is manifested in the following paragraphs which present the students' responses in the Vee Heuristics, their Concept Maps and their written reflection about this reflective educational journey.

The choice of setting – the Bachelor of Education course at the University of Malta – was dictated by the fact that this happened to be the only Higher Education Institution in Malta which caters for teacher training. Lectures took place at the University of Malta and were held once a week for seven consecutive weeks during the first semester of the academic year. Each lecture had a duration of two hours. The programme was offered as an optional credit to B.Ed students who were in their second, third or fourth year of the course. As a result, the group of participants in this pilot study is self-selected since they attended at their own free will. It is also worth mentioning that in this way the students participating were following different subject specialisations.

4 Data Analysis and discussion

The following paragraph includes the whole process of the Vee Heuristics along with Concept Maps that were generated throughout the whole credit. This paper shall be presenting a sample of only two different learners. During the first lecture the students were asked to reflect, answer and write about the three steps found on the left hand side of the Vee (Figure 1). Their responses were collected at the end of this lecture, analysed and the learning programme was planned so as to accommodate the learners' different learning preferences. All the lectures were presented through Concept Maps where prior knowledge and new knowledge construction was negotiated through active discussion and participation. During the last lecture the students were asked to complete the right hand side of the Vee (Figure 2). Finally, they were asked to organize and compare and contrast all the steps in the Vee Heuristic by presenting, as an assignment, the left and the right hand side of the Vee, the first Concept Map depicting their prior knowledge and the second Concept Map illustrating their new knowledge construction. They were also asked to write a final reflection about their own personal growth during the programme, if any, and how they thought that this process had helped them to become more effective teachers, if they considered that it had done so at all.

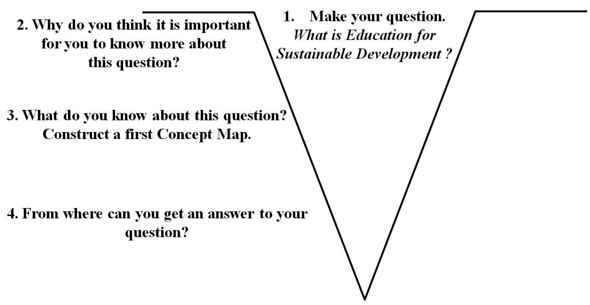

Figure 1: Vee Heuristic presented *before* the learning programme**.**

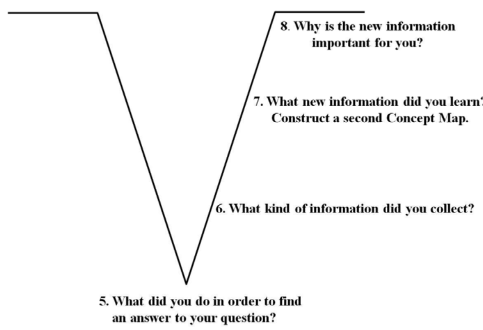

Figure 2: Vee Heuristic presented ***after*** the learning programme.

4.1 Learner 1 Maryanne

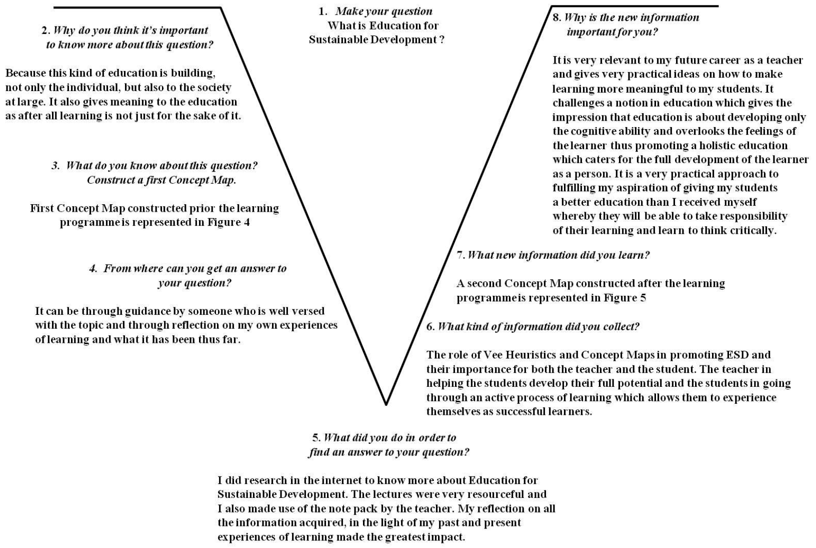

Figure 3: Maryanne's Vee Heuristic

This Vee Heuristic illustrated in Figure 3 reveals this learner's development in her thinking process. A very clear difference can be observed between the left hand side of the Vee, which was completed during the first lecture, that is, prior to the learning programme, and the right hand side of the Vee, which was completed during the last lecture, upon completion of the learning programme. The information given for question No.2 reveals that this learner had few ideas of what ESD is all about and this is corroborated by the first Concept Map she constructed before the learning programme, as represented in Figure 4. It is worth noting that this question also tries to capture the learner's feelings about the issue in question and one can deduce from the learner's response that this learner was very much interested in wanting to know more about the focus question. The reply to question No. 2 reveals Maryanne's level of motivation and interest in studying this topic and one can observe that this learner found this topic interesting and relevant to what she was studying.

The replies given to questions No. 4 and 5 illustrate how this learner planned to learn more and what this learner actually did to learn more. This learner planned to learn through "*guidance by someone who is well versed with the topic*" and she carried out research on the internet and read the reading pack which was given so as to have more information and all of this reflects the learner's preferred way of learning. However, it is worth noting that she also planned to learn through reflecting on her experiences. From the responses given on the right hand side of the Vee one can easily observe how this learner developed her knowledge related to both ESD and the learning process. This learner gave specific details to answer questions No. 6 and 8 and the new knowledge constructed is also illustrated in her second Concept Map constructed after the learning programme as represented in Figure 5.

When observing the first and second Concept Map represented in Figures 4 and 5, one can easily note that the number of concepts and propositions has increased, **revealing that learning has taken place**. The first Concept Map clearly depicts a linear way of thinking and it contrasts with the second Concept Map showing a change even in the way of thinking. Furthermore, Maryanne not only increased the number of concepts but also changed and developed the original concepts constructed in the first Concept Map.

The fact that this learner was eager to expand her knowledge reflects that she enjoys having more detailed information about what she is learning. This is present not only in her Vee but also in her four page detailed reflection where clear references to related literature were made. In this reflection she discusses how she looked at herself as being "*a product of a system of education which promotes transmission of knowledge regardless of the process of learning*" and how she changed and developed herself throughout this credit: "*This has opened my eyes and mind to a way of teaching and learning which are new to me and which I have found to provide a better teaching and learning as compared to other traditional methods of teaching which feed students with information rather than allowing them to go through a process of learning.*"

She also refers to the 'bigger picture' when discussing teaching and learning: "*I will make use of Concept Maps in my teaching. This is because they give learners the opportunity to be active participants in the learning process.*" She also suggests that the Vee Heuristics helped her to "*give a true picture of who the students really are as learners. This will help me to cater for the needs of the students' in my classroom, appreciate them more with their diversity and help them to develop to their fullest potential. The Vee Heuristics and the Concept Maps build on the students' prior knowledge. As proposed by the constructivist theory, students learn best when information is based on what they already know.*"

She also indicated how she could eventually implement all that she had learnt in her own classroom and finally she described the relevance of this credit to her experiences as a University student and as a future educator: "*My experience during this unit was a very positive one. I feel that this unit was helpful to me beyond my expectations when I chose it as an optional credit. I have found it to be one which touches my present life as a student and my future career as a teacher. I feel that I have been challenged and encouraged at the same time*."

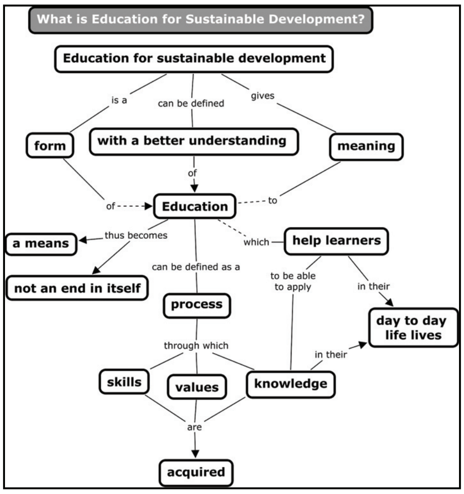

Figure 4: Maryanne's first Cmap, constructed ***before*** the learning programme

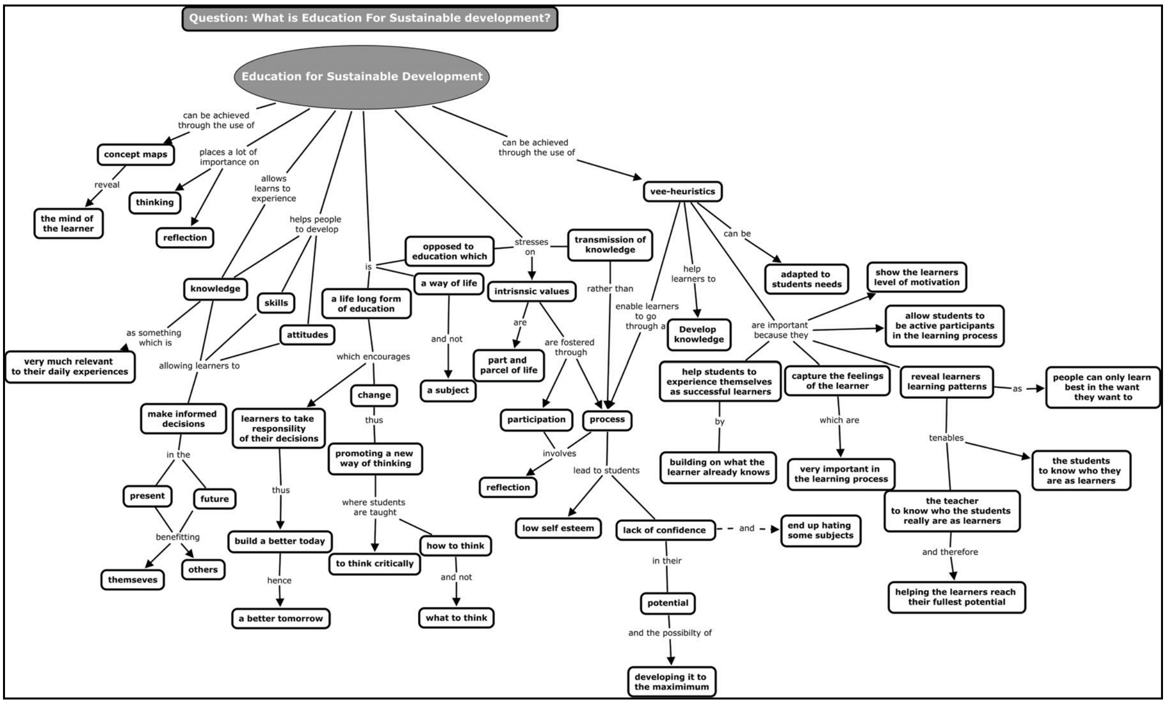

Figure 5: Maryanne's second Concept Map constructed *after* the learning programme

4.2 Learner 2 Stefan

From this learner's Vee Heuristic, presented in Figure 6, one can easily observe a significant difference between the left hand side of the Vee which was constructed during the first lecture before the learning programme and the right hand side of the Vee which was compiled after the learning programme. It is also worth noting the response given to question No. 2 in the Vee. This response is quite vague and surely reveals the low level of motivation which the student had for this credit. Actually, during discussions with this learner, he confessed that he had registered for this credit simply because it was the only one which did not clash with his time-table. This is also manifested in response No.4 where we see this learner's uncertainty in going through this programme. This learner was not at all planning to learn from the lectures. However, it is important to note that he planned to do his learning only through real life experiences. Nowhere did he mention that he planned to read or do research to find more information.

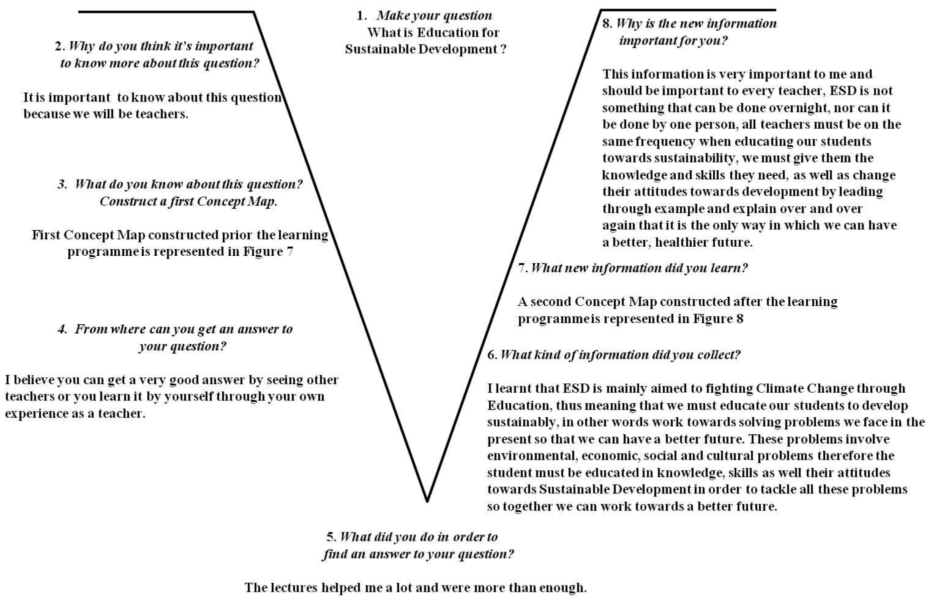

Figure 6: Stefan's Vee Heuristic

The information gathered from Stefan's Vee was very important to me as the teacher: I took it into consideration when planning the credit and I ensured that the student's preference for learning from real life experiences, as well as his avoidance of detailed information, was taken into account. This analysis of the Vee is critical if the teacher expects meaningful learning to take place. Coffield (2004:17) states that *"teachers who understand their own styles and those of their learners can reduce the harm they may otherwise do"* and consequently they will develop more effective skills to interact with and respond to students.

The reply to question No. 5 "*The lectures helped me a lot and were more than enough*" suggests a few things. First, that this learner found the lectures helpful and interesting but on the other hand the latter part of the comment indicates that I must have overdone it with information from this learner's point of view. It also tells me that this learner did not feel the need to go and look up more information because what I delivered in the lecture was *'more than enough.'* This contrasts sharply with the Vee Heuristic as presented by Maryanne since that learner thoroughly enjoyed the extra information I provided.

The responses given on the right hand side of the Vee clearly contrast with the responses given on the left hand side. This reveals that through the learning programme this learner's motivation to learn increased, he also found this unit quite meaningful as his answer to No.8 reveals: "*This information is important to me and should be important to every teacher.*" As we can observe from the first Concept Map represented in Figure 7, this learner did not have a clue of what ESD meant, however, the response given to question No.6 reveals that he has grasped the meaning behind ESD and this is also corroborated in his second Concept Map illustrated in Figure 8. In the response given to question No.8 one can note a sense of determination and commitment in this learner's tone revealing once again that this programme left its mark on this learner who initially found himself doing this credit just by chance. It is worth noting that this learner's preferred way of learning through real life experiences is also mirrored in question No. 8 where he suggests a change of attitude towards sustainable development "*by leading through example and explain over and over again*." Actually, one finds more information in the Vee Heuristic and Concept Maps than in the ten line short paragraph presented as the written reflection. Although all the information given in these ten lines was correct, the sentences were very short and straight forward.

From the first Concept Map generated during the first lecture as presented in Figure 7, one can easily observe a Concept Map presented as a chain revealing little or no knowledge about ESD. This kind of Concept Map also reinforces the answers given to question No.2 and No.3 in the Vee illustrated in Figure 6. In the second Concept Map constructed after the learning programme one can observe a change from a linear train of thought to a net of thoughts and ideas. Although this Concept Map may have a few flaws in Concept Mapping skills, what is more important is that it reveals how this learner's knowledge has developed. There is a marked increase in concepts and propositions and therefore learning has taken place.

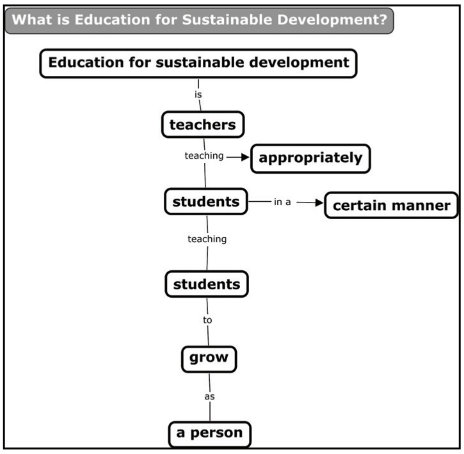

Figure 7: Stefan's First Concept Map created ***before*** the learning programme.

Stefan's Concept Maps differ from the other Concept Maps presented in this study because they lack details and this could be related to the fact that the dominant learning schema of this learner is typical to this learner who avoids details and likes to go straight to the point. However, the most salient points relating to what ESD is all about are present: the differences between Stefan's two Concept Maps reveal that this learner has learned meaningfully although he started off on this programme with a lack of interest and motivation. It also stands to be said that although this learner purportedly avoids details, his second Concept Map exhibits more details than the paragraph he presented as a reflection. It is also worth noting the way in which the first Concept Map (Fig. 7) was constructed and the way in which the second Concept Map (Fig.8) was created. There is a difference in colours and even in the arrowed lines showing that this learner enjoyed constructing the second Cmap more than the first one and put more time and effort into the process. The way in which this learning programme was presented and experienced may have helped in increasing this learner's interest and motivation.

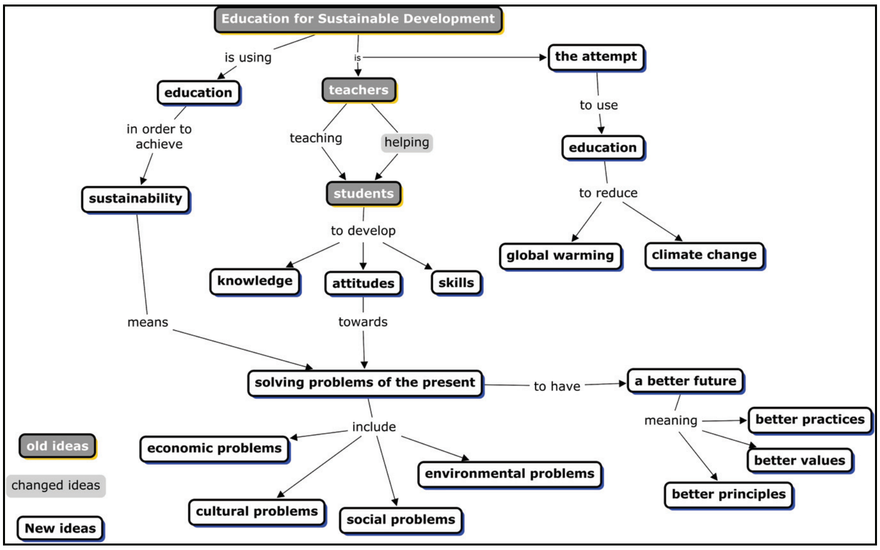

Figure 8: Stefan's second Concept Map constructed ***after*** the learning programme.

5 Concept Maps

One of the main focuses of this research revolves around the learning process as an interaction of thinking, feeling and acting. Although Concept Maps in themselves do not reveal the affective side of learning, the actual process of constructing a Cmap **does involve these three mental processes**. In contrast with "traditional" teaching and learning where the students are asked to represent their knowledge through ways which rely mainly on memory, in order to regurgitate chunks of information (surface learning), when students are asked to represent their knowledge by constructing Concept Maps, they are be going through a process of metacognition (deep learning). Metacognition entails mulling, connecting, rehearsing, expressing, assessing, reflecting, revising and learning. Actually, when one is constructing a Concept Map, one goes through these processes and this is the reason why Concept Maps facilitate meaningful learning and challenge rote learning. Furthermore, when one is constructing a Concept Map one is not simply reproducing chunks of information which are totally irrelevant to one's own experience (because it would have been studied by heart). When the learner is constructing a Cmap, since he/she is presenting knowledge according to his/her own cognitive structure, the learner is creating knowledge according to his/her own perspective and this will automatically be related to the individual's own personal experience. This is why learning becomes more meaningful.

6 Vee Heuristics

Novak (1998) reveals that the shape of a Vee was chosen above other shapes because by using this format, one can clearly recognize and differentiate that both thinking (concepts and theories) and doing (methodology) are implicated in the process of constructing knowledge. The right hand side of the Vee, reports the action part of knowledge construction taking place. One can, in fact, visually see what the learner is doing to develop his/her own knowledge. In addition, the learner can reflect and observe the development of the new knowledge taking place as opposed to his/her prior knowledge on the left hand side of the Vee. In this way, prior knowledge has been developed; misconceptions have been altered while new knowledge has been constructed. It is in this way that the transmission model of education is being challenged, since the learner is learning on autonomously, with the teacher only facilitating this process by providing the necessary tools. If rote learning does not impart meaningful learning, the way forward must lie in the use of metacognitive learning. Research in this study and elsewhere prove that Vee Heuristics promote metacognitive skills. Similarly, Novak argues that *"giving learners the correct information does not displace their faulty conceptions! It takes a lot of negotiation of meanings, a lot of shared experience to help learners reconstruct their internal concept Maps to be congruent with the expert's knowledge"* (Novak, 1998:118). Therefore, this process facilitates more teacher/student interaction. An added value is that this whole process makes the teacher stop and reflect on his/her own practice. In order to bring about transformation one must be ready to transform oneself first and foremost and the starting point should be to reflect critically for "If we want pupils to learn meaningfully and reflectively, then their teachers ought to first learn how to learn meaningfully and reflectively" (Åhlberg in Cañas et al 2004:39).

7 Conclusion

The integrated use of Vee Heuristics and Concept Maps along with an awareness of how students prefer to learn may promote the reflection and action that is required to stimulate change in education, in this case Higher Education. Implementation of these teaching and learning tools will hopefully lead to the development of creative and reflective practitioners in our society, empowered to become agents of transformation.

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CONCEPT MAPPING AND WRITING

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Abstract. The writing process can benefit from applying external representations, such as outlines, or other graphic organizers, such as concept maps. We propose, based on Flower and Hayes' (1981) writing model, that there is value to instructing students, in the planning stage of writing, in employing concept mapping techniques: to elicit prior knowledge and brainstorm an issue, to organize ideas, and to develop writing plans. We present an intervention study to evaluate these ideas. It appears that concept mapping instruction and application during pre-writing contributed to the accessing and use of prior knowledge for written essays and improved their rhetorical structure in comparison to a control instruction.

1 Introduction

Writing can be viewed as a complex problem solving process, where a problem is some times ill-defined, and so is the expected product. We use tools to solve problems. They can be tools for calculation, for simulation, or for representing the problem. All those are cognitive tools. Can writing be aided by using cognitive tools, such as concept mapping? Writing or composing is a complex cognitive process and requires assembling many cognitive resources and juggling many constraints. Writing receives considerable attention in education, literary, and linguistic literature. But the many studies in there are mostly qualitative, descriptive, and prescriptive research. Traditional models of writing (e.g., Rohman, 1965) describe discrete stages of writing, such as Pre-Writing (before words are crafted on paper or screen), Writing (a physical product is created), and Re-Writing (modifying and editing the product). While such models are convenient for instructional purposes, and indeed, identifying the Pre-Writing stage, aided instructors in devising composition curricula and identifying components of this stage, such as goal setting, knowledge assembly, idea generation, and organizing the writing plan, stage models have not captured the entire complexity of the writing project.

Among theories about writing processes, Flower and Hayes' (1981) cognitive process model of writing is one of the first and best known. It provides a relatively comprehensive framework for research and application (see Figure 1). The diagram identifies various cognitive structures and processes of the writing environment. It consists of an external task environment and an internal memory structure of the individual, a long-term memory and a working memory, where cognitive macro-operations are executed. These process components include planning the writing act, translating the plan into a produced text, and reviewing and editing the product. The processes are not necessarily sequential, with component processes embedded within other components, forming a recursive-like chain of operations. Further developments of process writing models include Hayes' (1996) refinement of the basic processes, distinguishing in the external task environment between a physical and a social environment. In the physical environment a further distinction is made between the content of the text produced so far and the given medium (i.e., paper vs. screen) that may alter the writing process and its products. In the social environment a further distinction is made between audience and collaborators. Reviews of additional writing models based on cognitive processes can be found in Becker (2006) and Galbraith (2009).

We focus on the planning of writing. Planning activities occur throughout the entire writing process, however, they are more evident at the beginning of the project, when the writing assignment is provided, and gradually decline at later phases while revision activities increase (Kellogg, 1988). Flower and Hayes (1981) identify three planning activities that we address in our research: *generating ideas, organizing, and goal setting*. *Idea generation* is based on those ideas that can be retrieved or generated from stored knowledge in long-term memory, or from accessing external, provided or selected sources, and even from the social environment. When time is constrained, like in standard writing assessments in academic settings, the writer relies mostly on previous knowledge and given resources. So, for example, when a student is asked to write about "What have we gained and what have we lost by using mobile phones?" she accesses her memory about mobile phones past experiences, her general knowledge about what mobile phones are, and recollected claims for or against mobile phone use. External resources, such as texts or (classroom) discussion, may provide additional data and stances (in argumentative writing) about mobile phone use. Following or intermixed with idea generation is an *organization activity* that **classifies** the generated ideas, according to her analysis of the writing assignment: Content: Mobile phone, Form: Pro-Con. Gradually, a *writing goal (plan)* is set, based on stored knowledge and analysis of the writing assignment. These are rhetorical plans that include analysis of the expected audience and other writing constraints like space limitations, and medium concerns.

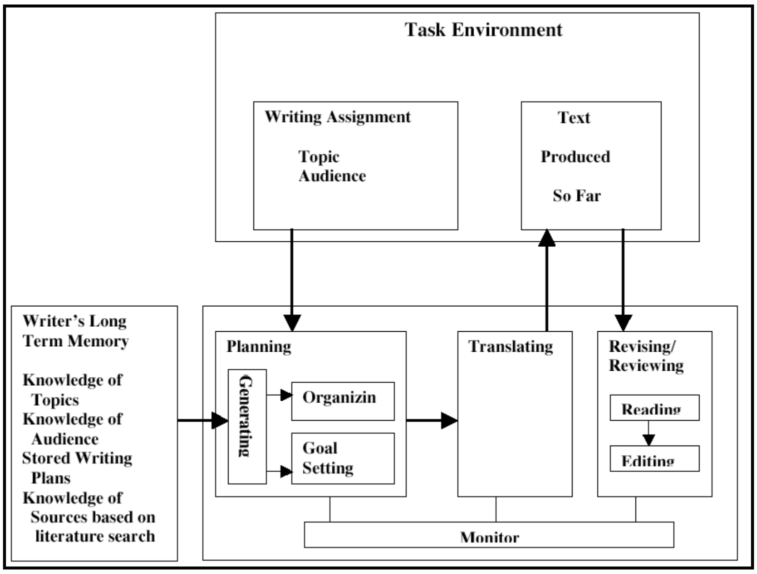

Figure 1. Flower and Hayes (1981) structure of a writing model

How can the planning process be supported? A natural candidate is concept mapping. Concept mapping is advocated as a strategy for knowledge elicitation and re-conceptualization (Cañas et al, 2003; Novak, 2010; Novak & Cañas, 2003). As such, it can also be utilized for studying textual and other media sources, by adding map structuring capabilities (Kozminsky et al, 2010), similar to the Jonassen et al (1993) proposal to represent structural knowledge. The original Novak and Gowin (1984) concept mapping idea was primarily aimed at knowledge work. They recommended constructing maps in a descriptive format, relating knowledge elements (propositions) to each other. The map is heterarchical in the sense that it originate in a focal question that designates a root proposition. From there the map is constructed by probing the student's (or the expert's) knowledge base, adding new nodes (propositions) and relating them to previously constructed ones, describing the retrieved knowledge in a network like fashion. For the purpose of learning from texts, Kozminsky et al (2010) proposed distinguishing between initially constructing descriptive concept maps, starting with prior knowledge activation and then adding text's content. The descriptive map is then transformed into more structured maps, depicting the content and the rhetorical organization of the text.

We propose to apply a similar procedure to writing, specifically at the planning phase. While instructing students in applying concept mapping to the writing process, we first ask students to brainstorm the writing assignment topic (e.g., Mobile phones), while constructing a descriptive map (Figure 2). Then, based on the assignment, the students classify relevant information from the descriptive map into an organized map (e.g., Pro vs. Con elements, Figure 3). The final step is to adapt the organized map into one that corresponds to a writing plan (Figure 4). We have not found many empirical studies that explore concept mapping in writing (e.g., Ojima, 2006, for Japanese ESL writers). Lee et al (2007) analyzed the possibilities of applying concept mapping with writers of divergent abilities. This analysis is based on Ainsworth's (2006) framework for learning with multiple representations. We present an intervention study in which student teachers in an argumentative writing class were instructed to apply concept mapping during the planning stage of writing. We asked whether the quality of their writing products changed compared with control classes.

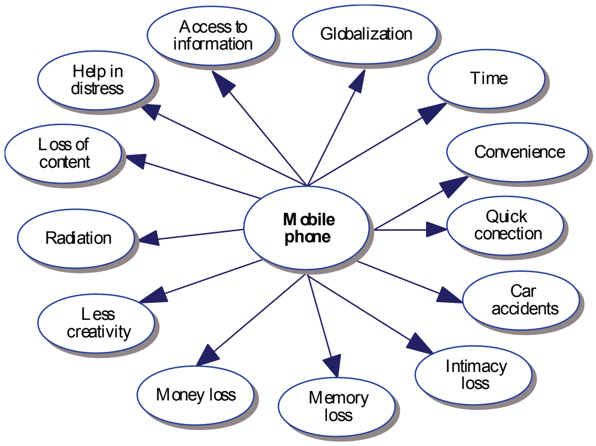

Figure 2. A descriptive (brainstorming) map example

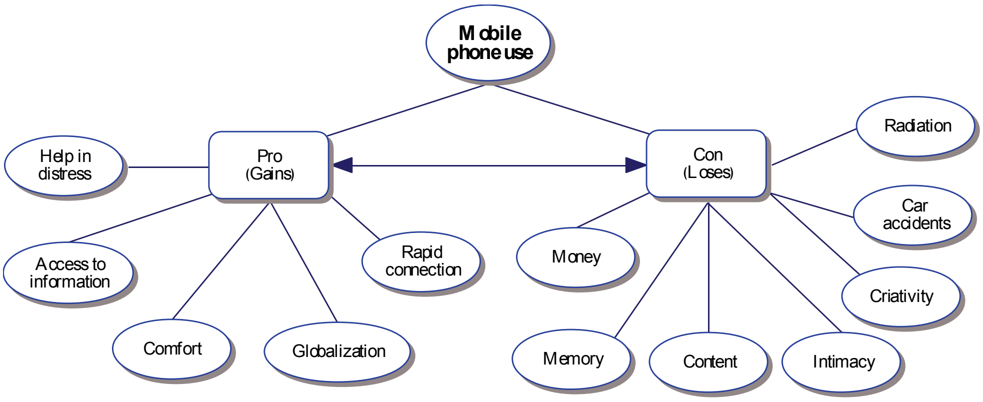

Figure 3. Classification map example.

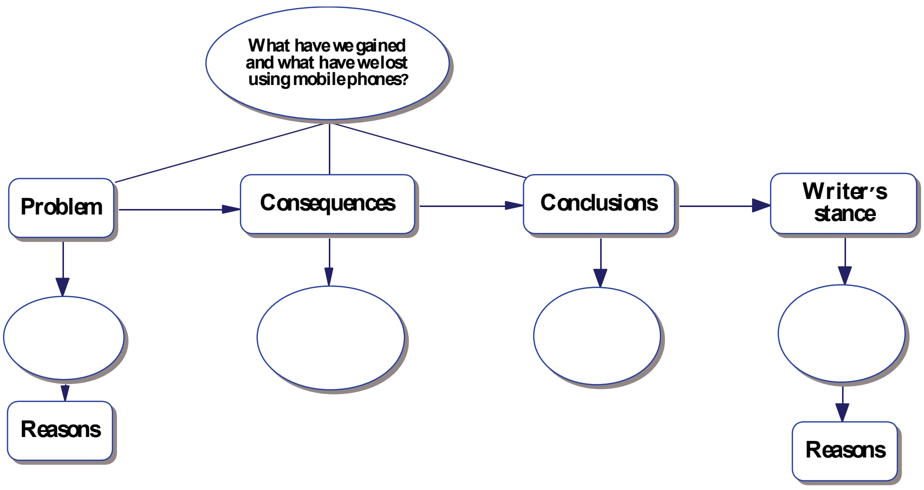

Figure 4. Writing plan (argumentation) scheme.

2 Method

2.1 Participants

49 students (mostly with teaching experience in elementary and middle schools) enrolled in semester writing workshops at an academic teachers college in Israel, taught by the same teacher. The students signed into one of

three workshops according to their preference of the workshop label, their time constraints and enrolment limitations.

2.2 Testing instruments and materials

2.2.1 Background information

Background information (16 items) was initially collected about the participants teaching experience and seniority, teaching subjects, language of teaching, and college seniority. Additional information was collected about their teaching practices, their familiarity with, and personal and instructional applications of graphic organizers in teaching.

2.2.2 Reading comprehension test

The test consists of two argumentative texts (400 and 700 words). Four questions were composed for each text: main idea, text structure, writer's and reader's stance on the text's issue. Each question was scored 0 (no or wrong answer), 1 (partial answer), or 2 (full answer) (Maximum score 16). The questions were answered immediately following reading. Testing time was one hour. The short text was read first and then the longer one.

2.2.3 Writing tests

The tests were composed by the researchers and were delivered before and after the intervention. It consisted of student reading two texts (about 400 and 700 words) and writing an argumentative composition on the issue provided in the texts. At the pretest the issue was Ebooks vs. printed books, and at the posttest it was providing or not providing soft drugs (e.g., cannabis) to the terminally ill. Testing time was 50 minutes, divided at the student will between reading and writing. The compositions were scored for general understanding of the issue, balanced (pro-con) and detailed argumentation, number of correct connective words, rhetorical structure (issue introduction, arguments, conclusions), writing complexity, number of correct punctuations, style, holistic evaluation, number of pro and con arguments, number of incorrect arguments (misunderstandings), number of arguments based on personal knowledge, and number of arguments based on personal misconceptions. Each criterion was scored either on quantity (i.e., number of) or on quality scale (from 0 (low) to 3 (high quality). Each composition was independently scored by two evaluators, based on a scoring scheme. Sample comparisons of agreement between the evaluators, yielded an average of 93%. Differences were solved in a conference.

2.2.4 Procedure

The three intervention (workshop) conditions were: (1) Academic writing (Experimental) consists of learning from argumentative texts and writing argumentative essays, with the aid of concept maps; (2) Thinking and learning from texts (Control 1) consist of learning the same texts as did the experimental class, and receiving the same learning and writing assignments, but with a traditional reading and writing instruction curriculum, with no added concept mapping instruction; (3) Reading for pleasure (Control 2), consists of reading papers on the subject and prepare a project of promoting young students to read for pleasure. Research assistants observed and recorded the lessons, to ensure adherence to the predefined curriculum of each workshop.

The research was conducted during 12 weekly 90 minutes lessons. The first and the last two weeks were pre- and post testing lessons. The eight intervention lessons were divided to four instructional cycles. In the first cycle, in the experimental condition, the students were introduced to the three types of maps: A knowledge brainstorming (descriptive) map; a classification (organization) map, and an argumentation (writing plan) map, before reading. And then, guided reading of two texts (a pro and a con text, 700-800 words each) on the issue of urbanization vs. open spaces, updating the writing plan, by adding newly gained information and correcting misunderstandings, and then individual writing on the issue. The next two cycles consists of student groups' discussions that include maps construction, followed by individual reading and writing. In the last cycle all the activities were individual. The issues that were discussed were: introducing women into the workforce; mobile phone dominance in our lives, and, environmental quality in modern life. The Control 1 class studied the same issues with the same texts, learning knowledge elicitation and organization, learning about text's main idea and text structure, using the board in a traditional manner, with no graphic aids. The Control 2 class studied pleasure reading. They read texts from various genres and discuss their pleasure value. Writing was not a focus and no argumentative writing was required.

Writing Criterion	Intervention Condition	N	Pre-intervention Mean	Pre-intervention SD	Post-intervention Mean	Post-intervention SD
Content (0 – 3)	Experimental	16	2.44	.63	2.31	.60
	Control-1	17	2.53	.72	**2.82**	.39
	Control-2	16	2.44	.73	2.25	.86
	Total	49	2.47	.68	2.47	.68
Balanced Argument (0 – 3)	Experimental	16	1.81	1.28	2.12	.72
	Control-1	17	2.35	.70	**2.94**	.24
	Control-2	16	1.62	.81	2.12	.81
	Total	49	1.94	.99	2.41	.73
Correct Connective Words (Number)	Experimental	16	7.44	3.56	9.56	4.57
	Control-1	17	8.18	4.77	9.53	3.95
	Control-2	16	7.12	5.45	9.25	5.80
	Total	49	7.59	4.59	9.45	4.72
Rhetorical Structure (0 – 3)	Experimental	16	1.69	.70	**2.44**	.63
	Control-1	17	2.41	.62	**2.88**	.33
	Control-2	16	2.31	.87	2.19	.54
	Total	49	2.14	.79	2.51	.58
Writing Complexity (0 – 3)	Experimental	16	2.19	.83	2.31	.60
	Control-1	17	2.47	.72	**2.88**	.33
	Control-2	16	2.25	.93	2.25	.77
	Total	49	2.31	.82	2.49	.65
Correct Punctuations (Number)	Experimental	16	17.94	10.32	18.31	12.68
	Control-1	17	28.94	11.86	33.41	15.62
	Control-2	16	20.50	14.40	20.12	17.34
	Total	49	22.59	12.96	24.14	16.51
Writing Style (0 – 3)	Experimental	16	2.25	.86	2.06	.68
	Control-1	17	2.53	.72	**2.88**	.33
	Control-2	16	2.12	1.02	2.06	.93
	Total	49	2.31	.87	2.35	.78
Holistic Evaluation (0 – 3)	Experimental	16	1.69	.70	2.19	.54
	Control-1	17	2.53	.72	2.82	.39
	Control-2	16	2.12	.96	2.25	.86
	Total	49	2.12	.86	2.43	.68
Text-based Correct Pro Arguments (Number)	Experimental	16	1.94	2.05	2.25	1.91
	Control-1	17	2.88	1.54	2.29	.85
	Control-2	16	3.44	2.25	2.69	1.40
	Total	49	2.76	2.02	2.41	1.43
Text-based Correct Con Arguments (Number)	Experimental	16	1.25	1.39	1.06	1.24
	Control-1	17	1.47	1.01	1.65	.79
	Control-2	16	1.81	1.80	1.50	1.21
	Total	49	1.51	1.42	1.41	1.10
Text-based Incorrect Arguments (Number)	Experimental	16	.00	.00	.19	.40
	Control-1	17	.00	.00	.00	.00
	Control-2	16	.06	.25	.44	.81
	Total	49	.02	.14	.20	.54
Personal Knowledge Arguments (Number)	Experimental	16	4.06	2.46	**4.31**	4.83
	Control-1	17	2.59	1.58	2.06	1.60
	Control-2	16	3.06	1.88	1.56	.89
	Total	49	3.22	2.05	2.63	3.13
Personal Knowledge Misconceptions (Number)	Experimental	16	.12	.34	.25	.58
	Control-1	17	.00	.00	.06	.24
	Control-2	16	.31	.60	**.75**	1.69
	Total	49	.14	.41	.35	1.05

Table 1: Pre- and post-intervention writing evaluation scores for the intervention groups.

(Bolded means indicate statistically significant difference ($P < .05$) from the other means)

3 Results

Since students were not randomly assigned to classes, we analyzed initial reading comprehension scores (M = 10.39, SD = 3.04). There was no statistical difference among the groups (F (2, 46) = .14). Analyses of writing criteria were performed using ANCOVAs, where the post-intervention criteria were dependent and the intervention conditions were independent variables with the respective pre-intervention criteria scores as covariates. The means and standard deviations of the writing criteria are displayed in Table 1. The analyses demonstrated the advantage of Control-1 over the experimental class in several criteria (content, argumentation, complexity, and style). The Control-2 class had more misunderstandings in their writing compared to the other classes. The experimental students had an advantage over the other classes in including personal knowledge arguments in their essays. Their rhetorical structure scores were similar to Control-1 and higher than Control-2 students.

4 Discussion

The sole effects of the concept mapping intervention at the planning stage of writing were the activation of personal prior knowledge and the introduction of its content into the essays. An example of a student concept map that depicts a gross writing plan is illustrated in Figure 5. It was constructed following brainstorming (Figure 2) and constructing a classification map (Figure 3). This map was then restructured and expanded by adding information gained from reading the textual sources and additional self knowledge elicitation, and served as a writing plan for producing a 500 word argumentation essay.

However, the advantages gained from concept mapping instruction at the planning phase were not translated into writing quality, as measured by traditional writing criteria. The class that received traditional reading and writing instruction (Control-1) faired best. We propose a time-on-task effect. Concept mapping instruction at the planning stage of writing required time resources that were diverted from teaching other elements of the writing curriculum. Perhaps, in addition to introducing concept mapping during planning, we propose that integrating concept mapping instruction within the additional phases of writing (translation and reviewing), as well as using concept mapping applications, such as Cmap Tools, may improve the prospects of this project.

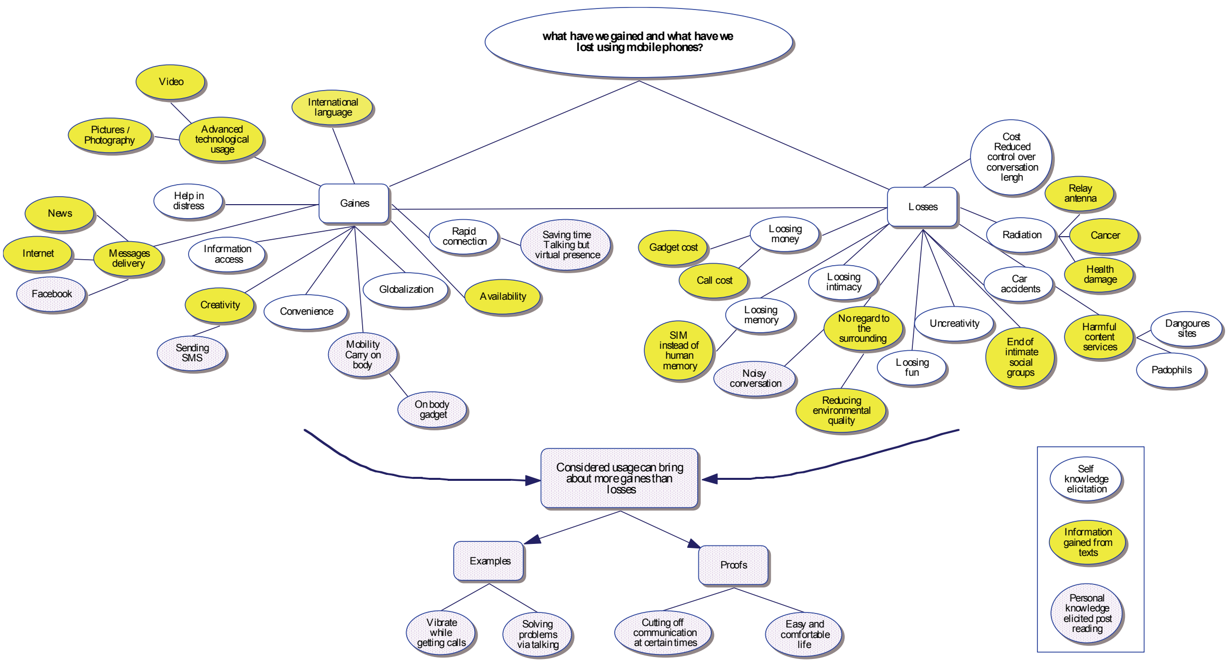

Figure 5. A concept map illustrating a student writing plan.

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CONCEPT MAPPING APPLICATIONS AND ASSESSMENT IN AN AFTER SCHOOL PROGRAM FOR ADOLESCENT STUDENTS

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Abstract. The purpose of this paper is to describe and discuss the concept mapping strategies we used to review and assess 6th grade middle school students' knowledge of a human geography curriculum. We report findings from spring 2010 and spring 2011 assessments and revisions to the curriculum in summer 2010. Concept mapping strategies used in the after school program included student-generated concept maps, the use of gaming to facilitate concept map creation, cooperatively-made concept maps, and student interviews.

1 Introduction

In this paper we describe and discuss the concept mapping strategies used to review and assess 6th grade middle school students' knowledge of a human geography curriculum. The students were participants in an after-school college reach-out program (CROP) first implemented with 6th graders during the 2007-2008 academic year. The overarching CROP goal is to build, within the urban core, a community of students who see themselves as academically able, emotionally ready, and active in their pursuit of positive futures in middle school, high school, and beyond by entering and successfully completing a post-secondary education program. CROP selection criteria includes low achievement on state reading and/or mathematics accountability measures, poverty status, and the potential to be a member of the first generation in their family to attend and complete college. Selected students attend one of two low-performing schools in the urban core of a large Florida school district. More often than not, CROP students have social or academic barriers or both to overcome and, as a result, are reluctant learners—often lacking the motivation to sustain sufficient effort necessary for academic success.

After school learning sessions focus on building background knowledge in human geography and students' self-concept. CROP activities occur weekly in 3-hour sessions led by a certified teacher and undergraduate college students who work with students in small and large group settings. Program design incorporates concept mapping strategies including use by teachers as an instructional strategy and by students as graphic organizers.

In spring 2010 and 2011 we used concept mapping for formative assessment of the CROP students' human geography knowledge (Monroe-Ossi, Wehry, & Fountain, 2010; Wehry, Monroe-Ossi, Cobb, & Fountain, 2012; Wehry, Monroe-Ossi, & Fountain, 2010). In the assessment, an expert concept map, developed by the teacher-researcher, was used to scaffold the learning of the participants. At the end of the review, the task for the students at each grade was to generate concept maps incorporating concepts from the expert map and adding the newly learned concepts. The assessments followed 18 weeks of CROP sessions.

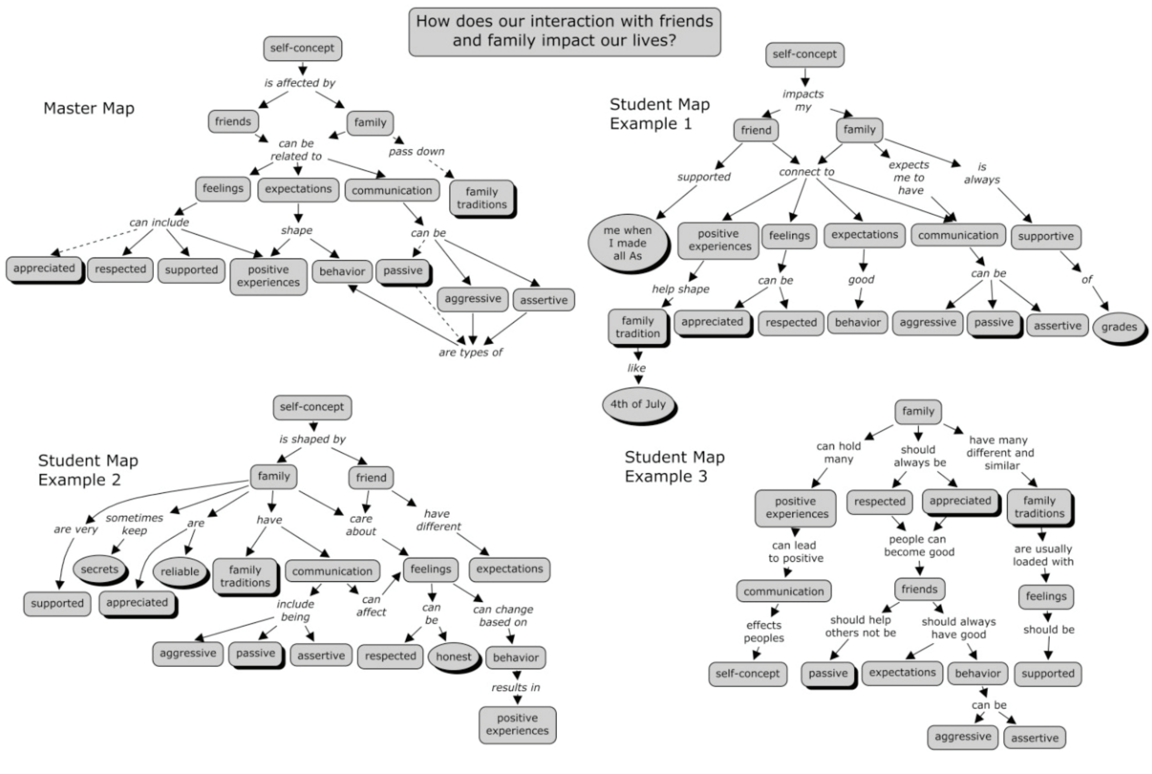
2 Purpose

The 6th grade curriculum was specifically designed to help students understand that they control their path to academic success, and to do so students must first see themselves in charge of their futures. To that end, the 6th grade CROP curriculum begins at the small, local end of the scale continuum with self, family, friends, and community. The 6th grade curriculum requires students to confront their interactions with others as those interactions define their beliefs about themselves. However, self-concept can be studied either as a sterile academic concept that resides outside the learner or through personal introspection of the kaleidoscopic layering of one's life experiences. Our initial interest in the students' knowledge about self-concept was academic because we thought understanding the theoretical construct would help students develop and sustain positive self-concepts. By spring 2011, we realized the importance of our mutual understandings of the factors that actually impact the student's self-concept in their specific neighborhoods.

The spring 2010 6th grade assessment involved the *Friends and Family* unit from the CROP human geography curriculum. Insights gained from the 2010 assessment of the academically-based self-concept lead to revisions to the human geography curriculum during summer 2010. In spring 2011, we again used concept mapping to enhance our understanding of the 6th graders' knowledge structure relative to the impact of families and friends on self-concept. In spring 2011 we implemented the revised concept mapping activity. The purpose of this paper is to report findings from the spring 2010 6th grade assessment using concept mapping, the summer 2010 revisions to the 6th grade CROP curriculum, and the development and implementation of the spring 2011 6th grade concept mapping activity.

3 Formative Assessment: Spring 2010

In spring 2010, after a review of the *Friends and Family* unit using the associated Master Map, students received supplies (blank chart paper, the 12 concepts on the master map, three additional concepts reviewed but not placed on the Master Map, blank Post-It Notes for original concepts, index cards on which to write linking phrases, a glue stick, and a pencil) to use in constructing individually-produced concept maps depicting the unit's content. Students had 20 minutes to complete the task while the CROP college students interacted with them by providing assistance and monitoring on-task behaviors. Figure 1 provides the Master Map and three examples of student-produced maps.



Note. In the Master Map (upper left), concepts depicted with black shadows and linked with dotted lines are concepts that we omitted from the Master Map discussed in class and provided to the students. In the Student Map Examples (upper right and bottom row), rectangular-shaped and shadowed concepts depict that the student used a provided concept that we omitted from the Master Map. Oval-shaped, shadowed concepts depict that the student used a self-generated concept.

Figure 1: *Friends and Family* unit master concept map and student-produced concept map examples.

Rather than quantitatively score the student-produced maps, we holistically examined the content and structure of the student-produced maps. As can be seen in Figure 1, the Master Map presents a hierarchical map structure using 15 concepts; however, we removed three concepts from the version of the Master Map used in the unit review and subsequently provided to the students. The student who produced the Example 1 concept map used the 12 concepts, added the three concepts omitted from the Master Map (*family traditions*, *appreciated*, and *passive*), and added three original concepts (*me when I made all As*, *grades*, and *4th of July*). The student maintained the hierarchy of the Master Map. In short, the Example 1 map reflects our expectations and would receive a higher score than the Master Map using almost any scoring system (e.g., Wehry, Algina, Hunter, & Monroe-Ossi, 2008). Similarly, the student who produced the Example 2 concept map used the 12 concepts on the Master Map, the three concepts omitted from the Master Map, and added three original concepts (*secret*, *reliable*, and *honest*). At first glance, the Example 2 concept map looks much like what we expected; however, a closer look reveals that the student deviated from the knowledge structure depicted in the Master Map. The Master Map equally emphasizes interactions of friends and family relative to self-concept while the concept map in Example 2 shifts the emphasis toward family and away from friends. In contrast, the student who produced the Example 3 concept map used the 12 concepts from the Master Map, added the three concepts omitted from the Master Map, added no original concepts, and turned the concept map's hierarchy upside-down. This student placed *family* at the first, most important level of the concept map, and placed *self-concept* at the lowest level subsumed under *communication* and cross-linked with no other concepts.

The 6th graders, for the most part, did not do as expected—concept map the academic structure of self-concept. Instead, they freely mapped the concepts relative to their personal thoughts and feelings. Actually, our focus question did not specifically ask about self-concept, but self-concept was included in the words provided for the student-generated maps and we assumed the students would use the class map to guide their maps. The framework presented by Ruiz-Primo and Shavelson (1996) describes concept map production as the interrelationship of three map facets: task for the respondent, format of the response, and a scoring system. Task demands for students range from the heavy cognitive demand of student-generated concept maps to the more moderate demands of fill-in type concept maps. Task constraints involve restrictions imposed on the task. The structure of the task results from combining the task demands and the constraints. Our assessment involved the production of student-generated concept maps potentially constrained by the list of concepts and the structure provided by the Master Map. For the most part, the 6th graders were not at all constrained by either feature!

3.1 2010 Findings and Revisions

The 6th grade concept mapping assessment indicated that students generally were not willing to use the Master Map to guide the construction of their concept maps, thus, we reconsidered assumptions made about the students' learning. One assumption we unconsciously made was that in learning self-concept as a theoretical construct, students would achieve the CROP goal of seeing themselves in charge of their futures. Our Master Map reflected an impersonal, theoretical approach, but to achieve our stated CROP goal, 6th graders needed to approach the construct from a personal, reflective perspective. Thus, the student who produced the Example 3 concept map completely reversed the hierarchy of the Master Map to reflect the student's life experiences. In summarizing methods used to assess concept maps for correctness, Kinchin (2000) stated that Ghaye and Robinson (1989) "interpreted maps that exhibited a close match with the teacher's knowledge structure as being indicative of a 'passive and reproductive' learning posture rather than a meaningful learning approach" (p. 41). Thus, we reconsidered our Master Map and how we designed the concept mapping assessment. We took this opportunity to change the focus of the assessment from assessing student knowledge to gaining insights to support student's positive self-concept.

During summer 2010, developers revised the CROP curriculum, including the 6th grade curriculum, to make more explicit connections to the foundational concepts of human geography. Additionally, we learned from the concept mapping assessment that, for the most part, students could produce concept maps depicting their understanding of the relationships between the personal interactions that influence their self-concept but they did not necessarily depict the academic structure of self-concept. In an effort to increase student engagement, CROP revisions focused on using instructional strategies that make academic content more interesting. Curriculum revisions required changes to the assessment of the *Friends and Family* unit.

4 Formative Assessment: Spring 2011

In revising the assessment, we considered two factors that could improve student engagement: motivation and games. Unfortunately, academic motivation tends to decrease as students, particularly adolescents, get older. Thus, we turned our attention to *interest* which Hidi and Harackiewicz (2000) defined as "an interactive relation between an individual and certain aspects of his or her environment (e.g., objects, events, ideas), and is therefore content specific" (p. 152). Situational interest, centering on contextual factors, is created by stimuli that focus attentions. Furthermore, "situational interest should also play an important role in learning, especially when students do not have pre-existing individual interests in academic activities, content areas, or topics" (p. 153).

The shift in education away from passive learning by listening and toward a more student-centered model that emphasizes an active role for the learner also moves learning away from the recall of facts and toward the ability to use information. Games provide opportunities to use information and develop winning strategies. A promising thread of research has provided some evidence supporting the effectiveness of games as a learning strategy even for complex subjects. In using games, the objective is to achieve a motivated learner, one who is enthusiastic, focused, and engaged—interested in what he or she is doing. Intrinsically motivating activities challenge the learner and frequently engage learners simply because of interest (Garris, Ahlers, & Driskell, 2002).

Game designers should match learning outcomes and game features. Garris et al. (2002) suggested that educational games should activate the game cycle: reactions such as interest, behaviors such as persistence, and system feedback. The cycle is iterative—increased interest leads to behaviors such as more intense effort and greater confidence, which lead to system feedback, which leads to increased interest. Several features, taken together, make games an effective instructional strategy. Games should have clear goals and rules and activities should provide an optimal level of challenge. Furthermore, "Linking activities to valued personal competencies, embedding activities within absorbing fantasy scenarios, or engaging competitive or cooperative motivations can serve to make goals meaningful" (Garris et al., 2002, p. 450). Finally, debriefing processes, a review and analysis of game events, provide the link between the game and the learning outcomes.

4.1 Conceptual Card Game: Spring 2011

Researchers working with the Panamanian project, *Conéctate al Conocimiento*, developed a game to help teachers introduce concept mapping to their students and students to construct better concept maps. The game required a set of cards having concepts on one side and a focus question provided by the facilitator. Student teams selected two cards at random from the deck and used them to form a proposition. The design of this game fostered collaboration as well as competition. The use of the conceptual card game in Panama resulted in the 5th graders producing a group concept map that was structurally and semantically complex (Giovani et al., 2008).

We adapted this game for use with the *Friends and Family* unit, and, similar to the Panamanian study, we did not replace the cards between turns. In addition to the *Friends and Family* cards, we provided a list of possible linking phrases and the focus question, *How do my friends and family impact my self-concept?* (See Table 1.) Consistent with the summer revisions, self-concept appeared only in the focus question.

Concepts		**Linking Phrases**
Emotions	Expectations*	*can be influenced by*
Behaviors	Communication	*effect*
Future	Social skills	*determines*
Goals	Historical events	*include*
Barriers	Family traditions	*relates to*
Likes/dislikes†	Neighborhood	*such as*
Family strengths	James Weldon Johnson	*lessens*
Family weaknesses	Passive	*increases*
Problem solving	Assertive	*can be*
Life experiences	Support	*are*
Outside influences	Respect	
Personal characteristics	Appreciate	

Note. * Class map Example 1 did not use the concept *expectations*. † Class map Example 2 separates likes/dislikes into two distinct concepts, *likes* and *dislikes*.

Table 1: Concept Card Game Concepts and Possible Linking Phrases

After a brief review of concept mapping, students formed two teams and flipped a coin to establish which team would begin the game. After randomly selecting two concepts from the card deck, the teams had 1 minute to form a sensible proposition using the selected concepts. If both teams judged the proposition *correct*, the team scored 2 points and had an additional minute to form two bonus propositions using the selected concepts and concepts already on the map. (At the first turn, bonus propositions are not possible.) Bonus propositions scored 2 points each, but the team must make two bonus propositions to score points. The team's turn was over when members could not make a *correct* proposition using the selected concepts within the allotted minute or when members exhausted the allotted bonus minute or created two *correct* bonus propositions. Figure 2 shows example concept maps from each school.

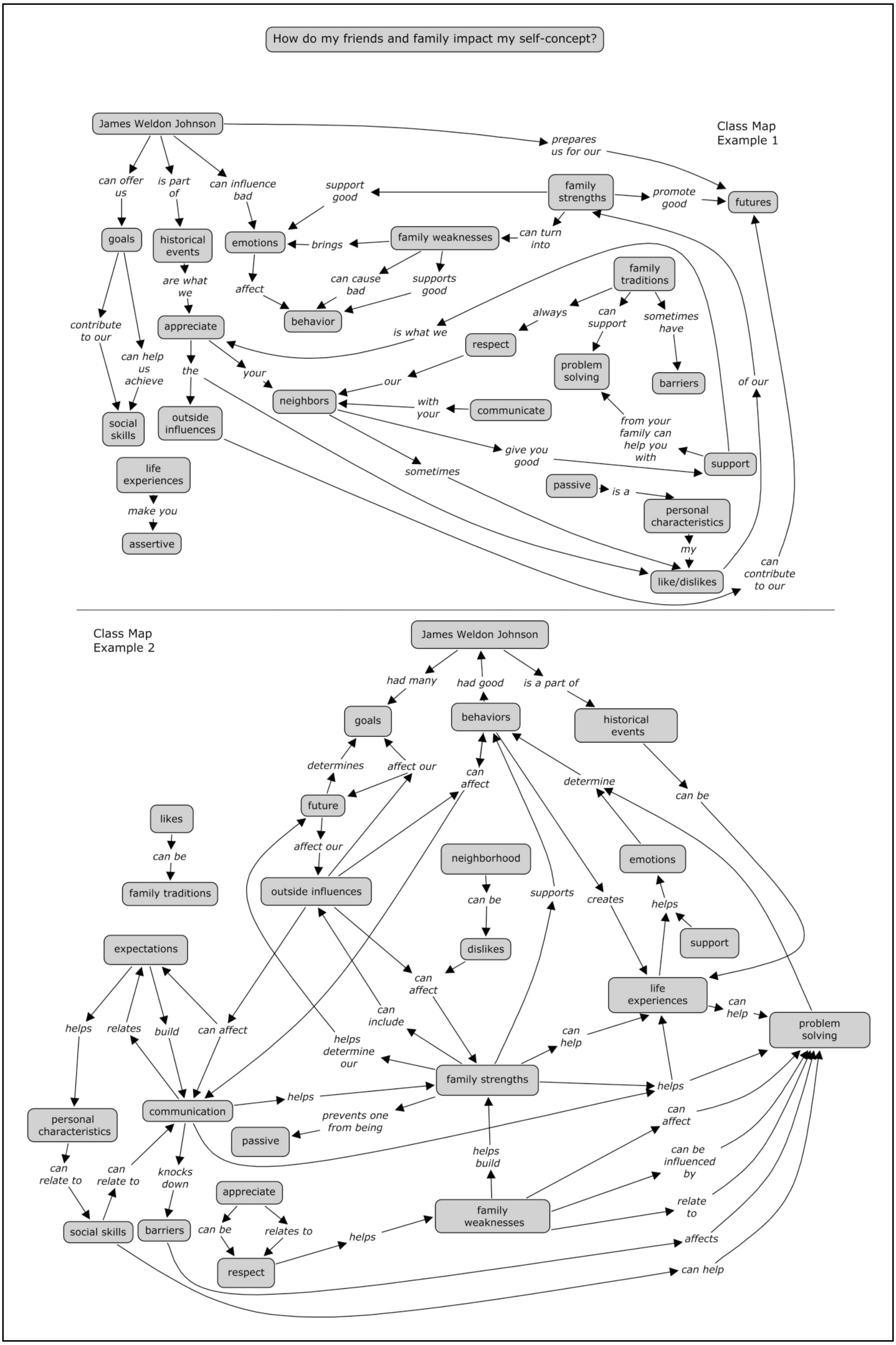


Figure 2: *Friends and Family* class concept maps generated using the Conceptual Card Game.

4.2 Spring 2011 Findings

Concept mapping assessment sessions were recorded allowing researchers to review the implementations of and student engagement during the Conceptual Card Game. This review process allowed us to compare and contrast the students' reaction to the game across the two settings. The students who produced the Figure 2 Example 1 class concept map were highly engaged—the first bonus points came during the fifth turn. Moderated by the teacher-researcher, during each turn, the teams engaged in rich discussions concerning the *correctness* of the propositions. These discussions also provided opportunities for students to edit and review language used in the propositions. After the seventh turn, the students began to acknowledge the list of possible linking phrases as a resource. As the game progressed, the student's engagement increased—it was also easier to make bonus points because the concept map was larger and more connections were possible.

Recordings revealed that students who produced Example 2 strategized earlier in the game than the students who produced the Example 1 map, and the Example 2 students scored the first bonus points during the third turn. The teams collaborated during their team's turn to edit their propositions and strategized during the opposing team's turns about bonus propositions. Team 2 students were more fully engaged earlier in the game than the Team 1 students.

At the end of the game, the teacher-researcher interviewed students concerning their thoughts about playing the game. The leading question in all interviews was a version of "*Tell me something about the concept card game you played today*." Follow-up questions elicited fuller information from the students. Table 2 provides transcripts of four interviews.

Girl 1 Interview Interviewer: Tell me something about the concept card game that you did today. Girl 1: It was kinda, it wasn't confusing, it was kinda hard because I kept getting frustrated because of the lack of time. Interviewer: What was frustrating about the time? Girl 1: 'Cause I couldn't think that fast in 1 minute—and I tried to get bonuses, but sometimes we wouldn't get the bonuses. I was frustrated. Interviewer: Was there anything you liked about the game? Girl 1: It was exciting because it's like a rush. I like games that you gotta rush and try to hurry up and do things—it's more interesting. Interviewer: Were you surprised about anything that people put on the map? Girl 1: Yea. Interviewer: Can you give me an example? Girl 1: I would get mad because it was super good, it was like better than what we did and I would get mad. Interviewer: Give me an example of something super good that was better than what you did. Girl 1: Like say *expectations* and *respect*. We would think of something all small and then they would think of something all—um what's the word [snapping her fingers]—intelligent. Interviewer: Was it easy or hard or just right? Girl 1: Just right.	**Two Boys Interview** Interviewer: Tell me, what did you think about today's card game? Boy 1: It helps your mind think. Interviewer: What makes you say that? Boy 1: … because we had to think of the ways to use two words in one or more sentence. Interviewer: Why do you think that is important? Boy 1: … to have more ways to communicate. Interviewer: Do you think the card game was fun? Boy 1: Yes, because we had to figure out ways to put the words in sentences. Interviewer: What did you think was easy about the card game? Or did you not think that anything was easy? Boy 1: It was both hard and easy. Interviewer: Tell me more. Boy 1: The easy part is that we had to like we could change the sentence. The hard part was making the sentence because uh you had to find out which word… Boy 2: … you had to figure out the words that make the sentence.
Girl 2 Interview Interviewer: What did you think of the card game? Girl 2: I think it was fun and challenging. Interviewer: Why and how? Girl 2: I think it was fun because, you like got the chance to write and put our thoughts out—of what we think the words mean and how they connect to each other. Interviewer: Why do you think that is important if you think it is important? Girl 2: I think it was challenging. Interviewer: Was it too hard, too easy, or just right? Girl 2: It was just right.	**Girl 3 Interview** Interviewer: Tell me what you thought about the card game. Girl 3: It was exciting and hard and easy—it sure did make me think. Interviewer: Why do you think that? Girl 3: Well, you had to put the names together like *James Weldon Johnson* and *support*—put together really fast to get points. In response to no particular question: Girl 3: I liked the way we could change things and how you could make it better.

Table 2: Concept Card Game Example Interviews

The interviews shown in Table 2 are representative of the collection of interviews and, for the most part, confirm our observations from the recorded lessons. Only one interviewee expressed dislike for the game and she simply did not enjoy team activities, either collaborative or cooperative learning. Girl 1's responses illustrate the issue of challenge. At one point, she indicates frustrations because of the time limit, and then says she likes to have to rush and hurry up. More than likely she was expressing the challenge of the game (her word: frustration), but that she enjoyed the challenge (her words: exciting and interesting). Girl 2 indicated the importance of having the chance to make their own connections. Surprisingly, two of the interviewees liked the chance to edit their work—this also comes across in the recordings. The students welcomed the opportunity to make their work better. In summary, students thought the game was exciting and interesting, thought the level of challenge was just right, were increasingly engaged, and developed strategies to win the competition.

A causal glance at the class concept maps in Figure 2 reveals differences in the topology of two maps. Neither concept map reflects a hierarchy, which is not uncommon when concept maps reflect processes rather than declarative knowledge. Maps can also contain cycles which show dynamic functional relationships among concepts. "A cycle is built from a constellation of concepts and represents a group of closely interconnected constructs" (Safayeni, Derbentseva, & Cañas, 2004, p.751). Topology can also be used to determine the relative importance of mapped concepts. One simple method is to look at the number of incoming and outgoing links (Leake, Maguitman, & Reichherzer, 2004).

Within Figure 2, the Example 1 map has simpler topology (with respect to important concepts when judged by the number of incoming and outgoing links) than the Example 2 map. The most important concept in Example 1 is *neighbors* which is involved in five cross-links: two incoming and three outgoing (5/2/3) for the number of links/incoming/outgoing, respectively. *Family strengths* (4/1/3), *family weaknesses* (4/1/3), *appreciate* (4/2/2), *likes/dislikes* (4/3/1), and *emotions* (4/3/1) form the second tier of important concepts. The Example 1 map exhibits only one cycle: *neighbors* give you good *support* is what we *appreciate* your *neighbors*. In contrast, the Example 2 map has three most important concepts: *family strengths* (9/3/6), *communication* (8/4/4), and *problem solving* (8/7/1). Additionally, Example 2 has two other important concepts: *behavior* (6/7/3) and *outside influences* (6/3/3). The Example 2 map also exhibits numerous cycles: a simple example involving all three most important concepts is *family strengths* help *problem solving* determines *behavior* can affect *communication* helps *family strengths*.

5 Discussion, Limitations, and Future Research

Discussion of the concept mapping activities focuses on the use of a game to motivate CROP participants to fully engage in a review of the impact of their friends and families on their self-concept. From the perspective of the game cycle, students expressed interest in the game and most indicated that they thought the game was exciting, fun, and challenging. The recorded lessons revealed that interest increased over time as indicated by student engagement, which lead to feedback from the game. As the game progressed students were able to score more bonus points (feedback) which in turn created more interest. Students, through their interviews and actions, indicated that the *correctness* discussions after the placement of every proposition was feedback as the review process provided affirmation as well as voice to their thoughts about the concepts. Students expressed that the challenge of the game was *just right*. Two students expressed that the required thinking provided the game's challenge.

The difference between the Figure 1 and 2 concepts maps is dramatic. Most concept maps produced in spring 2010 exhibited a hierarchy with few cross links or cycles. The spring 2011 group concept map did not exhibit a hierarchy and represented more causation. Both activities would be useful in review of the *Friends and Family* unit. The differences between the two Figure 2 concept maps might be explained by the differing contexts of the two schools. While both schools enrolled high percentages of minority students from low-income families, differences existed within the neighborhood attendance boundaries. Neighborhoods of the school enrolling the Example 2 concept map students encompass the most extreme forms of poverty—bringing with it high crime, drug trafficking, sex workers, and gangs. The CROP students at this school chose not to be involved in their neighborhoods; thus, it is not surprising that their concept map expressed *family strengths*, *problem solving*, and *communication* as the most important concepts rather than *neighborhood*.

Our findings are limited by the conceptual content of the game, the settings which supply the situational interest, and the differences in the parking lot of concepts used across schools in the 2011 activity. We feel that the card game was successful in activating students' thinking about how their friends and families influence self-concept. Because our settings created situational interest, others may or may not find similar usefulness when using different content and/or settings.

As can be seen in Figure 2, mapped concepts are not the same across examples. The games were played using the same deck of cards; however, parking lots were created during the initial review and the words used were not checked for correctness. It was only in the review of the resulting maps that we discovered the games were not exactly the same. Additionally, in many instances our labels for concepts were noun-forms of words more often used as verbs. More care in selecting labels for concepts might produce less unplanned difficulty. Our label choices combined with our suggested list of linking phrases, in too many instances, prompted passive voice which can be problematic.

Areas for future research include the influence of the rules of the game on the outcome map. The order in which the concepts are selected influences the concept map's topology. For example, students who produced Example 1 selected *communicate* during the games' third turn and *neighbors* during the fifth turn. Students who produced Example 2 selected *communication* and *neighborhood* during the sixth turn. Would the Example 2 map been different if the students had selected *neighborhood* earlier in the game and not with *communication*? Also, how would outcomes differ if bonus propositions were not limited to connections between selected concepts and concepts already on the map but rather the rules permitted bonus propositions between any two concepts on the map? Opening up this rule has the potential for reducing bias caused by the order of concept selection.

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Valletta, Malta 2012

CONCEPT MAPPING AS AN ASSESSMENT TOOL IN SCIENCE EDUCATION

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Abstract. Concept mapping is a method to determine the achievement of knowledge. Concepts are linked with labelled lines to proposition. The concepts create a graphical structured meaningful relationship. The method is also proved to be effective for testing, indicating well students' mentality and its structure. This article describes three case studies using concept maps as assessment tools. Two studies measured the necessity of animations describing abstract topics in chemistry. Memorizing time period, different learning materials, topics, and structure of animation were used as parameters. The third study detected the time when higher taxonomy scored concept maps were created. Could students find concept themselves from the exercise, or should they be given by the instructor? We argue that concept mapping method gives a unique possibility to visualize the structure of students' knowledge.

1 Introduction and theoretical background

The article aims to analyse how to use concept mapping for assessment. Concept mapping was used as data collecting method. Two studies aimed to analyse, how students understand animation and whether it is possible to collect data with that method for analysing such study.

Concept mapping method was developed by Joseph Novak's research team in early 1970s. The method is based on the *meaningful learning* theory of Ausubel (1968). It assumes that learners construct knowledge, being already influenced by previous knowledge. Concept maps consist of concepts (words, things, pictures, symbols), which are linked with labelled lines to proposition (Reiska et al 2008; Novak et al 1983). It is a collection of propositions constructed in a certain way. It expresses graphically structured meaningful relationships existing between different concepts (Ruiz-Primo et al., 1997). Concept maps can prevent rote learning, to summarize already studied knowledge or class discussions, to create presentations etc. They can also be used as assessment tools to detect students' mentality and its' structure (Gouli et al 2003, Novak, 2010). There are some weaknesses of the concept mapping as an assessment tool. Creating acceptable structure of cards could be hard for novice. For instructors, it may be hard to evaluate the result (Chang et al. 2005). Validity and reliability of concept maps has also been questioned (Ruiz-Primo and Shavelson 1996; Ruiz-Primo, 2004).

To evaluate concept maps, we need certain dimensions for measuring. Cañas *et al* (2006) developed a topological taxonomy for evaluating created concept maps. Topological levels were defined by five criteria: 1) recognition and using concepts 2) presence of linking phrases 3) degree of ramification 4) hierarchical depth and 5) presence of cross-links (Reiska et al 2008). The taxonomy consists of 7 levels: from 0 to 6. Maps valued 5 and 6 were considered as satisfying almost all criteria. There are several measures for analysing concept maps: number and quality of propositions, size and hierarchy of the concept map, clusters of maps**.**

Concept maps can be used for formative assessment (Trumpower and Sarwar 2010). This must identify student's strengths and weaknesses.

Cañas, Bunch and Reiska created the software program *CmapAnalysis* to assess concept maps. It enables to analyse various algorithms, rubrics and techniques of concept maps. Parameters can be defined by the researcher. The software helps instructors, researchers and teachers to have automatically routine analytical operations (Cañas et al 2010). *CmapAnalysis* software supports a) taking input Cmaps in the open CXL file format (in addition to the cmap format), allowing the analysis of concept maps developed by concept mapping programs that utilize CXL, b) users are able to add other measures to the program. *CmapAnalysis* enables to measure different categories: size, quality, and structure.

Animations as moving illustrated materials are used at schools to depict dynamic changes over time and location and to illustrate phenomena or concepts that might be difficult to visualise (Nakhleh, 1992; Mayer & Moreno, 2002). New methodologies and visualisation technologies enhance students' understanding of central scientific concepts (Kozma & Russel, 2005; Soika, 2007). The effectiveness of the animation depends on the student's personality (Mayer & Moreno, 2002), structure of the used animation and the method of using the animation in the classroom (Ruiz et al., 2009; Wu & Shah, 2004).

2 Case studies

Three studies were carried out in 2010 and 2011. For every study we had different research questions, but every time one of the data collecting methods was concept mapping. Our previous study (Soika et al 2010) pointed out that concept mapping method allows analyse structure of students' knowledge better than questionnaires.

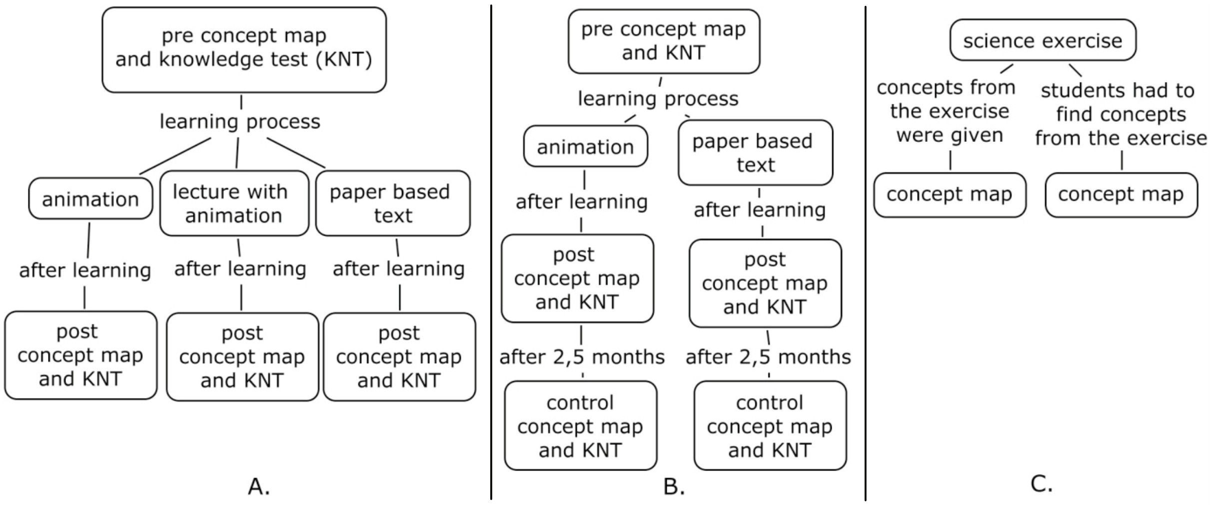

Figure 1. Structure of data collection in three different case studies

2.1 First Study

Aim: to investigate the impact of animation to student knowledge. **Research questions:** 1) what impact animation has to the students' knowledge, if students are studying individually? 2) Are there any differences in students' knowledge if the same animation is explained by a teacher? 3) Are concept maps of different groups of students similar? 4) Which group create more high valued propositions, those, who studied from the animation, or those, who read the paper based text? Our previous study (Soika et al 2010) shows that after concept maps analysis, students from various groups had created absolutely different concept maps. We had to examine these results.

Data collecting and analyzing: 77 students were divided into three groups. One group studied individually from the animation. For the second group, animation was supported by teacher explanation. The third group studied the same topic individually from a paper based text. Studying material was identical and new for students. The main data collecting method is shown in Figure 1. A. Students had to create 2 concept maps from 20 given concepts in appointed time. Pre- and post- concept maps were analysed with software *CmapAnalysis*. Content and correctness of the sentences were assessed manually. Results were compared in MS Excel. Results:

Students group	proposition count [1]	Proposition quality [2]	taxonomy score [3]	knowledge test (KNT)
Animation	2,63	0,19	-0,27	0,21
teacher explained animation	5,56	0,20	1,25	0,31
Paper based text	4,58	0,29	0,97	0,27

Table 1 Average changes in measures per students

The best results are for a group, who studied from an animation, when a teacher was explaining- the results seem to be similar to the group, who studied individually from the paper. The group, who studied individually from the animation, had different results.

[1] Proposition count - the number of propositions (i.e. concept-linking phrase-concept) in the map. Min and max

[2] Proposition quality – proposition „mark", where an expert has decided if the sentence is right or wrong and evaluated the proposition with a number.

[3] Taxonomy score – is calculated by different measures; it includes: average words per concepts, branch point count, concept count, linking phrase count, separated concepts count, proposition count; count of concepts, that has outgoing connections but no incoming connections (root child), sub map count; it is expresses with a number between 0 and 6 where higher scores typically indicate higher quality concept maps.

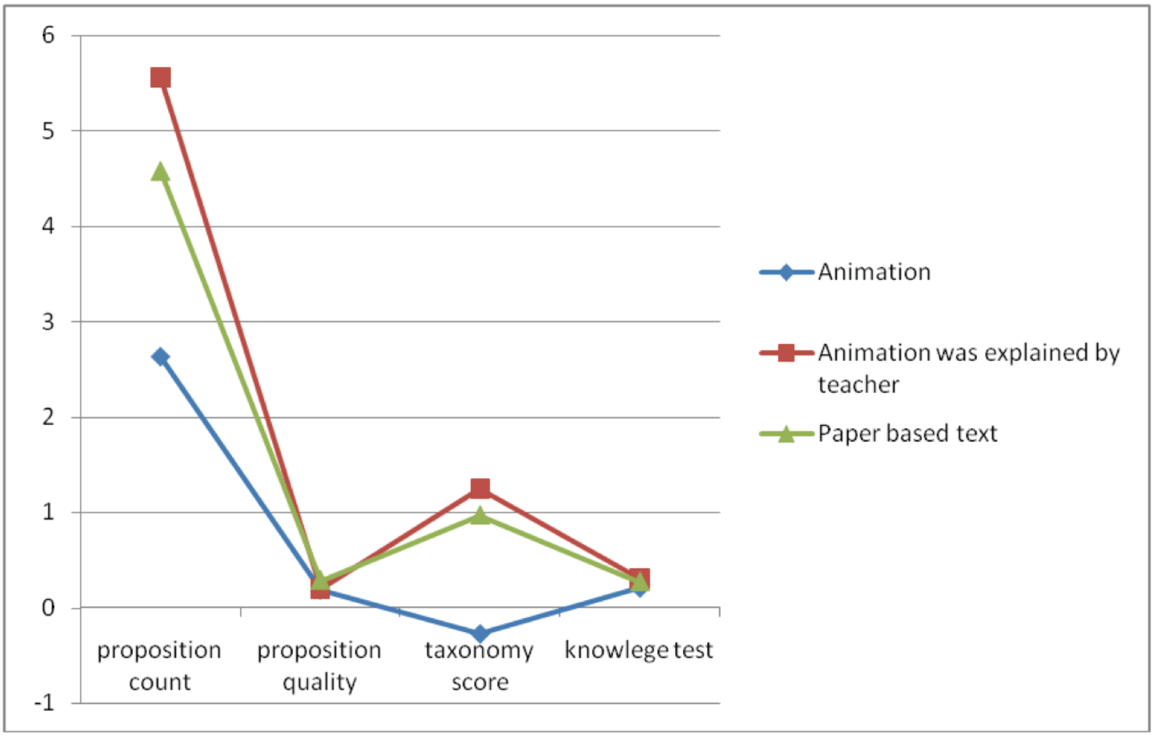

Figure 2. Changes in values of different measures

Results: The structure of created concept maps depends on the studying method, but we can't see such difference in the results change of knowledge test. If students are studying individually from the paper based text, the results are better than when they have been studying individually from the animation. The taxonomy score of the group, who studied from the animation fell. Concept maps of that group also didn't have so many new propositions.

2.2 Second Study

Research questions: 1) What impact do the long time period has to knowledge based concept maps? 2) Are there any differences in knowledge of various groups of students? 3) What kind of similarities are in concept maps of various groups?

Data collection and analysis: 62 students were divided into two groups. One group studied individually from an animation. The second group studied the same topic individually from a paper based text. Studying material was identical. The main data collection method is shown in Figure 1. B.
Students had to create 3 concept maps in appointed time from 22 concepts given to them. Pre concept maps (were made before learning), post concept maps (were made in the same day after learning) and control concept maps (were created 2, 5 months after learning), were analysed with CmapAnalysis software. The content and correctness of the sentences were assessed manually. Results were compared in MSExcel. Most important results of the study were:

	group of students	proposition count [4]	proposition quality [4]	taxonomy score[4]	knowledge test (KNT)
Before and after learning	Animation:	-0,83	1,03	0,084	0,95
	Paper based text	5,7	0,47	0,54	0,87

[4] See footnotes behind Table 1

Before and after 2,5 months learning	Animation	-0,5	0,365	0,41	0,31
	Paper based text	-0,6	0,475	0,44	0,30

Table 2. Average changes in measures per students

Results: After learning from animation, concept maps of students were similar to each other and had less propositions than maps made after learning from the paper based text. The studying method impacted connections between concepts. We also had a question based knowledge test before and after learning process. There were no significant differences of changes between different groups. After 2, 5 months control maps of both groups were similar again. There had been an influence in students' knowledge.

2.3 Third Study

Aim: to understand how to collect data from students who have to connect concepts from a science exercise.

Research questions: 1) what kind of concepts are students going to find out from the narrative science exercise? Are these concepts similar/ same for concepts found out from the same exercise by teacher? 2) Do different conditions measure same results of learning? Conditions were: a) students had to create a concept map in appointed time from given 20 different level exercise based concepts, b) students had to find 20 concepts from the exercise and to create a concept map in appointed time.

Data collection and analysing: 54 students were divided into 2 groups having the same exercise. Students had to read the text, to find answers to different level multiplied questions. Thereafter they created a concept map, which had to describe natural science and everyday life connected purport of the exercise. They had 20 minutes to read and solve the exercise and 20 minutes to create a concept map about the exercise. We analysed these maps manually and with the software.

Results: Students, who had got certain concepts created higher taxonomy scored maps and more propositions per students than other group (average taxonomy score 3,75/ 3,03; average propositions per students 18,5 /16,6 (illustrated in Figure 3.)). Looking at maps, we notice visual difference (Figure 5, Figure 6.). Of course the result depends on the given concepts. In our study 14 concepts of 16 most represented self found concepts were given also from the instructor to the other group. In appointed time students are going to create higher taxonomy scored concept maps (which also point out more their visual background), when certain concepts are given to them.

Calculation differences in connections for three most central concepts offer opportunity to analyse the structure of the whole map. When we didn't give concepts, the map of concepts was as a "star". When we gave concepts, the connections between concepts created network (diagram in Figure 4 Illustrative concept maps are in Figure 5 and Figure 6.).

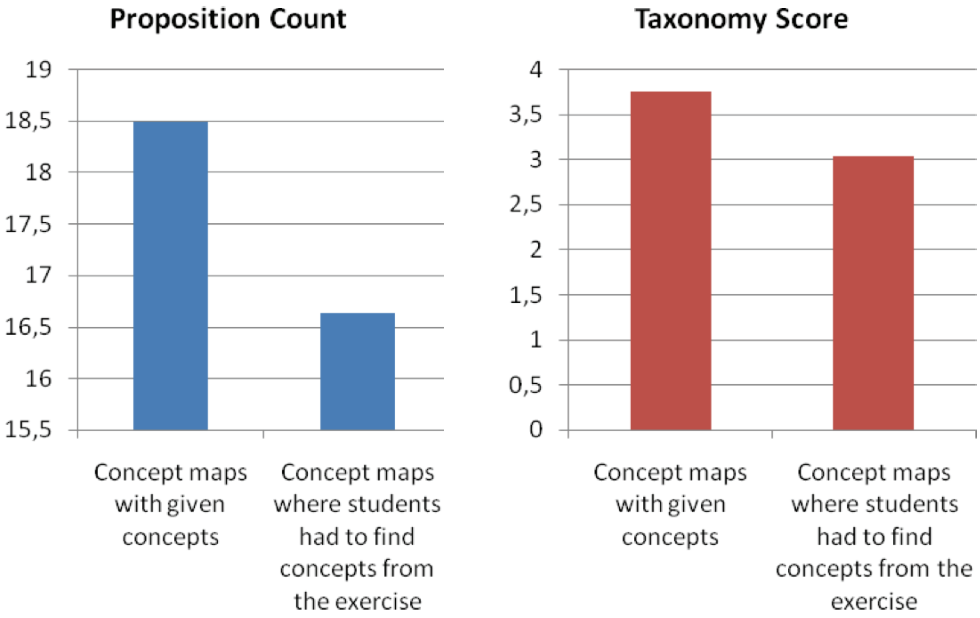

Figure 3. Differences in proposition count and taxonomy score of various groups of students.

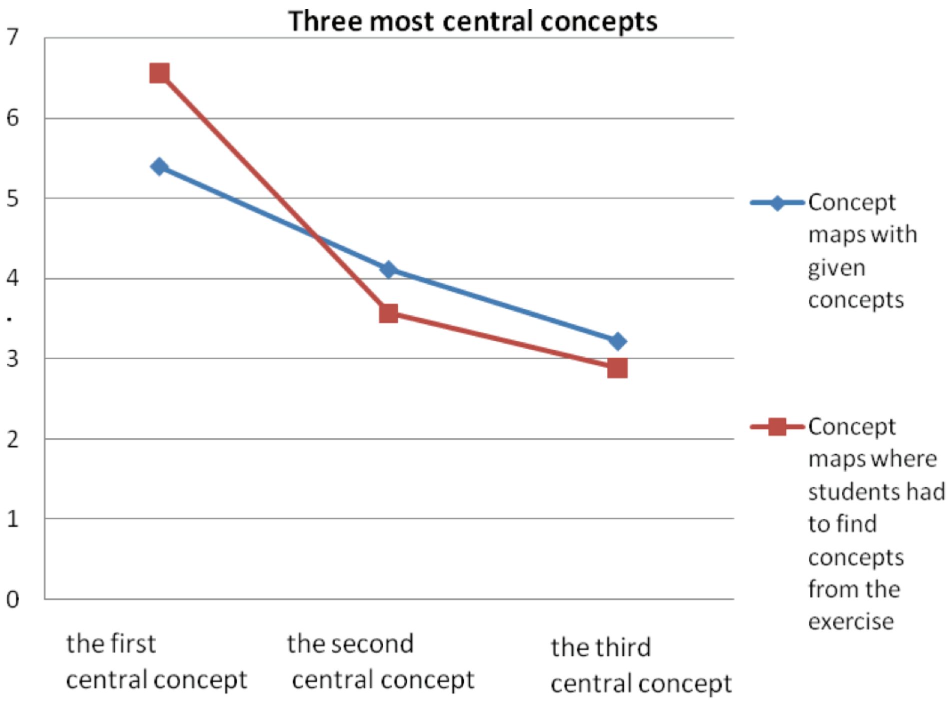

Figure 4. Differences in links of three most central concepts in various groups of students.

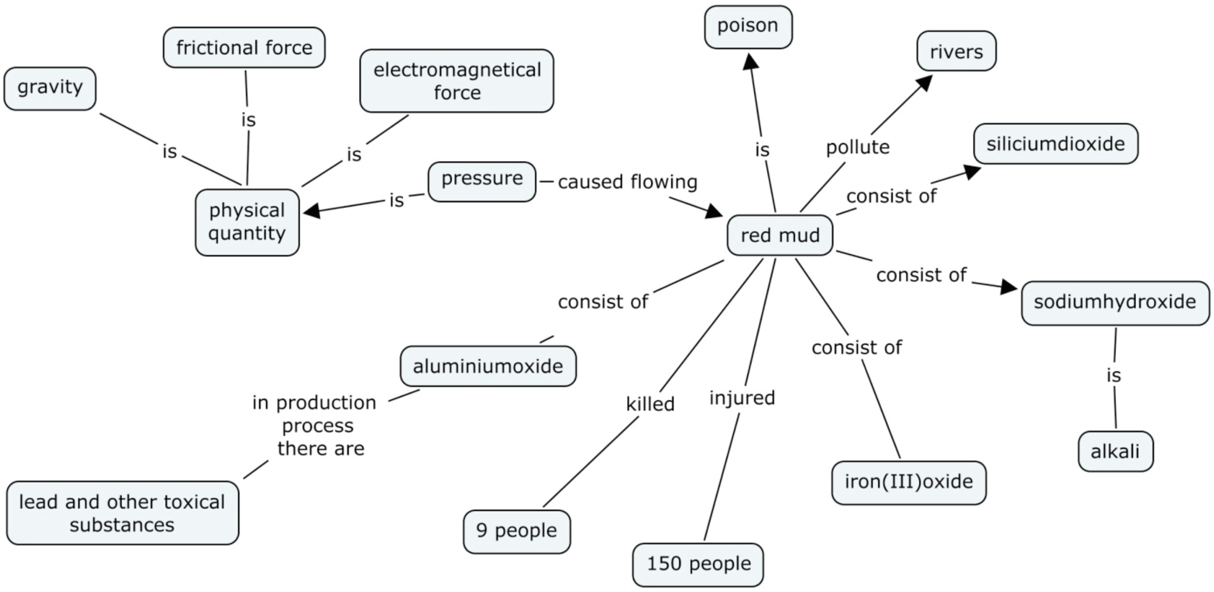

Figure 5. A concept map, made by a student, who had solved a science exercise and had to find concepts by herself from the exercise.

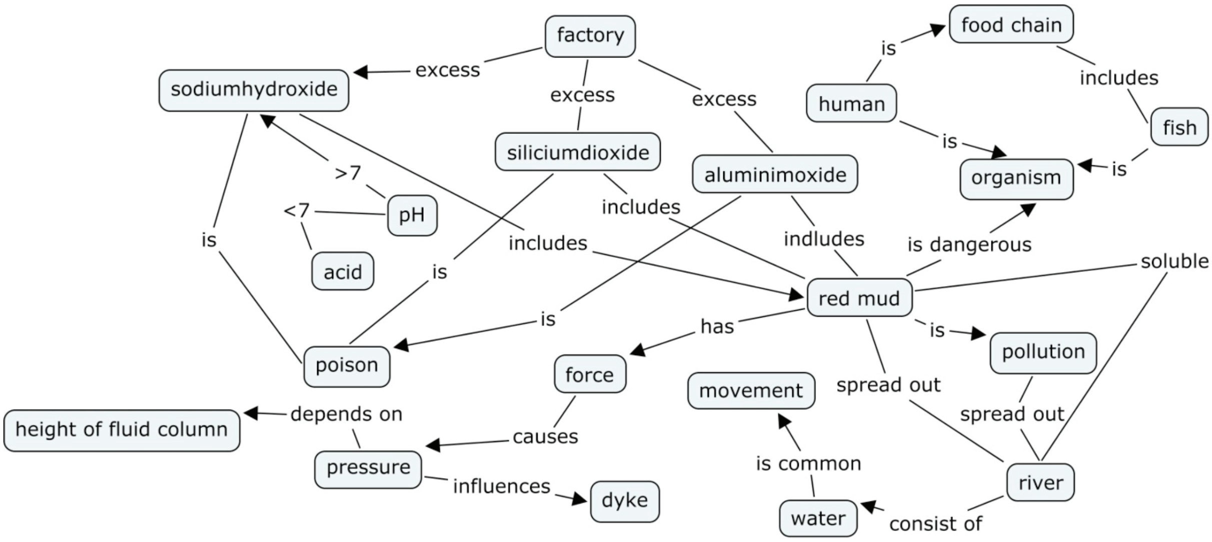

Figure 6. A concept map, made by a student, who had solved a science exercise and had got certain concepts about the exercise from the instructor.

3 Discussion

Concept mapping method could be used as an assessment tool. We couldn't see such differences in students' knowledge with any questionnaires as we noticed in our two studies about the animations. The new national curricula for basic and secondary school (2010) set new purposes and competences developed at school. New assessment tools are needed to assess these competences. Teachers must use more formative than summative assessment.

Our studies revealed the potentiality of concept mapping method. It is easier to understand the knowledge of students with concept maps than with ordinary tests. Concept mapping is not the only "right" assessing tool, but this is an opportunity for evaluating students. Our third study revealed that while using concept mapping to assess students, we must remind the purpose of the work. The result depends deeply on that.

4 Acknowledgements

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Concept Maps: Theory, Methodology, Technology
Proc. of the Fifth Int. Conference on Concept Mapping
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CONCEPT MAPPING IN THE TEACHING OF PHYSICAL SCIENCE: ASSESSMENT OF REAL WORLD APPLICATIONS OF WAVE ENERGY BY PRE-SERVICE TEACHERS NEGOTIATING CONCEPT UNDERSTANDING

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Abstract Understanding the relationship between sound, light, and electricity can be a very challenging topic for pre-service students in a physical science class at the undergraduate level. Traditional lecture materials usually present this material as discrete topics. For this reason concept maps were used to develop an instructional unit on wave energy. Hands-on lab activities, and interactive computer simulations additionally supplemented instruction for each section of the unit. The effects of the use of concept maps were determined by a pre-post-test design. In addition to fill-in-the blank concept maps, students were asked to create group and individual concept maps, which were used to track their understanding of these concepts. The way this knowledge was applied largely depended on the students' understanding of electromagnetism. In particular it was observed that the participating pre-service students demonstrated capacity for distinguishing between the different conceptions of application of wave energy. Only students with a developed capacity for distinguishing between models were able to reason in a logical manner. They recognized the limits of models and were not only able to specifically designate changes from models and levels of models, but also to apply these in an accurate manner.

1 Introduction

Understanding the relationship between sound, light, and electricity can be a very challenging topic for pre-service students in a physical science class at the undergraduate level. For this reason an instructional unit-using concept maps on wave energy was developed. Hands-on lab activities, and interactive computer simulations additionally supplemented instruction for each section of the unit.

These pre-service students were enrolled in an Integrated Sciences: Physical Science course, a pre-service teacher science course in the Early Childhood Special Education program at a College in Central Georgia. They were involved in a two-week-long thematic learning unit to examine the relationship between different forms of wave energy. In order to answer the question "how do we make science real", pre-service students were required to build an electromagnet to power either a bell or a light bulb. The pre-service students had been introduced to the concepts of Wave Energy in their undergraduate classroom.

Besides analyzing the overall effects of using concept maps to enhance pre-service student understanding, the evaluation tracked their ability to successfully apply their understanding to the real-world use of wave energy. The study examined the following scientific question: What is the impact of concept mapping used by pre-service students on the comprehension of the basic concept of wave energy? The research was based on the hypothesis that pre-service students, who have developed an understanding between alternative conceptions, use models confidently and appropriately in the context of wave energy, while pre-service students without this capacity for distinguishing between alternative conceptions are not able to explain wave energy consistently.

Teaching science to elementary pre-service teachers typically involves boosting their self-efficacy towards science, overcoming popular misconceptions and content inaccuracy, and helping them develop scientific reasoning in order to engage in problem-solving by using methods of science inquiry. Communicating scientific ideas in the absence of a real-world context leaves pre-service teachers with a superficial understanding of the relevance of science in everyday life. Whereas, being able to visualize their own learning about physical science principles fundamental to wave energy and applying their understanding to find a real-world situation becomes a creative act, involving real-world experiences filtered through developing understandings translated into new teaching possibilities.

2 Theoretical Framework

Concept mapping in its elemental form is a learner-centered process. The process of constructing a concept map is a powerful learning strategy that forces the learner to actively think about the relationship between the terms. This makes concept mapping especially suited to science education as the learners often perceive, incorrectly, that studying science means simply memorizing facts (Dorough and Rye, 1997). The versatility of concept mapping allows use both for instruction (Martin, 1994; Mason, 1992) and for assessment (Stoddart et al., 2000;

Schau et al., 2001). The instructor can thus implement concept mapping based on the area that best suits the topic and the learning environment.

An increasing number of studies highlight the use of fill-in-the-blank concept mapping in identifying students' prior understanding of a particular topic (Yin *et al*. 2005). In addition, concept maps can also be used to promote cooperative learning. During group concept mapping students work in small groups and discuss their understanding of a topic and then collaborate together to produce a group concept map. This approach engages students in discourse about the concepts and encourages students to articulate their thoughts about, and experiences with, the concepts (van Boxtel *et al*, 2002). Since the group of students work on the same map, it helps strengthen interdependency and negotiation between the collaborating students.

Fill-in-the-blank concept maps can be used as 'advance organizers' and formative assessment of student conceptual understanding. Teachers/students can construct a concept map, which focuses on content in the upcoming lessons. This allows individuals to identify the connections between their existing conceptions and the new material being introduced. With concept maps, information can be presented in a concise manner without the loss of complexity and meaning. The visual presentation allows the students and teachers to accurately identify the relationship between different topics without the dense presentation of words and verbal compositions (Gul and Boman, 2006).

3 Methods

Pre-service students' understanding about the unit on wave energy was determined by a pre-post-test design. In addition to fill-in-the-blank concept maps, students were asked to co-construct concept maps, which were used to track application to a real-world model construction. A total of 64 pre-service students from 5 different sections of the course participated in the study; so the pre-post test analysis consisted of a total of 128 fill-in-the-blank concept maps and 64 co-constructed maps. These students were enrolled in 5 different sections of the course over a period of three semesters, between Fall 2010 through Fall 2011. For the purpose of analysis, the student concept maps were sorted into two groups: Group A, were concept maps from students who were able to successfully complete the final lab activity; and Group B, were concept maps from students who were unable to successfully complete the final lab activity.

The fill-in-the-blank concept maps to be worked on by the pre-service students consisted of 10 sets of propositions, which had been extrapolated from a feasibility study with previous-groups of pre-service students. Recent research has shown that the more constrained the map structure, of fill-in-the-blank maps, the higher was the reliability correlating to other forms of classroom assessments (Schau et al., 2001). For the purposes of this study, the fill-in-the-blank student map scores were appreciable when compared to co-constructed concept maps and the final lab activity.

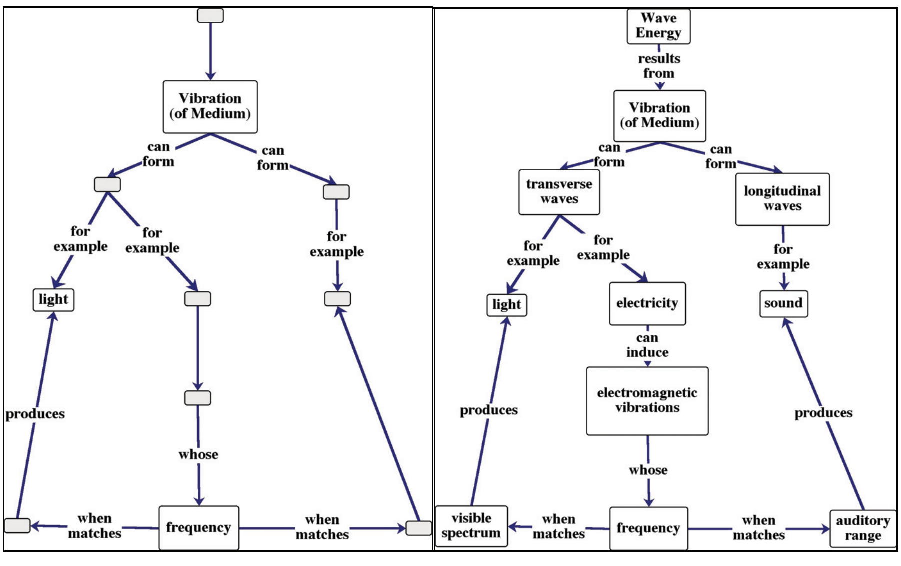

Figure 1: (a) Sample fill-in-the-blank concept map [on left, missing concepts in gray boxes & linking terms] and **(b)** comparison completed map [on right] used for pre- and post-test

The participating students were asked to fill-in either terms and/or linking terms. Sample templates of fill-in-the-blank maps and completed expert map used for the pre- and post-test were generated according to Figure 1a & 1b. Data from individual student fill-in-the blank concept maps were then analyzed based on their contents, and the structural parameters of the student maps based on accuracy of propositions were compared to the completed expert map. During the implementation of the unit, participants were also exposed to hands-on activities on each sub-topic for example light and electricity. Student comprehension of relationship between concepts regarding wave energy was measured by whether they could translate their understanding directly as applied to the lab activity of building an electromagnet without instructor guidance. The lab activity was conducted during class under strict guidelines to use only the materials provided by the instructor.

4 Results

In the pre-test, students in Group B demonstrated only rudimentary knowledge of wave energy; yet, the concepts of energy transfer were linked by logically correct propositions. The expressed knowledge was however reproduced from the students' rote knowledge. Students in Group B were not familiar with the formation of magnetic energy due to electricity. The propositions connecting the concepts confirm misconceptions regarding visible electromagnetic waves (Figure 2). The post-test and co-constructed maps show that structural development of concepts is evidently triggered by the ability to visualize concept understanding (Figure 3).

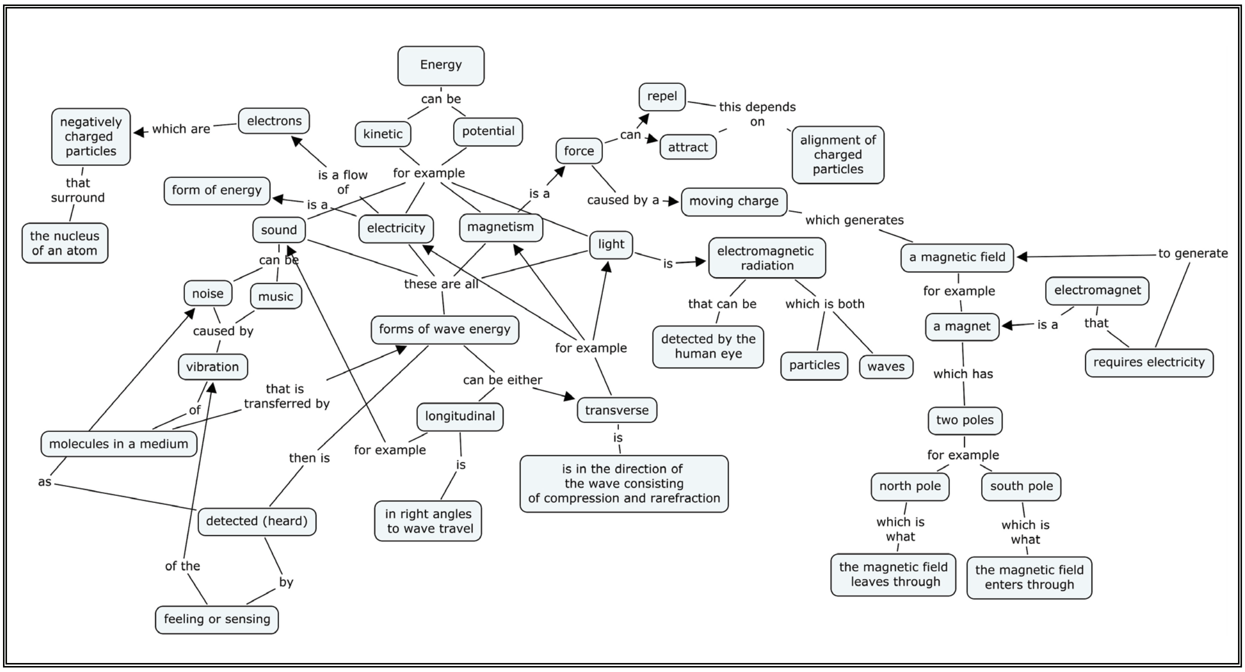

Figure 2: Example of a concept map co-constructed by students from Group B.

The comparison of propositional knowledge between the different types of concept maps (fill-in-the-blank and co-constructed) indicates that there was not only a highly significant increase in knowledge for each group of students, but also that this knowledge was consolidated. The analysis of student knowledge/understanding focused on concepts used for both types of concept maps, i.e. fill-in-the-blanks and co-constructed, were specific to concepts related to wave energy and allowed for a valid comparison of the accuracy of propositional knowledge presented in the student concept maps. Accurate relationships between concepts related to wave energy provided the degree of student understanding about these concepts. The consolidation of this knowledge largely depended on whether the pre-service students were able to accurately build an electromagnet and harness the energy to either ring a bell or light a bulb (Figure 3).

Analysis of the pre-test concept map shows evidence that students find it challenging to connect the different aspects of wave energy (Figure 3: Group B, n=50). Only those pre-service students, who had developed a deeper understanding of relationship between concepts were able to correctly apply their knowledge to accurately complete the required lab activity (Figure 3: Group A, n=14). They were consistently able to build an electromagnet, without instructor-guidance, and apply the electromagnetic energy to power the bell/bulb. Group A pre-service students were able to construct an electromagnet, present their propositions in a logical manner (Figure 4), recognize the limits of models and in levels of models, by applying their understanding to harness electric magnetic energy.

Pre-service students (Group B), without this capacity for recognizing the transformation between different types of wave energy were unable to successfully complete the lab activity (kept searching for a magnet among their lab materials to use in their model) and showed inconsistent patterns of explanation more frequently than pre-service students who exhibited a deeper understanding (Group A). This also correlated to the higher percentage of correctly marked propositions in Group A post-test concept maps.

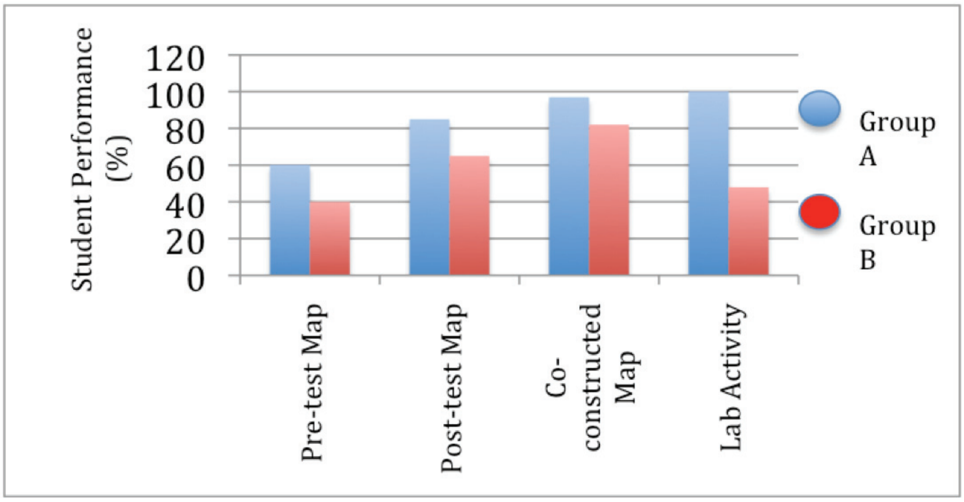

Figure 3: Graph showing pre-service student understanding of concepts as related to wave energy. Group A represents students successful in lab activity and Group B represents students unsuccessful in lab activity.

End-of-term course evaluations suggest that 100% of students from Group A and 50% of students from Group B reported that they benefitted from using the concept maps to monitor their own learning. About a third of the students from Group B indicated that they found concept mapping challenging and not helpful to their learning because the course material in itself was challenging. The last 20% students from Group B did not responded to the end-of-term course evaluations. All students who responded to the course evaluation reported that engaging in group discussions, while co-constructing the concept maps, helped them figure out gaps in their understanding of wave energy.

5 Conclusions and implications

The findings of this study confirm the positive impact of knowledge visualization for introductory survey courses at the undergraduate level. The capacity demonstrated by the pre-service students for distinguishing the relationship between the different forms of wave energy is of critical importance. Pre-service teachers, especially training to teach in elementary classrooms, are key in introducing science concepts accurately at the elementary school level. Therefore, more attention should be paid to the development of meta-conceptual awareness in physical science classes, so that the relationship and interdependence between concepts can be discussed and re-examined.

There is no shortage of new developments in the world of science education, to help teachers teach new information to students in a way that promotes meaningful learning. However, many of the tools required for teaching science require additional resources and a large amount of time for re-tooling and implementation. These factors often create challenges and constraints for classroom teachers. While concept mapping can offer a technique for revealing students' cognitive structure, the instructor and learner need to be well trained in the art of concept mapping before it can easily be subsumed within present classroom constraints.

What concept mapping is, is an alternative way of representing scientific knowledge differing from the usual written text in that information is presented in a hierarchical manner. Concept mapping gives students the freedom to answer a specific focus question using concepts that they understand and hence encourages meaningful learning. Concept maps are extremely versatile and can be used both for instruction and assessment.

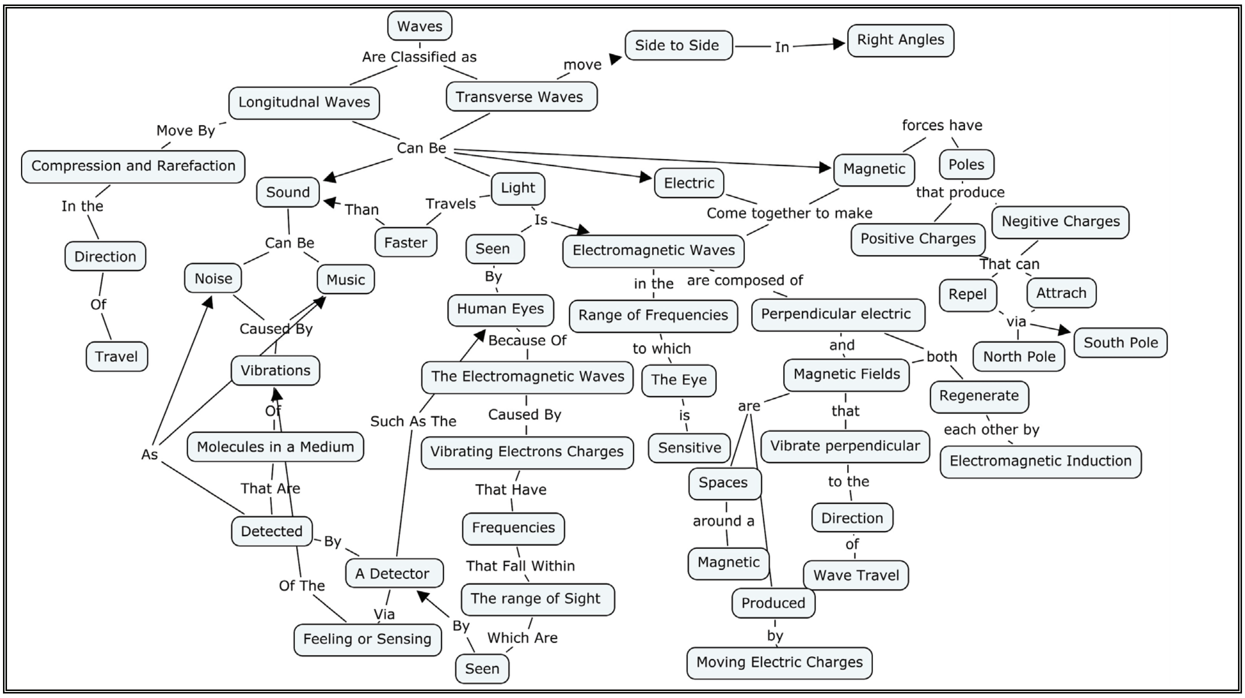

Figure 4: Example of a concept map co-constructed by students from Group A.

This study suggests that Concept Mapping can serve as a useful tool in science education by helping students to understand concepts more easily, link prior understanding to new knowledge and represent their understanding of those concepts. The majority of pre-service student participants reacted positively to the use of concept maps and felt that it has several benefits to their own learning and for their future career in teaching. The findings from this study show that it is of advantage that discussions based on co-construction of concept maps are implemented in introductory science courses, especially physical science, and that the students have the opportunity to scrutinize the limits of their understanding by visualizing their own learning through concept application.

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CONOCITY: VÍDEOS ENRIQUECIDOS CON MAPAS PARA LA GESTIÓN DEL CONOCIMIENTO

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Abstract. La facilidad para expresar el conocimiento y difundir sus representaciones a todo el mundo es una de las mayores ventajas del desarrollo de la Web20. Más allá de los canales tradicionales de comunicación, sin tener grandes audiencias, se puede expresar, representar, compartir y publicar el conocimiento con facilidad, utilizando las nuevas herramientas. La Web 2.0 surgida en el 2004 posibilita una nueva forma de consumir y usar la información, lo que ha supuesto un cambio comunicativo, reflejado en la peculiar distribución de las audiencias (lo que se denomina "la larga cola"), porque ha cambiado la gestión de atención de los usuarios de Internet, obligando a los medios tradicionales mayoritarios, a volcarse en las redes sociales. En la ponencia se presentarán las características básicas de los vídeos enriquecidos con mapas conceptuales, su potencialidad educativa, así como las tecnologías de representación conceptual para visualizar las estructuras cognitivas y el género narrativo empleado. Se repasan las estadísticas de utilización de estos vídeos: inserciones en webs y blogs, menciones en publicaciones digitales etc. que YouTube y las herramientas de Analitics ofrecen. Finalmente se comentarán una serie de posibilidades y líneas de avance que puedan ser útiles para otras organizaciones e instituciones que quieran usar estrategias similares de gestión y transferencia de conocimiento, como las prototipadas para enseñar y aprender en Conocity.

1 Introducción: el contexto comunicativo y educativo para los nuevos aprendizajes

La idea de Conocity surge por la necesidad de aprender, y comunicar lo aprendido, en la nueva época de las comunicaciones. Empezó siendo un sencillo bloc electrónico personal, en el que apuntar las cosas que no debían olvidarse. Y recogía las recomendaciones, informaciones y sitios en los que localizar los "contenidos de aprendizaje" de los estudios universitarios. En el año 2006, para poder cursar asignaturas virtuales comienza el uso de las herramientas gratuitas que ofrecía la red (blogs en blogspot, vídeos en YouTube, escritos en Writely, etc). De aquella época es el mapa de la Figura 1 sobre la Web 2.0 que resumía una primera visión de la red,

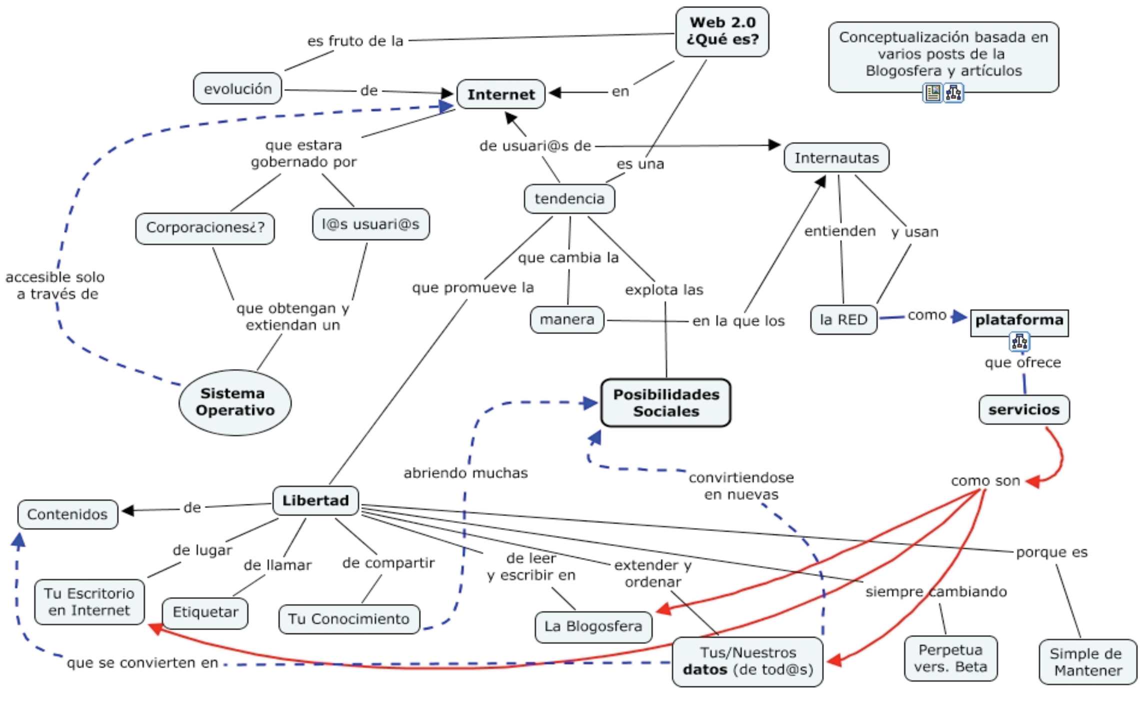

Figura 1. MC sobre la Web 2.0, elaborado en el 2006, al de poco de nacer y conocer esta nueva manera de entender la red.

Durante varios años, hasta acabar los estudios de Comunicación Audiovisual en la UPV (2009), esta ha sido la manera mas efectiva, rápida y generosa, de compartir las ideas de otras personas para utilizarlas en mi aprendizaje; como de compartir, hacer público y comentar los aprendizajes: todo un sistema de enseñanza-aprendizaje, sin coste económico añadido. Y con todos los aprendizajes construidos, en el 2010, coincidiendo con el CMC2010 (Sánchez et al, 2010), dió el salto a la nueva ubicación y el nuevo formato, basado en los vídeos enriquecidos: Conocity **(**blog conocity.eu**)**

2 Algunos antecedentes: relatos y narrativas del conocimiento en la red

Los años de estudio y profundización en Comunicación AV, han posibilitado el conocimiento del relato AV. Si relato es una forma de narración (de extensión breve) para contar una historia, poniendo énfasis en determinados momentos decisivos... coincidiremos que es una estructura discursiva caracterizada por la heterogeneidad narrativa. La narración es a la vez un proceso y un resultado de la enunciación narrativa, es una manera de organizar un texto narrativo. Y Sánchez Navarro (2006) dirá que "los seres humanos damos sentido al mundo que nos rodea mediante la construcción y el intercambio de historias posibles".

Ya Aristóteles creía que las historias causan placer por su imitación de la vida y de su ritmo peculiar. Y seguramente por eso se utilizan los relatos, porque resultan placenteros, porque entretienen a quienes las escuchan, ven o leen, produciendo algún cambio en su estado de animo o mental. Sánchez (2006) plantea que los textos expositivos narrativos circulan porque sus historias son dignas de explicar, porque valen la pena; y responde a estas 5 preguntas básicas, similares a las famosas 5 Ws:

1. ¿quién habla?
2. ¿quién habla a quién?
3. ¿quién habla y cuándo?
4. ¿quién habla y con qué lenguaje?
5. ¿quién habla y con qué autoridad?

En el siguiente esquema se intenta recoger este acto y las situación comunicativas, expresadas por Sánchez Navarro en "Narrativa Audiovisual" (2006).

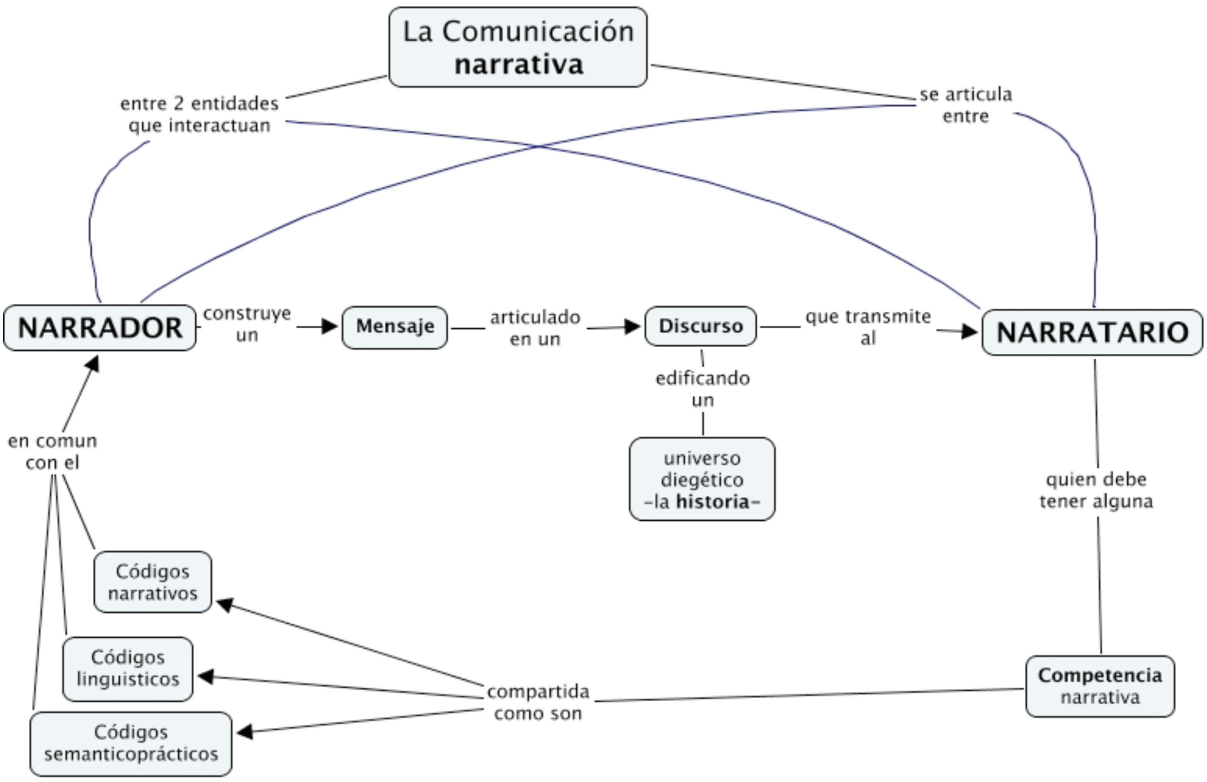

Figura 2. MC de la Comunicación narrativa, elaborado con las explicaciones de Sánchez Navarro en su libro "Narrativa Audiovisual".

2.1 La Narración Audiovisual

Peña Simón (1990) hace referencia al concepto de imagen, como "categoría organizadora del pensamiento humano, ya que la imagen constituye tanto una forma de ordenación como de representación de la realidad ordinaria. Y la Narración Audiovisual (..) es una de las múltiples formas de manifestación que, de forma similar a los lenguajes y metalenguajes escritos y no escritos, posee la categoría principal de imagen para ordenar y representar la realidad sensible. (...). La imagen es por tanto, uno de los múltiples sistemas de representación de la realidad sensible, que intenta aproximarse lo mas posible a ella.

El relato audiovisual ha de tener una estructura discursiva constituida por una narración con diferentes materias y sustancias expresivas (visual, sonora etc.) construida con uno o mas sistemas semióticos o conjuntos significantes, donde el autor implícito ha dispuesto de una determinada manera las categorías discursivas y ha previsto una estrategia discursiva desde la perspectiva de la pragmática narrativa, ordenado en un soporte Audio-Visual, actualmente digital, que normalmente añade algún tipo de interactividad con quien lo ve/oye/lee. Francisco García les llamará lecto-autor y auto-lector a estas nuevas formas de participación en la construcción y apropiación de la ficionalidad, en el contexto de unas nuevas formas de fabricar y consumir ficciones en el espacio digital, traspasando la linealidad con la hipertextualidad, y estableciendo una interatividad y unas nuevas relaciones narrativas entre el autor, el texto y el lector, abriéndose nuevas formas de participación.

Esta nueva manera de entender y practicar la comunicación en la red, que se asimila a una nueva actitud Web20, ha recibido varias denominaciones: desde Emi-Rec utilizada por el profesor canadiense Jean Cloutier en los años 70, también llamados en la red prosumidores, mezcla de productores y consumidores, o la de *produsuarios*, productores y usuarios, que se refleja en este mapa conceptual albergado en la UPNA.

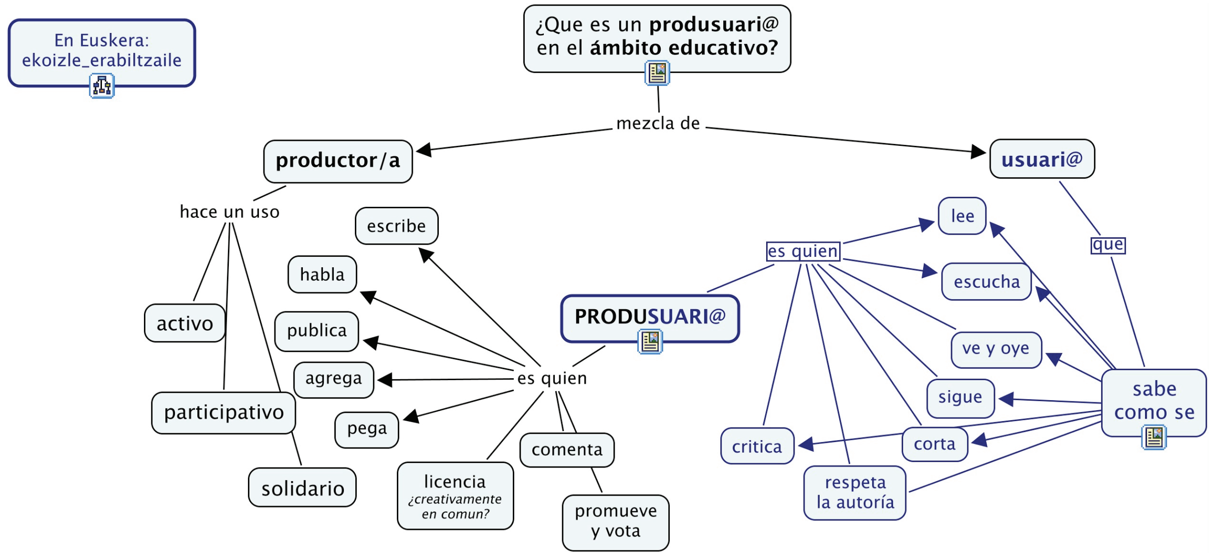

Figura 3. MC de la nueva manera de entender las relaciones en la red, y en el ámbito educativo: produsuarios son quienes usan también producen, quienes leen a la vez escriben, quienes siguen agregan, quienes critican y comentan generan contenidos en la red.

2.2 La narrativa de los mapas conceptuales

Aguilar Tamayo (2004) plantea que los mapas conceptuales, como sistema simbólico, permiten representar y fijar la narración, lo que conlleva dos implicaciones:

1. ubicar al mapa conceptual en la esfera pública, convirtiéndose en un objeto expuesto a la interpretación, y que
2. la representación de la narración afecta a la organización jerárquica del mapa.

En la teoría de los mapas conceptuales, como veremos mas adelante, la jerarquía y las relaciones entre conceptos son dos elementos claves organizar el mapa. La jerarquía, estructura y distribución del mapa, pueden ser modificados por la narración que pretenda dibujar un mc, apareciendo los elementos propios de la narrativa: el autor, la secuencia narrativa, la coherencia del relato o el sentido que pretende transmitir. Ya Bruner (1988) distinguió 2 modalidades de pensamiento, con relatos y narrativas diferentes:

1. el conocimiento científico que requiere de procesos de explicación, que exigen la verificación mediante pruebas formales y empíricas; y
2. el conocimiento cotidiano y el de las ciencias humanas que se construyen en un proceso de interpretación que pueden derivar en la construcción de un relato o narración, con pretensión de verosimilitud, mediante la coherencia interna del propio relato.

La explicación y la interpretación son dos formas distintas de conocer, que no son excluyentes. Y ambas modalidades son requeridas en distintos momentos de la construcción de la ciencia y del relato. El encuentro se da en los procesos de enseñanza-aprendizaje, o en el de comunicar el conocimiento. Este sería el caso de obras cuyo sentido sería explicar, el dar a entender, alguna teoría o conocimiento, propio o de otros.

En el caso de los mapas conceptuales, al prepararse para ser leídos por otros implica en el autor establecer una relación imaginaria con "otro", un lector, destinatario del mapa. Humberto Eco (1992) denomina esta relación "lector ideal y autor ideal", en la que la construcción y la interpretación de un discurso o de un texto, va mas allá de la representación análoga y "objetiva" de la estructura del discurso.

Aguilar Tamayo (2004) concluye que "la narración se introduce en la estructura del mapa conceptual en la medida que este es un medio para el autor para representar y comunicar su perspectiva del conocimiento. Aún cuando se pretende una descripción "objetiva" que pretenda respetar la estructura del discurso del cual proviene el tema que se trata, la elaboración de un texto, implicada al autor imaginar a un lector o comunidad de lectores a los cuales narrar y explicar un tema e introducirlos a un campo de conocimiento o teoría. La jerarquía del mapa conceptual se establece entonces, no sólo en relación al discurso al que representa y a la especificidad de un concepto o enfoque, depende también de una estrategia, implícita o explicita, para narrar y construir el conocimiento (ver el mapa en el servidor de Cmaps de UIB).

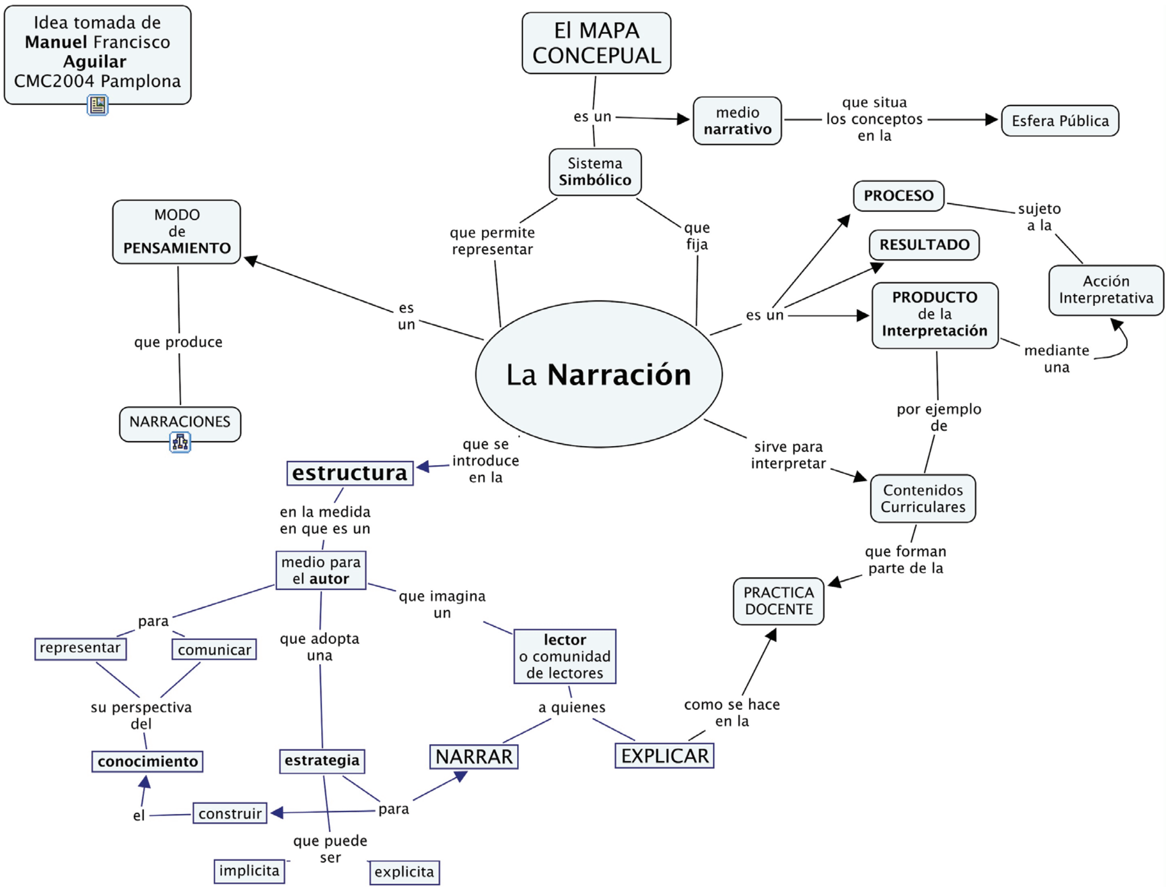

Figura 4. MC sobre la utilización de un interés narrativo en los mapas conceptuales que pueden modificar su estructura y organización jerárquica, por una estrategia discursiva, con intención de representar y comunicar.

1.1 Los Mapas Conceptuales Esqueletos.

Un MC esqueleto está basado en la experiencia de un experto en el tema a enseñar o aprender, permitiendo a estudiantes y a docentes construir su conocimiento sobre una base sólida. Sirven como una guía o ayuda para aprender, como si fuesen andamios (*scaffolding*) en la construcción o restauración de un edificio. La idea de que los aprendices puedan entrar en un campo de conocimiento nuevo de la mano de una persona con experiencia es tan antigua como la humanidad. Pero en la sociedad del conocimiento, hay que descubrir nuevas formas de introducir a los estudiantes, moviéndose en la zona de desarrollo/aprendizaje próximo que les suponga el estímulo necesario para re-elaborar y construir su propio conocimiento.

Y los vídeos de Conocity, se enriquecen con estos MCE: en las vídeo-entrevistas el experto que conoce y estructura el tema, se ve junto a la representación gráfica de sus estructuras cognitivas, las relaciones conceptuales que establece en su pensamiento; tiene esa pretensión "iniciática" para la sociedad del conocimiento. Los mapas en pantalla ayudan a construir nuevos esquemas mentales a los aprendices, tansmitiendo la idea de proceso: a la vez que escucha al experto se ve crecer el mapa en pantalla, evitando la idea de que el conocimiento YA esta hecho y descubierto, de que es complejo y difícil de entender.

Tener la suerte de conocer a través de Jordi Adell experto pedagogo de la Universidad Jaume I de Castellón, que es un PLE o la competencia digital, y poder ver su esquema; oír de boca de Joan Queralt la explicación de un eportfolio como Mahara, tras llevar varios años usándolo en el IOC; entender que es una empresa líquida de boca de Pilar Kaltzada, directora de comunicación de Innobasque; o escuchar a Julen Iturbe como explica el concepto de Empresa Abierta tras su investigación y trabajo con empresas innovadoras, es tener un acceso privilegiado a sus experiencias personales y su elaboración intelectual.

2 Vídeos enriquecidos para la gestión del conocimiento en la Web 2.0

Las herramientas Web 2.0 usadas en Conocity, que están gratuitamente en manos de los usuarios y usuarias de Internet, han modificado la manera de recorrer la espiral de la gestión, y sobre todo la velocidad de **producción** del conocimiento. Al vídeo en la red se le llama desde hace unos años una "Killer Application" por su uso tan generalizado como intenso; y entre la gente joven, cada vez mas extendido.

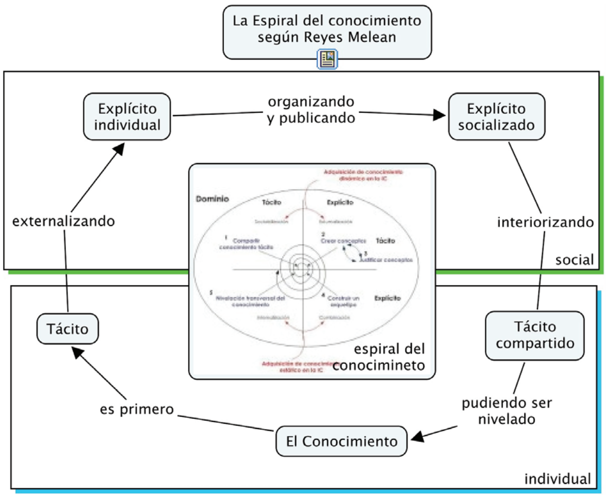

Figura 5. Espiral del Conocimiento que Espiral del Conocimiento que representa las 4 fases descritas por Nonaka y Takeutchi ampliamente reconocidas en el mundo de la gestión empresarial y del conocimiento corporativo.

El vídeo digital es sin lugar a dudas, una de las que actualmente tiene mayor impacto: podríamos decir una "bala de plata", utilizando la metáfora del premio nobel de medicina Paul Ehrlich "*silver bullet* " que consiguió una formula *casi mágica* para curar una enfermedad temida, que fue reflejada en la película de 1930 Magic Bullet.

Hoy en día los vídeos propagan el conocimiento en Internet como la pólvora; o parafrasear la idea de *viralidad* que caracteriza a las redes sociales, como las enfermedades se contagiaban hasta que el Dr. Ehrlich descubrió su cura mágica. Nonaka & Takeutchi (1995) plantean 4 fases en la gestión del conocimiento, en el mapa de la Figura 5 con el gráfico adaptado de Reyes Melean (2004).

Proceso de producción de vídeos enriquecidos
El proceso de trabajo que hace posible la producción de los vídeos se asemeja a esta espiral, que expresada a modo de reloj, indica mediante el giro de las manecillas el avance las fases de realización videográfica y de su publicación (ver Figura 6).

2.3 Expresión del conocimiento tácito: Exteriorización

Recoger en vídeo una charla o entrevista a una persona entendida en un ámbito, es el primer paso para la gestión del conocimiento: lo que esa persona sabe, y sobre todo, la manera que lo tiene organizado en su cabeza, es un valor fundamental en la sociedad del conocimiento.

Para ello es clave seleccionar la persona adecuada, establecer el contacto buscando una relación de confianza, y acordar la manera en la que su sabiduría va a ser recogida, elaborada y publicada.

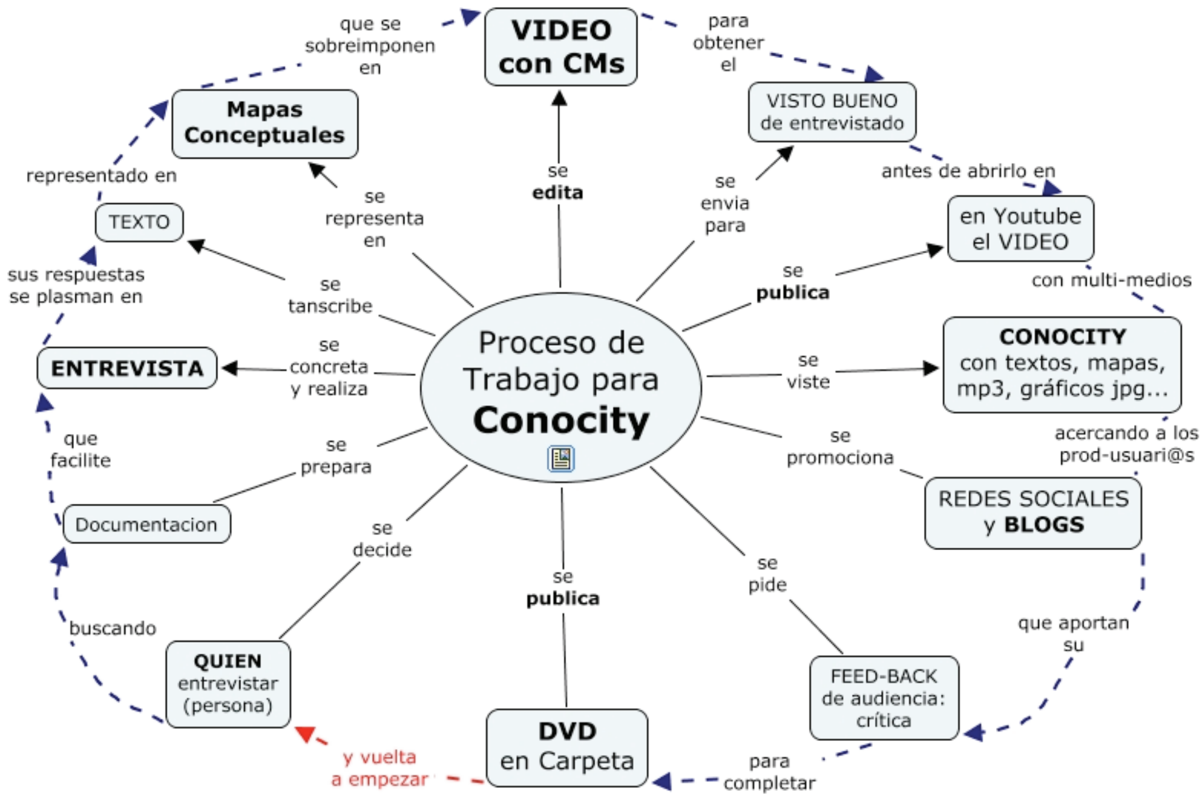

Figura 5. Espiral del proceso de trabajo de Conocity: el tiempo de elaboración de un vídeo simulado en una hora de reloj. Si comienza a menos 25 la producción de la entrevista, y a menos cuarto se graba, a menos cinco se elaboran los MCE, y a la hora en punto se edita el vídeo incluyendo los enriquecedores MC en pantalla. Para y cuarto se publican en el blog, tras tener el visto bueno de los expertos. Para y veinte se mueve en las redes sociales y para y veinticinco se obtiene la retroalimentación de la audiencia. A y media se da el proceso por finalizado.

La manera en que el conocimiento representado va a ser puesta al servicio de la comunidad educativa, forma parte de ese "contrato" virtual: poner al servicio de todo el "público" mediante una licencia que permite su uso libre, sin restricciones de derechos de autor, es una manera cada vez más extendida en la red de compartir lo que sabemos. La nueva ecología de la Internet 2.0, y la cultura de la remezcla que se está generalizando cada vez más entre sus produsuarios, hace posible y creíble esta manera de gestionar el conocimiento en red.

Figura 7. Jordi Adell profesor de la UJI entrevistado en Barakaldo, representando en una hoja de papel con dos rotuladores qué es un Personal Learning Enviroment, (PLE)**.**

2.4 Representación del conocimiento: Expresión Gráfica

Las vídeo-entrevistas suelen tener una duración aproximada de una hora, de las que pueden surgir dos, tres o media docena de vídeos editados. Primeramente sus ideas son transcritas en un texto con minutado, y después son representadas en un mapa conceptual que las sintetiza, relaciona y resume gráficamente.

Los "cortes" de vídeo, en la edición incorporan esta visualización del conocimiento, enlazando los conceptos con las frases que el experto ha ido utilizando durante su relato. En los vídeos enriquecidos podemos distinguir los tres niveles narrativos siguientes:

1. El relato del *experto*: lo que cuenta en la grabación, el texto podíamos decir, de su explicación
2. el relato *audiovisual*: los elementos específicos del lenguaje fílmico que se utilizan en TV o el cine: los cortes, fundidos, subtítulos, transiciones, mezcla de imágenes etc.
3. el relato *conceptual* que aportan los mapas, con los que se

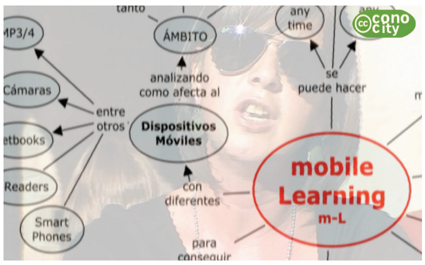

Figura 8. Mar Camacho explica que es el mobile learning (mlearning) durante el encuentro Edutec 2010 celebrado en Bilbao. El mc en pantalla recoge su imagen metal del tema abordado.

enriquecen los dos niveles anteriores, y se posibilita visualizar las conexiones y relaciones abstractas y teóricas que existen en la mente del entrevistado sobre los temas abordados.

2.5 *Aprobación del entrevistado: Acuerdo Dialogado*

Para poder mantener la confianza inicial con el entrevistado, y sobre todo, para que su vídeo refleje su opinión y visión del tema y la forma de pensar, es fundamental enviarlo de manera confidencial a la persona experta. Para ello las herramientas Web20 ofrecen vías rápidas y seguras que permiten ver, contrastar, corregir y acordar de nuevo los elementos visuales, textuales y elementos enriquecedores del relato. Los vídeos son publicados "sin clasificar" para que no aparezcan en las búsquedas, de manera que solo acceda la persona que recibe la URL completa, y se pueda llegar a un acuerdo dialogado entre ambas partes.

Desde una imagen a suprimir, un texto mal escrito en pantalla, o un mapa conceptual errónea o insuficientemente elaborado, el dialogo entre el entrevistado y el realizador, da lugar a las correcciones y matizaciones necesarias.

Con las herramientas gratuitas que utilizamos en Conocity (email, blog, documentos compartidos on-line a modo de wiki-editor), en cuestión de minutos pueden ser corregidos y re-elaborados entre personas que se encuentren a 10 km, 500 km o en distintos continentes del planeta (p.e. hay varios entrevistados que lo han hecho desde América en unas pocas horas.)

Este paso es una pieza clave para aumentar la confianza del experto en el proyecto y para cumplir el "contrato virtual" mencionado en el punto 3.1. La generosidad demostrada por los "donantes de conocimiento" no se ha visto defraudada hasta ahora. Se dan casos en los que el entrevistado decide que su vídeo no sea público, por ejemplo, para no aparecer en las búsquedas de Google asociado a este tema, y se respeta escrupulósamente su decisión.

Figura 9. David Pinyol dialoga con Lluisa Nuñez sobre el elearning durante la celebración de la Moodle Moot Spain 2011 en una amena video-entrevista para Conocity.

2.6 *Publicación: en la Nube*

La versión definitiva del vídeo enriquecido, junto a un texto explicativo y la representación del conocimiento en un MC, se publica en la nube, apareciendo en el blog, junto a la invitación abierta a todos los visitantes de la web y a los habitantes de Internet a leer, oír, ver, analizar, sintetizar y aprehender el conocimiento compartido: en el apartado .

Las herramientas gratuitas posibilitan la promoción y difusión en la red, con la agilidad de la inmediatez y con la interacción de "gente conectada". En Conocity encuentran la posibilidad de navegar por el blog:

- mediante etiquetas que responden a una folksonomia ágil y flexible
- utilizando trackbaks o pingbacks desde sus blogs y haciendo links en las redes sociales como Facebook, Twitter o Google Plus
- embebiendo los vídeos en paginas webs, blogs, wikis y cualquier otro medio de comunicación Web 2.0

Figura 10. Portada de Conocity con Marco Antonio Moreira hablando sobre la importancia y posibilidades de los MC, remarcando que lo importante son las relaciones construidas.

2.7 *Interacción en las redes sociales: promoción en Red*

La efervescencia de las redes sociales posibilita que el conocimiento se mueva en las nuevas conexiones neuronales colectivas:

- a través de Twitter llegan referencias a los textos y vídeos, que otras personas suelen re-twittear, responder o embeber en sus correspondientes blogs o sitios web; las menciones a conocity se reflejan en el blog.
- mediante Scoop.it o Facebook se extienden las referencias a los video-conceptos, posibilitando las adhesiones individualizadas de los usuarios ("me gusta"), a la vez que se interactúa con otros usuarios

interesados en esta temática. Es digno de reseñar el grupo de CmapTools existente en Facebook, donde son casi 800 usuarios de esta red social los que interactúan, preguntan cuestiones relacionadas con el programa y su uso, y sugieren temas para solucionar o comentar.

- en Google Plus se comparten los enlaces a los post, mencionando a las personas que se quiere citar, referenciar o implicar, que automáticamente reciben un aviso y pueden responder, replicar, matizar etc.

Esta manera de conectarnos, como dice Sue Waters editora de The Edublogger, nos permite construir conocimiento *individual y colectivamente***,** sintiendo que formamos parte de una comunidad de aprendizaje global, en la que lo que cada uno aporta y pone, enriquece la sabiduría y el conocimiento de los demás.

A pesar de que algunos servicios de Internet obtengan gran impacto de audiencia, otros muchos servicios "minoritarios" consiguen un nivel de interacción mas pequeño, pero de ninguna manera desdeñable, como lo indica la distribución denominada *la larga cola* que representa Chris Anderson en gráficos como el adjunto.

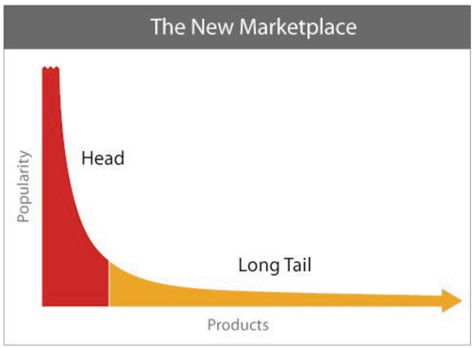

Figura 11.. Distribución de la audiencia en Internet, caracterizada por una larga cola muchas webs visitada poco visitadas, suman un numero de produsuarios muy significativo en la suma total de sitios.

2.8 Impacto del Relato Enriquecido en la Red

Conocity, en el 2010 comienza a compartir sus producciones de vídeo enriquecido con mapas conceptuales, licenciando todo ello como CC-by-SA; la invitación es clara: úsalo citando la fuente.

Con una treintena de entrevistados y representando su conocimiento y relacionando sus ideas, un centenar de mapas ha conseguido compartir en el ámbito educativo y empresarial ideas sobre comunicación, la educación, el aprendizaje, los procesos de formación y de innovación, de *elearning* de las personas y las empresas, favoreciendo con herramientas gratuitas el aprendizaje significativo, liberando y compartiendo conocimiento experto bajo licencia Creative Commons.

El impacto de esta novedosa manera de contar, de publicar y de posibilitar el acceso al conocimiento ha quedado reflejado en las redes sociales y demás herramientas de la Internet actual: blogs, wikis y páginas web.

Un par de botones de muestra son los vídeos enriquecidos elaborados con la video-entrevista a Jordi Adell realizadas junto a un estanque en la casa de cultura Clara Campoamor de Barakaldo. En una hora aprox. El profesor de la UJI explicó qué es la CD, la Competencia Digital y qué es un PLE, además de dar algunos datos biográficos profesionales.

Cuando han pasado casi dos años, ambos vídeos han sido visualizados más de 30.000 veces en todas las áreas geográficas del planeta. Y día a día suben las visitas, como se puede comprobar en la tabla siguiente:

Videos publicados y Experto entrevistado (fecha)	**Numero de Visitas (Mayo - Junio)**
PLE Personal Learning Environment Jordi Adell (2009)	10663 - 17298
CD Mapa Conceptual de la Competencia Digital Jordi Adell (2009)	8790 - 13897
Aprendizaje en el Futuro Aníbal de la Torre (2012)	1727 - 1985
Empresa Liquida Pilar Kaltzada (2009)	830 - 988
Mahara (eportfolio) según Joan Queralt (2011)	536 - 618
EA Empresa Abierta Julen Iturbe (2011)	368 - 469

Tabla 1: Vídeos publicados en Conocity clasificados por el numero de visitas (a principios de mayo y finales de Junio del 2012)

Son dignas de mención tres iniciativas gubernamentales (que conocemos) en el ámbito castellano-parlante:
1. Departamento de educación de Argentina: "En el "año del Trabajo Decente, la Salud y la Seguridad de los trabajadores", en nombre de la Dirección General Unidad e Financiamiento Internacional, desde el "Programa de Educación Media y Formación para el trabajo de los jóvenes," de Buenos Aires, hacen una "Solicitud de derechos de artículo web" para usar el vídeo. En estos términos: "solicitar la cesión de los derechos del vídeo "Competencia Digital" publicado en YouTube (indican la URL completa) para ser incluido en un material digital que será distribuido en forma gratuita entre los docentes e instructores de formación profesional de Argentina.
2. Gobierno de Canarias, en su programa Medusa.

3. Y la de una institución docente con implantación global: los claretianos de Cornella, que han incluido los vídeos de Jordi Adell en su canal de Youtube para la formación del profesorado, con más de 10.000 visitas.

3 Prospectiva: algunas líneas de avance

En el futuro, Conocity va a centrarse en los usos educativos y de gestión del conocimiento aprovechando las potencialidades de la web 2.0 y la efectividad comunicativa del video, su innegable poder de "Killer-App", para buscar nuevas maneras de representar gráficamente las estructuras cognitivas y *mapear* las conexiones mentales de personas con experiencia en estos campos.

Los esqueletos conceptuales, *scaffolding* o andamios de pedagogos, metodólogos o que ayuden a quienes los vean, lean y escuchen, comunicando por diferentes canales convergentes, conocimiento estructurado, jerarquizado y seleccionado, de la mano de expertos en la materia, explicándola de manera breve y asequible.

Una idea que diferentes organizaciones orientadas al conocimiento, su generación y transferencia puede aprovechar, tanto utilizando los materiales ya existentes, todos con licencia CC, como investigando en esta confluencia de materias expresivas concurrentes en estos relatos digitales, o investigando en la manera en que la interacción con el conocimiento en la web 2.0 favorece los procesos de enseñanza-aprendizaje. De esta forma podemos seguir contando cada uno lo que sabe, para que todos podamos aumentar nuestro conocimiento.

4 Reconocimiento y agradecimientos

Hay un dicho castellano castizo que proclama "de bien nacidos es ser bien agradecidos", y este es el momento de agradecer públicamente a todas las personas que han colaborado desinteresadamente con esta ciudad de conocimiento, donando generosamente su tiempo y su sabiduría a cambio de nada, a cambio de unas visitas en la red, y algún comentario de animo a cambio. Merecen una mención especial Jordi Adell profesor de la UJI y Alberto Cañas del IHMC, que desde el comienzo ha estado cercano al proyecto, con comentarios y sugerencias. Todos los aportantes quedan recogidos junto a los temas de las entrevistas en este post y su correspondiente mapa.

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CONVERGENT VALIDITY: CONCEPT MAPS AND COMPETENCE TEST FOR STUDENTS' DIAGNOSIS IN PHYSICS

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Abstract. In almost every lesson teachers diagnose their students concerning knowledge and activities, but most of them do so without appropriate diagnostic instruments. With the use of concept maps, the present study aims to offer physics teachers a suitable diagnostic instrument with an adequate analysis form for an instant use in their lessons. In a preliminary step, we first pinpointed what kind of knowledge concept maps measure. Therefore a sample of 79 ninth-grade German secondary school students drew concept maps under the instruction of two different task formats and afterwards filled out a competence test. For both task formats the concept maps were evaluated with the same scoring system and were tested for convergent validation against the competence test on the physics topic of energy. The results show a positive correlation between these two instruments and figure differences between the different task formats.

1 Introduction

Diagnosing students is among one of teachers' basic responsibilities. It is needed to evaluate and to reflect students' activities and to use this information to further adapt instruction. However, conducting diagnostics, which formally means "the systematic collection and preparation of information with the aim to obtain knowledge about people" (Jäger, 2009, translated into English), and performing the diagnosis require a suitable diagnostic instrument. It should be highlighted here that physics teachers in Germany are in a particularly disadvantageous position because appropriate and standardized diagnostic instruments for their instruction have not yet been developed. Given this general dearth of diagnostic tools, it was thought that concept maps drawn by students might be an appropriate way to diagnose their knowledge structures. Concept maps do not need any preparation and at a first glance it seems that they are easy to assess. A review of research about concept maps and concept mapping shows that they are an often-used topic in the international scientific community. Ruiz-Primo and Shavelson (1996) summed up and illustrated a multifaceted picture of how and in which way concept maps are used in research. They concluded that concept maps can be classified by three categories: task format, response format, and scoring system. They exposed the huge variability each of these categories can have. In the same manner as tests with different answer formats (e.g. multiple-choice, short-answers, etc.) and scoring systems measuring different aspects of knowledge, these varied concept mapping methods can generate distinct representations of knowledge. Therefore, it is not remarkable that results in research concerning reliability and validity are not consistent (for an example, see McClure, 1999). Reviewing German research on concept mapping, Peuckert and Fischler (2000) also pointed out that concept maps with specific forms of task format, response format, and scoring system measure characteristics of knowledge that cannot be perceived with other methods, like tests. It is demonstrably common that concept maps can measure knowledge as declarative knowledge, but in which way concept maps may also provide access to other kinds of knowledge is still an open question. Results on convergent validity of concept maps compared to other methods are, therefore, considered to depend specifically on task formats and scoring systems (Schecker and Klieme 2000, 47). According to Schecker and Klieme (2000), concept mapping tasks on a more theoretical and abstract level seem to be more closely related to competence test results than to tasks on a level of concrete daily experience. The latter allows more insight into the question of how concepts are connected to everyday language and life (Sumfleth and Tiemann, 2000).

The aim of this study is to develop a specific concept mapping task format and scoring system that is suitable for ad hoc assessments in school lessons and allows individual diagnostics for students' competences. In order to make this format and system suitable, a time-saving but sufficiently reliable scoring system is needed. For this study, a concept map-evaluation sheet has been developed, allowing for a thoroughly holistic evaluation of concept maps. The holistic rating of the concept maps is cross-checked with semantic measures of the software AKOVIA (Pirnay-Dummer and Ifenthaler, 2010).

With this background, the following research question leads the present study:
What relations exist between task format, scoring system of concept maps and students' competences measured by a competence test?

It is assumed that a concept map scoring – done with a concept map-evaluation sheet – will correlate positively with a competence test. Secondly, it is expected that a task format on a conceptual level will correlate more with the competence test than a task format with an everyday context[1].

1.1 Exursus: Basis Concept "Energy"

A short excursus is necessary at this point to understand the notion of the basis concept of "energy" within the German education system.

The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany decided years ago to develop so-called basis concepts for the natural sciences in order to provide overall links between the different science subjects and their special topics. For example, the basis concept "energy" can be taught in different grades with different levels of abstraction and related to different subtopics of physics (like mechanics or electricity). While knowing different energy forms is the main point in grades 5 and 6, learning the concept of energy conservation is the focus in grades 10 and 11. It is assumed that learning "energy" is done in four steps – so-called competence steps (Liu & McKeough, 2005): 1) energy form and energy sources, 2) energy transfer and energy conversion, 3) degradation of energy, and 4) energy conversation. The longer the students stay at school and learn physics, the more differentiated their concept of "energy" becomes.

2 Method

2.1 Instruments

2.1.1 Competence Test

The competence test for measuring students' competences in "energy" has been based on the work of Viering (2012) and Neumann, Viering, Boone & Fischer (under review). Twenty-two multiple-choice single-select items from a Rasch[2]-scaled item pool from Viering's work were selected for this current study. In the items the students have to apply theoretical knowledge about energy in concrete daily situations. The selection of the items was adjusted for the ninth grade to the four competence steps as mentioned in the excursus.

2.1.2 Concept Map Task Format

Two different concept map task formats were used in this study. In task format A, students had to choose at least 10 words out of 25, which are appropriately to the ninth grade. Furthermore, they could use the rest of the 25-word list or could add completely new words. The 25-word list consists of words belonging to the concept of energy, (e.g. energy form, energy storage, kinetic energy, power, energy loss, etc.). Thus, task format A is on an abstract, conceptual level.

In task format B, students were first presented three photos showing three different everyday physics situations: a girl jumping on a trampoline, a cooking pot with water, and an electric torch. They were asked to draw a concept map about the concept "energy" using self-chosen words. After drawing this concept map, they received the same 25-word list as in task format A and were asked to add at least 10 words using a pen in a different color. In this way, task format B starts on a concrete everyday level and switches to the conceptual level afterwards. The use of different pens allows for investigations on the connection between these levels. It also gives insight into students' active knowledge before hints from the 25-word list are given. In some ways, this can be compared to testing the Zone of Proximal Development (Vygotsky, 1978).
The students had 35 minutes for each task format. The association phase in task format B lasted about 14 minutes.

2.1.3 Concept Map-Evaluation Sheet

As previously mentioned, a so-called concept map-evaluation sheet was designed to evaluate the concept maps for the two task formats. The evaluation sheet consists of 18 statements concerning the physics basis concept

[1] The task formats will be explained further.
[2] The explanation about Rasch analysis is not the focus of this paper. For further general information about Rasch, see Bond and Fox (2007).

“energy”, which have to be rated by a four-step Likert-scale. The following example shows the main structure of the sheet.

Dear Teacher, In the following, you will find statements which you need to evaluate based on the concept map your student has drawn. Please mark an X at every statement that applies to the student’s concept map. The student…				
	Strongly agree (3 pts.)	Somewhat agree (2 pts.)	Somewhat disagree (1 pt.)	Disagree (0 pts.)
1. …knows that objects can possess energy, e.g. a battery has electric energy.	☐	☐	☐	☐
11. …has identified that energy forms can be converted into each other, e. g. potential energy will be converted into kinetic energy or thermal energy will be converted into internal energy.	☐	☐	☐	☐
16. …has identified that degradation of energy proceeds only in one direction (irreversibility), e.g. thermal energy which is released into the environment cannot be used anymore.	☐	☐	☐	☐
17. …has identified that total energy of a (closed) system rests conserved and is balanced, e.g. energy loss does not really exist, because energy conservation weighs and energy cannot be produced and discreated.	☐	☐	☐	☐

Figure 1. Instruction for teachers how to use the concept map-evaluation sheet and example-items of the concept map-evaluation sheet.

2.1.4 AKOVIA and modal maps

Additionally, a fully automated evaluation of the undirected relations (neglecting their labels) uses the software AKOVIA (Pirnay-Dummer and Ifenthaler, 2010). This software generates an average modal map of all individual maps (task format A and B) and compares each map to it. The creation of a modal map is after Hucke and Fischer (2000) a help to make sure that all linkages of the individual maps are used in an equal way. We gave the software a so-called 10%-limit which means that only propositions which can be found in at least 10% (more than 7 maps) of all 79 maps become part of this modal map. This fairly low limit had to be chosen due to task format B, which forced students to create their own vertices. This causes less overlap between the maps. Although the two task formats generate rather different maps, we wanted to generate a single modal map for both, in order to be able to compare them. The 10% limit seemed to be appropriate for that purpose, although for task format A higher limits would have worked as well.

For this study only the semantic indicators which AKOVIA calculates are important. The conceptual matching of an individual map is computed as the sum of the vertices that are semantically similar to the modal map. It is a general indicator of an accurate understanding compared to the modal map. The propositional matching calculates the number of propositions (vertex-edge-vertex) compared to the modal map. Only the connections between the vertices are compared, ignoring the edge labels. Propositional matching indicates a correct and deeper understanding of the subject domain represented by the modal map (Ifenthaler, 2010). Thus the creation of the modal map is essential to both indicators.

2.2 Sample

Participants of this study were ninth-grade physics classes in two German secondary schools. Altogether N=79 students took part. It was assumed that most of the students would not know what concept maps are and would need practical experience in order to draw concept maps. Therefore, the students first received a 45-minute training with practical sessions about how to draw concept maps. A few days later, the students were asked to draw a concept map for the physics basis concept of “energy”. Each class was divided into two groups for the two task formats – sample distribution for task format A N=40 students and for task format B N=39 students. After drawing the concept maps, the students filled out the competence test which also dealt with the concept of “energy”.

2.3 Data preparation

Before going into detailed results, it must be mentioned what happened after the students drew the concept maps. Before starting the final calculations, all concept maps were rated by six students who were at the beginning of their advanced study period in physics education for lower secondary schools. Each of them evaluated all of the 79 concept maps by using for each concept map the previously presented concept map-evaluation sheet. The points for each item of the evaluation sheet were summed up to give the rating score. So, for each concept map six different scores from the six raters exist. For further analysis, the six scores have been averaged. The number of students’ correct answers in the competence test was summed up, so that a general view concerning the basis concept of energy is done, not a differentiated into the four competence steps.
All calculations were done with the statistic program PASW 18, when not mentioned else.

3 Results

3.1 Concerning the interrater reliability in the concept map-evaluation sheet

One of the most challenging aspects of concept maps is achieving objectivity in the form of interrater-reliability. In the current study, six different raters evaluated all concept maps. The intraclass-correlation-coefficient (ICC) was chosen as a degree of reliability for interval scales. For the six raters an $ICC_{(M=6)}$ with .515 on a level of $p<.001$was calculated, which is acceptable.

3.2 Concerning effort in time

The six raters were asked about the time they needed to score the 79 concept maps. The time for scoring one concept map was in average 5.47 minutes ranging from 3.79 minutes to 8.35 minutes.

Rater	Time for score set of 79 concept maps (min)	Per-map scoring time (min)
1	405	5.12
2	300	3.79
3	360	4.55
4	660	8.35
5	420	5.31
6	450	5.69

Table 1: Time required for raters to score 79 concept maps.

3.3 Concerning convergent validity between concept map-evaluation sheet and competence test

In order to prove convergent validity, students’ scoring in the competence test was correlated with their scores given in the concept map-evaluation sheet by the six raters. Table 2 presents the results both on a general level and differentiated in the two task formats.

Correlation between…

Competence Test and Concept Map-Evaluation Sheet	Competence Test and Concept Map-Evaluation Sheet in task format A	Competence Test and Concept Map-Evaluation Sheet in task format B
$r = .273^*$, $p < .05$	$r = .314^*$, $p < .05$	$r = .331^*$, $p < .05$

Table 2: Correlation on Pearson between the competence test and the concept map-evaluation sheet (averaged across all raters); significant level p<.05 marked by *; p<.01 marked by **.

There is a significant correlation between the two instruments – competence test and concept map evaluation sheet.

3.4 *Concerning convergent validity between relational analysis by AKOVIA and concept map-evaluation sheet*

By using the computer program AKOVIA an automated relational analysis of concept maps (Pirnay-Dummer & Ifenthaler, 2010) can be compared with the results of the scores given in the concept map-evaluation sheet. For this comparison only semantic measures are considered.

The table below presents the results of this comparison by using a correlation-calculation on Pearson.

			Task Format A (N=40)	***Task Format B (N=39)***
		Score on Concept Map Evaluation Sheet (averaged across all raters)	Score on Concept Map Evaluation Sheet (averaged across all raters)	Score on Concept Map Evaluation Sheet (averaged across all raters)
Semantic Indicators (AKOVIA)	Conceptual Matching	*r* = .484** *p*< .01	*r* = .688* *p*< .05	*r* = .194 *p*= .237
	Propositional Matching	*r* = .132 *p*= .245	*r* = .092 *p*= .572	*r* = .060 *p*= .719

Table 3: Correlation on Pearson between the relational analysis by AKOVIA and the scoring in the concept map evaluation-sheet; significant level p<.05 marked by *; p<.01 marked by **.

The indicator conceptual matching shows a good agreement with the evaluation sheet across all maps and especially for task format A, but not for task format B. There is no correlation between the propositional matching and the score on the evaluation sheet.

3.5 *Concerning convergent validity between relational analysis by AKOVIA and competence test*

Analog to the comparison previously, a correlation calculation for triangulation between AKOVIA's semantic indicators and the score on the competence test was done. The results in the table show the supposed results. The competence test cannot be described by the semantic indicators which is comprehensible.

			Task Format A (N=40)	***Task Format B (N=39)***
		Score on Competence Test	Score on Competence Test	Score on Competence Test
Semantic Indicators (AKOVIA)	Conceptual Matching	*r* = .112 *p*= .327	*r* = .178 *p*= .271	*r* = .067 *p*= .686
	Propositional Matching	*r* = -.037 *p*= .747	*r* = .098 *p*= .548	*r* = -.103 *p*= .429

Table 4: Correlation on Pearson between the relational analysis by AKOVIA and the scoring in the competence test; significant level p<.05 marked by *; p<.01 marked by **.

3.6 *Concerning task formats*

By using a t-test for independent samples, the analysis for the two task formats shows no significant difference between the two student groups on the competence test. Keeping in mind the theory about what concept maps measure, there is a significant difference between the two student groups and therefore the two task formats. On average, students who worked with task format B received significantly more points in their rating than the students who worked with task format A. The following table sums up the results:

		Task format A (N=40)	*Task format B (N=39)*
	Score on competence test	*M*=9,15, *SD*=0,59	*M*=8,62, *SD*=0,49
	t-test	*t* (77)=0,693, n.s., *p*=.49, *d*=0.33	
Averaged on all raters	Score on concept map-evaluation sheet	*M*=7,03, *SD*=0,61	*M*=9,59, *SD*=0,51
	t-test	*t* (77)=-3,20, *p*<.01, *d*=0.66	

Table 5: Students' scoring divided into the two different task formats and instruments; t-test for independent samples and Cohen's *d* for effect size.

4 Discussion and conclusion

A primary purpose of this study was to find out whether a specific task of concept mapping (task format A and task format B) with a specific scoring system (concept map-evaluation sheet) measures the same ability that a competence test does. The interrater-reliability between the six raters is acceptable, but from a scientific perspective, upgradable. It should, however, be highlighted that the concept map analysis done with the concept map-evaluation sheet is holistic, and high interrater-reliabilities are not necessarily to be expected.

To date, the results on convergent validity show a slight positive connection between the two instruments – competence test and concept maps. It can be assumed that concept maps in the form in which they were used in this study can represent competences in the basic concept "energy".

Compared to the automatically calculated semantic indicators of AKOVIA, the rating with the evaluation sheet worked better. The needed time is almost acceptable time. The conceptual matching strongly depends on the use of equal labels in the vertices. In task format A a list of possible labels is provided, whereas in task format B the students are allowed to choose the vertices on their own. Thus, there will be little overlap in the modal map for task format B, due to the fact that synonyms like 'kinetic energy' and 'energy of motion' might be used. For the same reason propositional matching does not work, since the vertices are free to choose and differ too much. Taking the conceptual matching as an indicator for accurate understanding the correlation of .688 to the score on the evaluation sheet in case of task format A means that holistic rating can estimate the understanding properly. Additionally, holistic rating can take into account propositional information, too.

Task format A correlated with the competence test roughly as much as task format B did, though the two task formats differ in general. While task format A is more abstract with the technical terms which had to be used and accounts more for structured knowledge, task format B is more applied and accesses more the contextual application of knowledge. Both seem to be important for the competence test in equal manner. Therefore the similar correlations are not contradictory to each other. As presented in the results, students who worked with task format B received more points for their concept maps than those who worked with task format A. This suggests that concerning the content task format B creates more meaningful maps than task format A.

For general work scenarios, the concept map-evaluation sheet needs to be shortened because an 18 item-long sheet is not feasible for school[3], and the interrater-reliability should be matched to the scientific quality criteria, e.g. teachers judge the existing sample of concept maps with the concept map-evaluation sheet. With the teachers' rating the interrater-reliability could grow.

But referring to didactical relevance (see also Helmke, 2009), it would be acceptable if teachers' diagnoses were somewhat less precise, provided that teachers are aware of this and can control it themselves. The didactical relevance of the diagnosis is more important for the teachers than the accuracy of the diagnosis is. Therefore the scoring of concept maps with evaluation sheets seems to be a useful method for practice in school.

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DESARROLLO DE COMPETENCIAS APOYADO EN ITINERARIOS DE APRENDIZAJE FLEXIBLES BASADOS EN MAPAS CONCEPTUALES

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Abstract. En el contexto de la institución educativa Gabriel García Márquez (Educación básica y media), se analizan 3 temas que tienen relación con el proyecto: El diseño curricular basado en competencias, las conexiones cognitivas incluyendo elementos que se derivan de ellas y finalmente pero no menos importante, los ambientes de aprendizaje basados en TIC. A partir de este análisis se determinan las características que se proponen para un diseño instruccional en ambientes de aprendizaje basados en TIC, a partir de los cuales se genera un proceso de aprendizaje autoorganizado, no lineal, apoyado en itinerarios de aprendizaje que basados en mapas conceptuales potencian el desarrollo de las competencias determinadas en el diseño curricular de la Institución objetivo. Los itinerarios de aprendizaje con un diseño basado en mapas conceptuales guían a los estudiantes por los contenidos, procesos, actividades, que aparecen organizados de manera no lineal, pero sugiriendo posibles secuencias. Lo anterior proporciona flexibilidad para que el alumno ejerza cierta autonomía en su proceso de aprendizaje.

1 Introducción

Orientada por la pregunta ¿Cómo los mapas conceptuales pueden apoyar el desarrollo de competencias en itinerarios de aprendizaje flexibles?, se describe una experiencia piloto en una institución de educación básica, buscando determinar características clave del diseño instruccional. El proyecto parte de los itinerarios de aprendizaje propuestos por Cañas & Novak (2010) y sigue las líneas de investigación del Postgrado en Tecnología Educativa: E-learning y Gestión del Conocimiento (Universidad de las Islas Baleares).

De acuerdo con Cañas y Novak (2010), un itinerario es un mapa conceptual que sirve como una guía para los estudiantes sobre cómo estudiar o aprender un tema en particular. El itinerario ofrece alternativas para que el estudiante elija la forma de proceder a través de las actividades previstas. Un itinerario no describe el tema, recomienda cómo el tema puede ser estudiado, por lo que es diferente de un mapa descriptivo tradicional. En este contexto, los mapas conceptuales pueden ser utilizados para generar procesos de aprendizaje autorganizado, procesos no líneales, orientados al desarrollo de distintas competencias.

2 Contexto institucional

Ubicada en la zona centro oriental de la ciudad de Medellín, Colombia, la Institución Educativa Gabriel García Márquez (IEGGM, a partir de ahora), atiende los hijos de aproximadamente 1200 familias, ofreciendo servicios educativos desde el nivel preescolar hasta grado 11°, que incluye media técnica en articulación con una institución de educación superior de la ciudad, lo que permitirá a futuro gran impacto laboral y profesional dentro del sector. En el momento cuenta con 1.920 estudiantes y 54 docentes.

La estructura curricular de los programas académicos, está constituida por un Modelo Pedagógico Integrado, fundamentado en varios modelos con énfasis en el desarrollo del individuo, los requerimientos sociales, procesos tecnológicos, desarrollo del conocimiento, proyecto de vida individual y social. Con enfoque investigativo, participativo, social, tecnológico, interdisciplinario, interinstitucional, intercultural y globalizante. Igualmente el programa académico enfatiza en las formas y métodos de conocimiento y la teoría pedagógica que lo sustenta es la autorregulación; en donde se pretende una transformación en la relación: profesor – estudiante, clase – estudiante, la acción del docente es integral y más flexible; las formas de evaluación más apropiadas con las formas de acción y relación pedagógica y la acción del estudiante es más participativa.

A partir del año 2009 se inicia el proceso de construcción de la malla curricular basada en competencias y estructurada en cuatro componentes: Comunicativo, humanístico, científico y técnico. Por su parte, el Plan de Gestión de TIC institucional ha logrado permear los aspectos académico, social, administrativo y de convivencia y apoya la formación docente para implementar las nuevas tecnologías en el desarrollo académico de sus áreas, lo que afecta favorablemente la formación de los estudiantes.

La institución trabaja con diferentes proyectos para responder a esos desafíos que demandan cambios en los sistemas educativos y promueven experiencias innovadoras en los procesos de enseñanza/ aprendizaje. Todos los docentes de la institución reciben formación en TIC y algunos están realizando estudios de postgrado y diplomados relacionados con su incorporación a la dinámica escolar.

La incorporación de las TIC implica transformaciones de la estructura organizacional y académica de la institución. Aquí se definió una política y estrategias tendientes a asegurar condiciones que permitan, mediante sistemas de aprendizaje basados en la tecnología, ofrecer experiencias con excelentes estándares de calidad.
El propósito es fortalecer la inmersión de los estudiantes en los procesos tecnológicos actuales, flexibilizar los procesos de enseñanza y aprendizaje, promocionar la innovación educativa y agregar valor a los procesos de consulta, transferencia tecnológica y gestión e integración del joven a la sociedad.

3 Referente conceptual

Entendemos que tres son los temas cruciales para el proyecto: El diseño curricular basado en competencias, las conexiones cognitivas incluyendo elementos que se derivan de ellas y finalmente los ambientes de aprendizaje basados en TIC. A partir de este análisis se determinan las características de un diseño instruccional para ambientes basados en TIC, generando un proceso de aprendizaje autoorganizado, a través de itinerarios de aprendizaje basados en mapas conceptuales que potencian el desarrollo de las competencias de la institución.

3.1 Diseño curricular basado en competencias

En el contexto de este proyecto, el término competencia puede ser definido como un "saber hacer, sobre algo, con determinadas actitudes". Es decir, una medida de lo que una persona puede hacer bien como resultado de la integración de sus conocimientos, habilidades, actitudes y cualidades personales (Tejada, 2005). La competencia, por tanto, tiene que ver con una combinación integrada de conocimientos, habilidades y actitudes conducentes a un desempeño adecuado y oportuno en diversos contextos. La flexibilidad y capacidad de adaptación resultan claves para el nuevo tipo de logro que busca el trabajo y la educación como desarrollo general, para que las personas hagan algo con lo que saben.

Esto implica una diferente gestión curricular que hace referencia a las acciones que se implementan para direccionar, planear, ejecutar y evaluar el currículo, buscando alcanzar unas metas de formación y aprendizaje, basados en un modelo educativo y considerando un contexto (García, Tobón y López, 2009a, 2009b).
Desde un diseño curricular basado en competencias, el modelo que asume la IEGGM se inspira en el enfoque por excelencia para orientar el diseño curricular, la didáctica y la evaluación en Colombia. Aunque su implementación se inició en la educación para el trabajo y la educación superior, se están haciendo reformas en los otros niveles, para responder a las orientaciones de la política educativa haciendo énfasis en:

- La integración de los procesos cognitivos, procedimentales y actitudinales en un desempeño;
- La construcción de programas de formación que respondan a los requerimientos del contexto a nivel profesional, social, ambiental y laboral;
- La orientación de la educación por medio de estándares e indicadores de calidad en todos sus procesos.

El diseño Curricular de la IEGGM tiene un enfoque por competencias que busca desarrollar en los estudiantes 18 competencias básicas y 7 específicas, estas últimas dirigidas al área de desarrollo de software. Para la organización de las competencias en las áreas obligatorias, se han conformado cuatro componentes (Fig 1):

Figura 1- Conformación de Componentes

Dos han sido los principales motivos que han impulsado el enfoque por competencias en el diseño curricular:

- El hecho de que la educación ha de formar para la vida y para el trabajo con calidad y debe trascender lo teórico y la transmisión del conocimiento a su búsqueda, procesamiento, análisis y aplicación.
- La cultura de la calidad, la globalización y la competitividad, provocando el auge de las competencias en la educación, demandando formación que permita competir en el mercado nacional e internacional.

3.2 Ambientes de aprendizaje basados en tecnologías

En un ambiente de aprendizaje el participante actúa, usa sus capacidades, crea o utiliza herramientas y artefactos para obtener e interpretar información con el fin de construir su aprendizaje (González y Flores, 1999). En este contexto, aparecen nuevos ambientes de aprendizaje que indican claramente que el entorno para acciones de formación, relacionadas con los nuevos objetivos de la sociedad de la información y con la anticipación de las competencias necesarias que la evolución futura requerirá, definitivamente no es el salón de clase. Aunque los ambientes de aprendizaje tradicionales no sean sustituidos, ahora son complementados, diversificados y enriquecidos con nuevas propuestas que permiten la adaptación a esta nueva sociedad (Salinas, 1997, 2009). ¿Qué entender entonces por "Nuevos Ambientes de Aprendizaje"? UNACAR (s.f.) plantea que es una "forma diferente de organizar la enseñanza y el aprendizaje que implica el empleo de tecnología" en otras palabras la "creación de una situación educativa centrada en el alumno y que fomenta su auto-aprendizaje, el desarrollo de su pensamiento crítico y creativo, el trabajo en equipo cooperativo mediante el empleo de tecnología de punta".

3.3 Conexiones Cognitivas

La teoría de la asimilación de Ausubel es una teoría del aprendizaje basada en un modelo constructivista y cuyo núcleo es el proceso de interacción entre el material recién aprendido y los conceptos existentes (Ausubel, Novak, Hanesian, 1983). Cuánto más rica sea la estructura cognitiva de un sujeto que aprende, más interconexiones relacionales logrará entre la nueva información y la que posee. Esas interconexiones hacen que el aprendizaje sea significativo, pues es cuando se incorpora a estructuras de conocimiento que ya posee el individuo y que luego las puede utilizar en otros campos de su vida, de acuerdo a sus necesidades o intereses. La secuencia lógica de los procesos, la coherencia en la estructura interna del material y las ideas inclusoras relacionadas con el nuevo material, que son los lazos que unen los conocimientos previos con los nuevos, son lo que Ausubel denomina Potencialidad Significativa y que junto con la disposición del sujeto para el aprendizaje, son las condiciones para que se dé un aprendizaje significativo.

Los mapas conceptuales (Novak 1988), son la principal herramienta metodológica de la teoría de asimilación para determinar lo que el estudiante ya sabe (Cañas y otros 2000). Esta manera de representar el conocimiento puede ser enriquecido con software que facilitan la creación de mapas propios y que además amplían la gama de posibilidades, tal es el caso de CmapTools (Cañas et al, 2004).

Los mapas conceptuales son usados en las aulas para ayudar a los estudiantes a representar sus estructuras cognitivas y el conocimiento auto-construido, identificar procesos de investigación, mostrar resultados de preguntas que han orientado el desarrollo de un proceso educativo, interpretar teorías, lecturas, obras literarias, diseñar propuestas, organizar trabajo colaborativo. (Novak y Cañas, 2006). Todas ellas pueden incorporarse de una forma u otra a las estrategias didácticas en los procesos de enseñanza y aprendizaje en entornos virtuales.

3.4 Itinerarios de aprendizaje

Una importante aplicación de los mapas conceptuales la constituyen los itinerarios de aprendizaje (Cañas y Novak, 2010). En lugar de explicar el tema a través de proposiciones, se orientan a cómo aprender el tema. Se trata de ocuparse del 'cómo' en lugar del 'qué'. Los itinerarios de aprendizaje basados en mapas conceptuales son, por lo tanto, una forma de organizar un proceso de aprendizaje y presentan rutas, opciones y recursos para desarrollar una competencia o un saber, apoyados en Objetos de Aprendizaje que guían al sujeto que aprende.

Novak y Gowin (1988) consideran que el profesor es un mediador entre la estructura conceptual de las disciplinas y la estructura cognitiva del estudiante. El resultado de tal mediación es el cambio de la estructura cognitiva que genera el aprendizaje y la mediación se da a través del diseño curricular. Los itinerarios de aprendizaje basados en mapas conceptuales facilitan la navegación comprensiva y jerárquica a través de los contenidos y objetos de aprendizaje a varios niveles, por lo que se constituyen en un modelo para dicho diseño.
Un itinerario de aprendizaje permite al profesor tener un control real para organizar la asignatura según el propio criterio, pues le ofrece gran flexibilidad para organizar los contenidos y los objetos de aprendizaje. Sólo

si el profesor tiene flexibilidad para organizar la asignatura, puede dar control a los alumnos. El mapa conceptual proporciona dicha flexibilidad.

Teniendo en cuenta aspectos de la teoría del aprendizaje significativo (Ausubel, Novak y Hanesian, 1983; Novak, 1998) un itinerario de aprendizaje se caracteriza por: Ser un organizador de los conceptos, temas a aprender o competencias a desarrollar, así como de los objetos de aprendizaje a utilizar. Dar una visión completa de lo que debe hacerse para comprender el tema en cuestión. Ofrecer opciones o alternativas a seguir en la construcción de la propia secuencia de aprendizaje de acuerdo con las características individuales, necesidades, estilo de aprendizaje, entre otros. Hacer uso de lo que se conoce como un mapa de experto.

La estructuración y secuenciación de los contenidos de una disciplina de acuerdo a un adecuado diseño instruccional, es uno de los elementos esenciales en los procesos de enseñanza y aprendizaje en entornos virtuales (de Benito, Darder y Salinas 2012). De esta manera, crear entornos de aprendizaje basados en mapas, hace que los conceptos adquieran mayor significado al proporcionar relaciones entre ellos y al mostrar su dependencia con conocimientos previos. Pero cabe resaltar que más que un organizador de conceptos y contenidos, el itinerario busca presentar un entorno de aprendizaje que posibilita una secuencia no lineal y facilita el acceso a objetos de aprendizaje que apoyan la construcción de conocimientos y el desarrollo de competencias.

Desde esta perspectiva, el sujeto que se forma y aprende a través de itinerarios basados en mapas, puede obtener las siguientes ventajas (de Benito, Cañas, Darder y Salinas, 2010):

- Suficiente flexibilidad para facilitar la autonomía en los procesos de aprendizaje.
- Consultar el material en función de sus necesidades, intereses, motivaciones y conocimientos previos.
- Establecer relaciones significativas entre los contenidos, recursos y actividades.
- Descargar el itinerario lo que facilita su personalización: Identificar los nodos visitados, agregar notas, enlazar evidencias, incluir recursos propios y otros objetos de aprendizaje.
- Libertad en su movilidad por el entorno de aprendizaje, de acuerdo al diseño del itinerario.
- Interactividad, al poder dirigir su propia ruta entre los contenidos, dentro de relaciones predefinidas.

4 Desarrollo de la experiencia

La investigación que se presenta está orientada por la pregunta que se planteó al inicio y enmarcada por los correspondientes objetivos de investigación.

Pregunta inicial: ¿Cómo los mapas conceptuales pueden apoyar el desarrollo de competencias en itinerarios de aprendizaje flexibles?

Objetivo General: Desarrollar un Modelo de currículo por competencias, basado en itinerarios de aprendizaje apoyados en mapas conceptuales.

Objetivos específicos:

- Describir las características de los itinerarios de aprendizaje que conformarán el modelo propuesto.
- Diseñar un itinerario de aprendizaje, apoyado en mapas conceptuales, que desarrolle una de las competencias propuestas por la institución.
- Implementar un itinerario del currículo vigente de la IEGGM, monitoreando el proceso.
- Facilitar el desarrollo de la competencia en los estudiantes seleccionados, a través de un itinerario de aprendizaje, apoyado en mapas conceptuales.
- Promover entre los alumnos participantes el proceso de autoformación y aprendizaje autónomo.
- Ajustar y evaluar el desarrollo del itinerario, de acuerdo al proceso realizado.

La investigación siguió metodología de diseño y desarrollo, dividiéndose en 5 fases (Figura 2).

Figura 2- Fases del proyecto

Diseño: Se determinaron los elementos básicos de la investigación: Definición del sujeto, objetivos y las preguntas de investigación, revisión de la literatura y la definición de marco teórico y conceptual, enfoques y técnicas metodológicas, indicadores de calidad. Esta fase incorporó el diseño del itinerario de aprendizaje apoyado en mapas conceptuales, que desarrolla una de las 25 competencias que conforman el diseño curricular

de la Institución educativa, teniendo en cuenta los elementos anteriores, su aprobación por parte de entidades y personas competentes y su aplicación al sujeto elegido en la etapa de diseño.
Implementación: Consistió en el trabajo de campo con los estudiantes, aplicando el itinerario de aprendizaje.
Análisis de resultados: Se miden los resultados de manera cualitativa y cuantitativa, a la luz de los indicadores de calidad definidos, teniendo en cuenta las características del sujeto y el objeto de investigación.
Socialización: La organización y presentación de los resultados del proyecto son el propósito de esta fase, en donde se da a conocer la respuesta a las preguntas de investigación, los aciertos y desaciertos del proceso, las buenas prácticas y las recomendaciones para la proyección futura del proceso.
Transferencia: A partir de los resultados, se proyecta implementar itinerarios de aprendizaje en distintos niveles de educación para otras competencias, ampliando el enfoque del modelo. Se debe hacer extensiva la propuesta a docentes que diseñen sus propios itinerarios de aprendizaje, siguiendo las características propuestas.

4.1 Procedimiento de la experiencia

Se da cuenta, sobre todo del proceso de implementación, inspirado en la pregunta inicial y objetivos planteados.
En el caso que se describe, de las 18 competencias básicas y 7 específicas de la IEGGM, se toma una del componente Técnico: Gestión de la información usando herramientas informáticas (Figura 1). La prueba piloto se realizó con estudiantes de la IEGGM, desde la básica primaria hasta la educación media- académica y técnica. Para esta fase de implementación, se trabaja con el grado noveno, en el cual hay tres grupos, lo que permite tener un grupo control y dos grupos experimentales. Los grupos tienen un promedio de 30 estudiantes y sus edades oscilan entre los 14 y los 16 años.

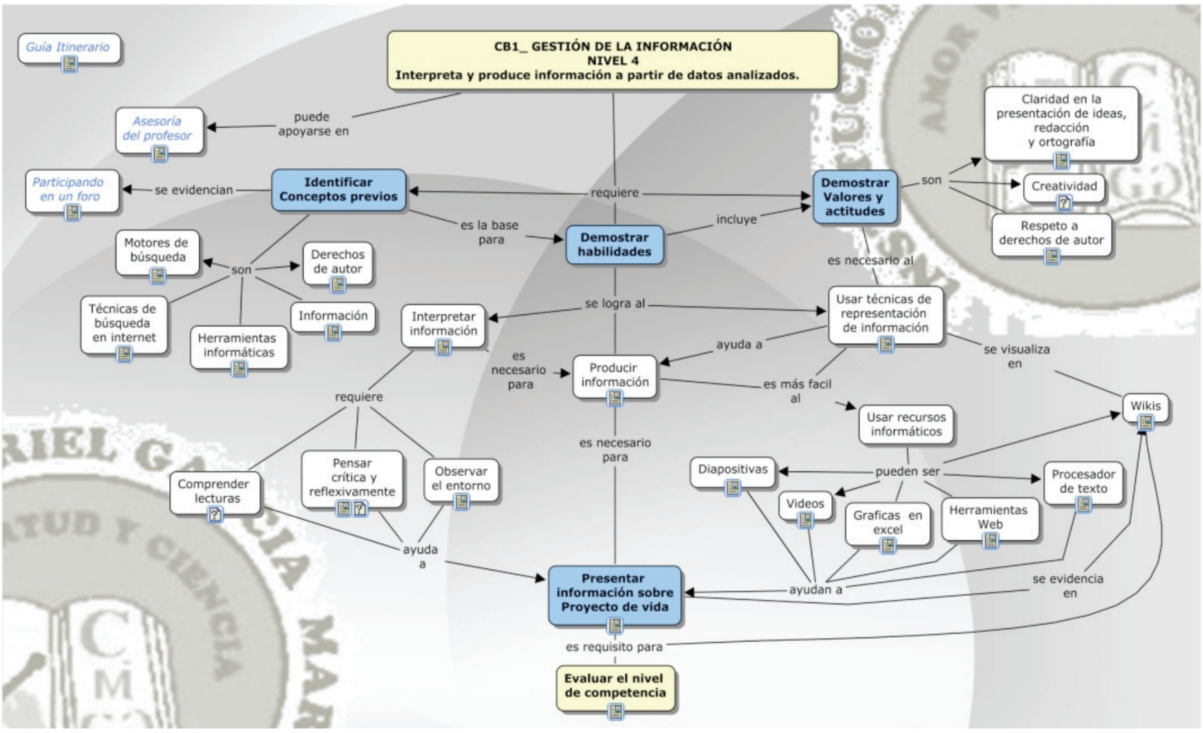


Figura 3- Itinerario aplicado: http://cmaps.cmappers.net/rid=1JWZSDH0P-1HMTFFT-1LLH/GI_Itinerario_NIVEL4.cmap.cmap

La competencia elegida para ser representada en el itinerario de aprendizaje tiene 5 niveles y dado el grado de los estudiantes, se trabaja el nivel 4 (Figura 3): Interpreta y produce información a partir de datos analizados. Este nivel de la competencia se trabajó durante el cuarto periodo académico de 2011, el cual está comprendido entre el 13 de septiembre y el 26 de noviembre. Las áreas que abordan esta competencia en este lapso de tiempo son las áreas del componente técnico: tecnología e informática y emprendimiento y se apoyan en el área de religión, del componente humanístico, desde donde se desarrolla la competencia: Construcción del proyecto de vida, que se convierte en el proyecto de aula que da sentido al desarrollo de esta competencia.
GE1- Grado 9º1: Trabajó el itinerario como apoyo al proceso presencial.
GC -Grado 9º2: Desarrolló la competencia en clase presencial sin apoyo de itinerarios de aprendizaje.
GE2 - Grado 9º3: Trabajó el itinerario de manera autónoma, el docente asume el rol de tutor virtual.

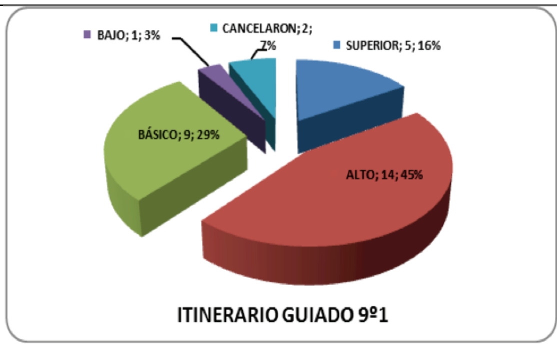
4.2 Resultados

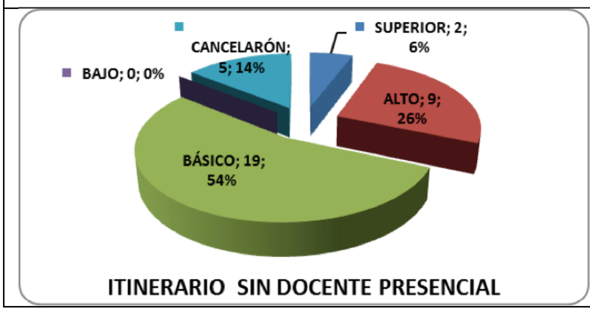
La aplicación de la estrategia de Itinerarios de aprendizajes con los estudiantes de los grupos experimentales GE1 y GE2 -grados noveno 9º1 y 9º-3, facilitó el cumplimiento temático correspondiente al cuarto periodo, uno de los más difíciles, dado que los estudiantes ya están finalizando el año y la gran pérdida de clases por las diferentes actividades programadas, ya sean institucionales o personales, influyen en el cumplimiento de éste. Durante la implementación de los Itinerarios se realizó un seguimiento de la experiencia y de incidencias.
Se presentan resultados en relación a tres aspectos:

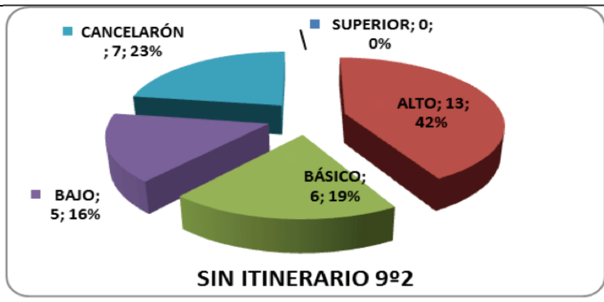
- Rendimiento académico (basados en los datos de calificación del periodo 4)
- Actividad desarrollada en el Itinerario (objetos de aprendizaje utilizados, etc.)
- Nivel de satisfacción con la experiencia

a) Resultados académicos: Se puede observar que los mejores resultados académicos se registran en el itinerario guiado (grupo Experiental 1), en el cual se cumple con un 61 % los cuales están representados en el desempeño alto y superior. Aunque los resultados más bajos en estos dos desempeños se presentaron en el itinerario sin docente presencial (Grupo Experimental 2), es importante destacar que el nivel de desempeño bajo en este grupo es menor que en el grupo control que trabajó con metodología tradicional, sin itinerario.

Nombre: **Estudiantes con desempeño alto o superior en el desarrollo de la competencia.**
Responsable: docentes del componente técnico
Fórmula: # de estudiantes con desempeño alto o superior # de estudiantes que desarrollan el itinerario
Meta: 60%
Origen de los datos: Seguimiento y calificación de las actividades y procesos planteados en el itinerario y demuestran el desarrollo de la competencia.

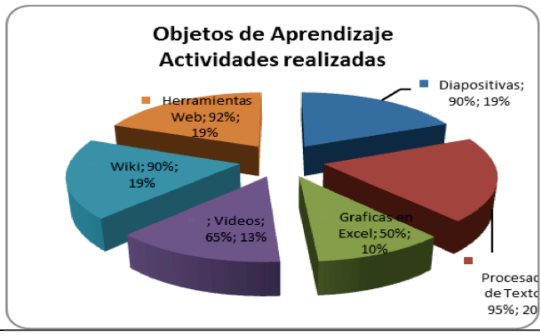




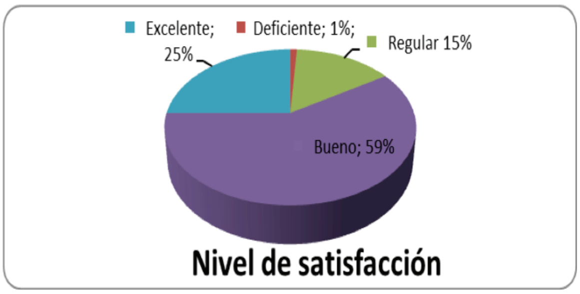


b) Actividad desarrollada en el Itinerario: Los objetos de aprendizaje visitados y las actividades desarrolladas fueron observadas a partir de la participación en las actividades propuestas y el seguimiento realizado al itinerario durante el periodo. En promedio se desarrollaron un 80.3 % de los objetos de aprendizaje y actividades propuestas en el itinerario, promediando los resultados de los dos grupos experimentales.

Actividades realizadas y/o Objetos de aprendizaje visitados %	
Diapositivas	90%
Procesador de Textos	95%
Graficas en Excel	50%
Videos	65%
Wiki	90%
Herramientas Web	92%
Libro Digital	2%
Edición de Imágenes	1%
Avatars	90%
Presentaciones Web	0%



Estos porcentajes son basados en los itinerarios desarrollados y lo observado en clase. Nótese que la herramienta de edición de imágenes, un recurso que exigía crear cuenta para poder utilizarlo y en ese momento no estaba permitiendo crear cuentas, no fue usado pero si visitado. El recurso más visitado y utilizado definitivamente fue el Avatars porque no requería registrarse para hacer uso de él y llamaba más la atención. Es importante destacar que en el grupo control (trabajó sin itinerario) no logró terminar ningún producto debido a las múltiples actividades extracurriculares, a los problemas de orden público que impidieron el desarrollo normal de las actividades escolares y a la dependencia total de la orientación de la docente. Estas dificultades se superaron con los itinerarios de aprendizaje donde se pudo evidenciar el trabajo autónomo de los estudiantes.



c) Nivel de satisfacción con la experiencia: En cuanto al nivel de satisfacción con el itinerario, éste se obtuvo mediante encuesta a los estudiantes y docentes encargados del área de tecnología. Se regieron el 84% de las encuestas entregadas. El nivel de satisfacción es de 84 %, representado en las encuestas por la motivación, la flexibilidad, los recursos, la autonomía que podían demostrar en el desarrollo de la competencia. Los que manifiestan más bajo nivel de satisfacción expresan no tener los recursos para acceder al itinerario en tiempo extracurricular y la dificultad inicial al aplicar una nueva metodología.

5 Reflexiones y lecciones aprendidas

- Los mejores resultados académicos se presentan en el itinerario guiado -Grupo experimental 1-. Entendemos que dada la edad, experiencias previas y recursos disponibles en el entorno, aun no les facilitan el proceso de aprendizaje autónomo. La flexibilidad del itinerario y la nueva metodología les da un grado de autonomía y motivación que permite superar los resultados de la metodología habitualmente empleada- Grupo control. Aunque el itinerario se utilizó en este grupo como apoyo al trabajo presencial, los estudiantes no siguieron las instrucciones de desarrollo que dio el docente al pie de la letra y terminaron desarrollando las actividades de acuerdo a sus propios intereses y motivaciones.
- El itinerario desarrollado por el grupo experimental 2 (9-3), permitió a los estudiantes desarrollar la competencia apoyados por el docente de manera virtual, esta situación fue problemática para los estudiantes que no están acostumbrados a este tipo de metodología, generándose ansiedad cuando no tenían disponible al docente de manera presencial para hacer las consultas necesarias, así estuvieran escritas en el itinerario. Sin embargo este grupo logro resultados positivos en un 100%, aunque no fue el más representativo en desempeño alto y superior, el nivel de pérdida (desempeño bajo) fue de 0%.
- En todo caso, los resultados obtenidos en el Grupo 9-1, que utilizó en itinerario sin apoyo del docente, puede considerarse exitoso dado el nivel de madurez de los alumnos. Entendemos que sigue siendo una vía de trabajo e investigación, en un formato complementario del Itinerario guiado por docente para aquellos casos con problemas de accesibilidad a las clases. En todo caso, puede ser interesante experimentar con grupos de un nivel más alto de madurez para contrastar los resultados.
- El diseño flexible del itinerario genera más investigación, trabajo en equipo, autoaprendizaje y autonomía en el desarrollo de la competencia y permite que los estudiantes avancen a su propio ritmo.
- La visualización de la totalidad del diseño instruccional: competencia, actividades, relaciones, objetos de aprendizaje genera más compromiso y mejor administración del tiempo tanto por parte de los estudiantes como de los docentes, a la vez que se convierte en una solución a los problemas de desescolarización.
- En el trabajo con itinerarios flexibles basados en mapas conceptuales, se requiere mayor habilidad del docente tanto para el diseño como para asumir el rol de guía, ya que los estudiantes están desarrollando diferentes actividades y contenidos al mismo tiempo y sus indicaciones no deben interferir en el proceso autónomo que se genera.

A manera de conclusión: El trabajo con itinerarios se presenta como una metodología novedosa, lo que generó expectativas y potenció cambios al interior del trabajo de aula: se mejora el proceso de investigación, el trabajo en equipo, las actitudes de liderazgo y el ambiente de trabajo. La visualización de todo el contenido y actividades en el itinerario, incentiva el proceso de auto-aprendizaje, el avance en el tiempo y el ritmo personalizado según los intereses. A la vez que permitió solucionar problemas ocasionados por la desescolarización.

El que los estudiantes no supieran leer y hacer mapas conceptuales; la cantidad de actividades en relación al tiempo disponible, y la calidad de algunos objetos de aprendizaje afectó la calidad del producto final. Desde el punto de vista del docente este tipo de experiencia permitió cuestionar su rol como docente, tutor y plantear estrategias para el desarrollo de las clases a futuro. Además, el recibir todos los trabajos a través de internet y en un solo espacio facilitó el proceso de evaluación.

6 Proyección futura

A partir de los resultados obtenidos, se espera poder generalizar la aplicación de este diseño instruccional en el desarrollo de otro tipo de competencias, y así mismo en otros niveles educativos. Previo a ello, se observa la necesidad de rediseñar el itinerario, introduciendo modificaciones necesarias para una utilización eficiente tanto en el caso de Itinerario flexible guiado por docente, como en el Itinerario flexible de utilización autónoma, aplicando las sugerencias dadas por expertos, docentes y estudiantes, incrementando el trabajo colaborativo, mejorando las guías y seleccionando o diseñando más y mejores objetos de aprendizaje. A partir de las necesidades detectadas, ya se está diseñando un itinerario para la formación de docentes. Esta formación requiere dos direcciones de trabajo: Por un lado capacitar para una adecuada guía y supervisión de los Itinerarios guiados, y por otra, la posibilidad de generar mapas con itinerarios propios. Todas estas líneas de trabajo contribuirán a identificar más elementos para caracterizar el modelo de desarrollo de competencias a través de itinerarios de aprendizaje flexibles, mediante mapas conceptuales.

7 Agradecimientos

La Universidad de las Islas Baleares a través de su equipo docente y administrativo ha apoyado el proceso de investigación y la revisión de las propuestas elaboradas. El Dr. Alberto Cañas apoyó con formación, seguimiento y soporte tecnológico el desarrollo del proceso. La línea de investigación en informática educativa de la Universidad EAFIT, que facilitó la formación en mapas conceptuales y en itinerarios de aprendizaje Las directivas institucionales permiten el desarrollo de estas propuestas y brindan los recursos técnicos, tecnológicos y logísticos, sin su apoyo no se podrían llevar a cabo este tipo de experiencias. La docente Nancy Camacho con una actitud abierta a la implementación de nuevas experiencias, facilitó el espacio académico con sus grupos de estudiantes y fue un elemento clave en el desarrollo de la propuesta.

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Valletta, Malta 2012

DIVERSITY OF CONCEPT MAPPING TASKS: DEGREE OF DIFFICULTY, DIRECTEDNESS, AND TASK CONSTRAINTS

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Abstract. Concept maps have been used for knowledge assessment already for several decades. At the same time no extensive overview has been made on possible concept mapping tasks and no formal methods have been developed for comparing the degree of difficulty of different assessment tasks based on concept maps. There are only some research studies on task characterization, task comparison, use of different tasks for assessing students with different knowledge level and extending task types considering constraints on sets of concepts and linking phrases. The paper examines diversity of concept mapping tasks from the perspective of possible task constraints which are considered in relation to the directedness continuum as a factor of the degree of task difficulty. The main contributions are the general view on diversity of concept mapping tasks and the detailed framework for identification of possible concept mapping tasks taking into account task constraints.

1 Introduction

Concept maps have well-established basis for their use in teaching, learning, and assessment processes. As an assessment instrument, they offer a wide range of tasks allowing elicitation of students' knowledge structures and their further examination with aim to identify and remediate knowledge gaps and misunderstandings. At the same time analysis of available information sources shows that no formal methods have been developed for comparing the degree of difficulty of different assessment tasks based on concept maps. There is only Ruiz-Primo's research about characterization of a concept map task assessment by a directedness continuum from high-directed to low-directed tasks depending on the information provided to students (Ruiz-Primo, 2004) and Yin's et al. study on comparison of two types of concept mapping tasks (Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2005). In the work of Lukashenko and Anohina-Naumeca, a student receives concept mapping tasks with the different degree of task difficulty taking into account his/her previous assessment results (Lukashenko & Anohina-Naumeca, 2010). Grundspenkis (Grundspenkis, 2011) has paid attention to possible types of tasks considering constraints on sets of concepts and linking phrases available to students during completion of tasks.

The paper examines diversity of concept mapping tasks from the perspective of possible task constraints which are considered in relation to the directedness continuum as a factor of the degree of task difficulty. The main contributions are a general view on diversity of concept mapping tasks and a detailed framework for identification of possible concept mapping tasks taking into account task constraints. The paper is organized as follows. Section 2 gives an overview of the developed concept map based intelligent knowledge assessment system which triggered the research presented in this paper because of necessity to extend a set of tasks implemented in the system. Section 3 describes the identified diversity of concept mapping tasks in the context of knowledge assessment. Section 4 focuses on task constraints taking into account the directedness continuum. Acknowledgments, conclusions, and directions of future work are presented at the end of the paper.

2 Overview of IKAS

Since 2005, the concept map based ***i***ntelligent ***k***nowledge ***a***ssessment ***s***ystem called IKAS has been developed at Riga Technical University, Latvia (Anohina-Naumeca, Grundspenkis, & Strautmane, 2011; Grundspenkis, 2011; Lukashenko & Anohina-Naumeca, 2010). It has two main goals: 1) to support students in self-assessment process of their knowledge, and 2) to support teachers in improvement of study courses through systematic analysis of students' knowledge. Assessment process in IKAS is based on concept maps.

The system is used in the following way. The teacher divides a study course into several stages and builds a concept map for each of them in such a way, that a concept map of each stage is nothing else than an extension of the previous one. Therefore, the concept map of the last stage includes all concepts studied in the course and all relations among them. At the end of each stage the created concept maps in the form of concept mapping tasks are offered to students for knowledge self-assessment. After completion of a task, the system performs automatic comparison of concept maps of the students and the teacher and provides feedback.

At the moment six tasks are implemented in the system (Table 1): four of them provide the structure of a concept map and students must fill it using the offered set of concepts and/or linking phrases, and two tasks assume construction of a concept map by students using the offered set of concepts and/or linking phrases. Ten transitions between the tasks are realised. Five of them increase the degree of task difficulty. They are carried out automatically if a student has reached the teacher's specified number of points in the current assessment stage without reducing the degree of task difficulty of the original task. Other five transitions reduce the degree of task difficulty after a voluntary request from the student during task solving. Teachers set the initial degree of task difficulty for their courses.

<table>
<tr><th>Degree of task difficulty</th><th>Task</th><th>Structure of a concept map</th><th>Concepts</th><th>Linking phrases</th></tr>
<tr><td>1st – the simplest</td><td rowspan="4">To fill in the structure of a concept map</td><td rowspan="4">Given</td><td>Part of concepts are already inserted into the structure, the other part is given as a list and must be inserted by students</td><td rowspan="2">Inserted into the structure</td></tr>
<tr><td>2nd</td><td rowspan="3">Given as a list and must be inserted by students</td></tr>
<tr><td>3rd</td><td>Not used</td></tr>
<tr><td>4th</td><td>Given as a list and must be inserted by students</td></tr>
<tr><td>5th</td><td rowspan="2">To construct a concept map</td><td rowspan="2">Must be created by students</td><td rowspan="2">Given as a list and must be related by students</td><td>Not used</td></tr>
<tr><td>6th – the most difficult</td><td>Given as a list and must be inserted by students</td></tr>
</table>

Table 1: Tasks Implemented in IKAS

During the period from 2005 till 2011, IKAS has been evaluated in 20 study courses. After use of the system, students are always offered to provide answers on a questionnaire eliciting their opinion about concept maps as a knowledge assessment method and functional capabilities of IKAS. So far 456 questionnaires have been processed. Regardless the fact that, in general, students evaluate positively their experience with IKAS, answers give evidence that the offered tasks are not suitable for all students (Table 2). First of all, there are students who do not like working with concept maps. Secondly, always there are students who do not want to use concept maps in future. Thirdly, the most part of students have difficulties in completing concept mapping tasks. These facts, by the opinion of the system's developers, call for necessity to extend the set of tasks implemented in IKAS in order to support diversity of students in terms of their knowledge level and way of construction of knowledge structures and to provide more objective assessment process.

Question	Answer	Number of students' answers (%)
Do you like to use concept maps as a knowledge assessment method?	Yes	317 (69,5%)
	Neutral	86 (18,9%)
	No	53 (11,6%)
Would you like to use such a knowledge assessment method in other courses?	Yes	182 (39,9%)
	Probably	205 (44,95%)
	No	69 (15,15%)
Was it difficult for you to complete concept mapping tasks?	Very difficult	44 (9,7%)
	Difficult	256 (56,1%)
	Easy	145 (31,8%)
	Very easy	11 (2,4%)

Table 2: Students' Answers on the Questionnaire

3 Diversity of Concept Mapping Tasks

Concept maps have been used in different assessment tasks. In general, tasks can be divided into two main groups:

- simple concept mapping tasks which apply concept maps as the main assessment instrument and do not use other types of tasks simultaneously;
- compound concept mapping tasks which include a simple concept mapping task only as a part of assessment, for example, a student writes an essay and gives its summary as a concept map, or gives an answer as a concept map which is followed by an individual interview about the content of the constructed concept map (Rojas, Sánchez, Barrios, Vergara, Torres, & Bravo, 2008), or vice versa, an interview is at first and then a concept map is constructed on the basis of the answers received (Wehry, Algina, Hunter, & Monroe-Ossi, 2008).

The diversity of the simple concept mapping tasks is determined by the fact that a task consists of a combination of three parts (Ruiz-Primo & Shavelson, 1996):

- task demands which correspond to a task statement or, in other words, specify what students need to do, for example, students need to fill-in the structure of a concept map, to compare two concept maps, to evaluate correctness of a concept map, to construct a concept map, etc.;
- task constraints which restrict students' activities, for example, they determine what kind of the topology should be provided, if students receive all concepts needed for task solving or only part of them, etc.;
- task content structures which are an intersection between the task statement and constraints and the structure of the problem domain, i.e., how the problem domain affects a task, for example, students need to draw a linear concept map representing sequence of processes.

Task demands determine the type of a task. Here, two main categories can be identified:

1) tasks directly related to externalization of students' knowledge structures (internal representation of knowledge), for example, construct a concept map for a particular topic or fill-in the missing concepts in the structure;
2) tasks where students manipulate provided concept maps or their elements. Examples of such tasks are evaluation of correctness of a concept map, evaluation of correctness of a proposition, concept sorting (Ruiz-Primo & Shavelson, 1996), comparison of concept maps, etc.

Further in this paper attention is paid only to the simple concept mapping tasks related to externalization of students' knowledge structures.

4 Task Constraints

The concept mapping tasks can be characterized with the directedness continuum, i.e., the degree of task difficulty is influenced by the fact how much students have been directed during task solving, more precisely, how much information about the concept map students receive (Ruiz-Primo, 2004). The higher is the degree of directedness, the simpler is the task. The degree of directedness is associated with the task constraints mentioned above.

In general, the task constraints emerge from possible constraints on the elements of a concept map as a graph and their characteristics. These elements are:

- the whole structure of a concept map which is characterized by:
  - its availability to students;
  - presence of arc direction;
  - presence of arc weights;
- nodes representing a set of concepts in a problem domain;
- arcs defining relations between concepts and characterized by a set of linking phrases specifying semantics of relations.

With regard to availability of the structure of a concept map, three possible values can be defined:

- a full structure. It corresponds to the so called "fill-in-the-map" tasks where students must operate with the already provided structure of a concept map taking into account constraints on other elements of the concept map;
- an absent structure. It corresponds to the so called "construct-the-map" tasks (opposite to the "fill-in-the-map" tasks) where the structure of a concept map is not provided and students must create it in the framework of constraints on other elements of the concept map;
- a partial structure. In this case a part of the structure is already given ("fill-in-the-map" task), but students must extend it by adding new nodes and arcs ("construct-the-map" task). This type of tasks can be called "adjust-the-map" tasks.

Figure 1 displays the degree of directedness in relation to the previously described constraints on availability of the structure of a concept map. As "adjust-the-map" tasks are a combination of "fill-in-the-map" and "construct-the-map" tasks, further in the paper attention is paid to the detailed analysis of the these two types of tasks.

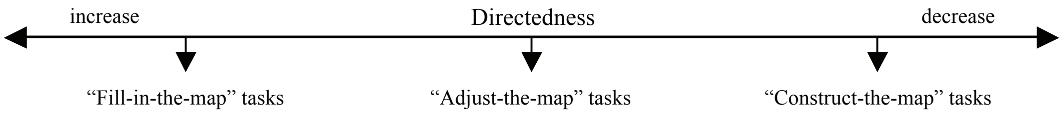

Figure 1. Task characterization with the degree of directedness.

Necessity to process arc directions increases the degree of task difficulty. Here, it is possible to define three main cases with some slight variations for “fill-in-the-map” and “construct-the-map” tasks:

- direction of arcs is not important in the context of the task and, therefore, the concept map is an undirected graph. It is suitable for tasks where linking phrases are not used and only the fact that concepts are related is important;
- direction of all arcs is important in the context of the task and, therefore, the concept map is a directed graph:
  - for “construct-the-map” tasks:
    - students constructing the concept map must provide direction for each arc;
  - for “fill-in-the-map” tasks:
    - direction of all arcs is provided in the structure of the concept map;
    - none of arcs are directed in the structure and students must provide direction of arcs;
    - a part of arcs in the structure are directed, for the other part students must provide direction;
- arcs are partly directed according to Novak when vertical arcs used for hierarchal relations are undirected and should be read from the bottom to the top and horizontal cross-links are directed (Novak, 1984):
  - for “construct-the-map” tasks:
    - students constructing the concept map must provide direction of arcs where it is necessary;
  - for “fill-in-the-map” tasks:
    - direction for arcs that need it is provided in the structure;
    - none of arcs are directed in the structure and students must provide direction of arcs that need it;
    - a part of arcs in the structure are directed, for the other part students must provide direction.

Figure 2 shows the degree of directedness taking into account constraints on direction of arcs in a concept map.

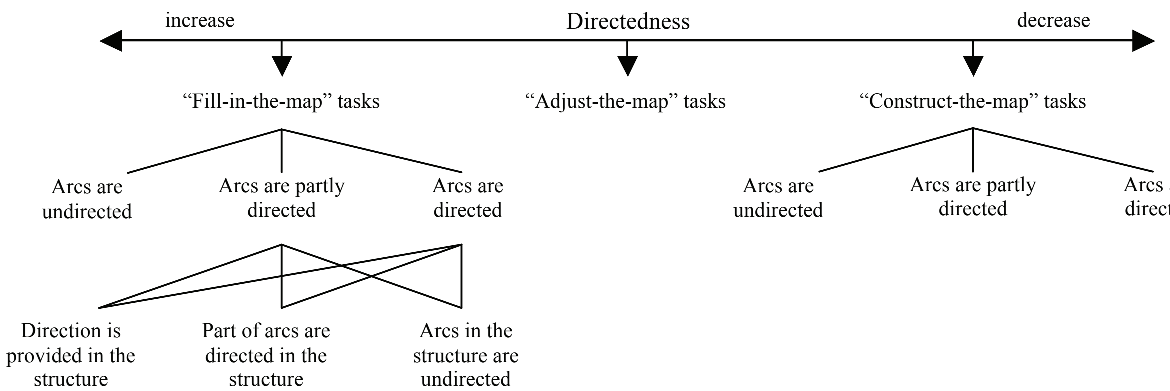

Figure 2. The degree of directedness in relation to constraints on arc direction.

According to Grundspenkis (Grundspenkis, 2011), concept maps are homogeneous graphs if all arcs in a concept map have the same weights or heterogeneous graphs if weights are different. In the former case, students must not care about determination of arc weights in “fill-in-the-map” or “construct-the-map” tasks. In the latter case, constructing a concept map students must provide weights of arcs. However, in “fill-in-the-map” tasks three different cases need to be considered (Figure 3):

- arc weights are provided in the structure of the concept map;
- arc weights are not provided in the structure and they must be determined by students;
- a part of arc weights are provided in the structure, the other part must be determined by students.

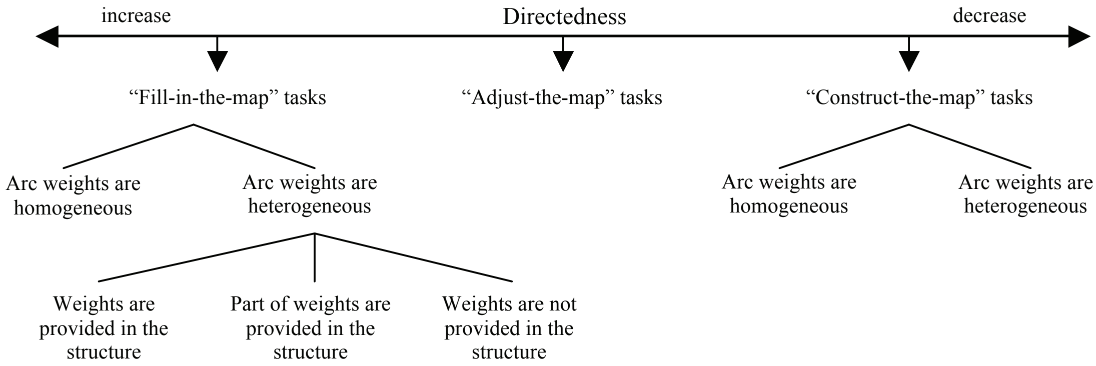

Figure 3. The degree of directedness in relation to constraints on arc weights.

A set of concepts is an integral part of any concept mapping task, because without it tasks do not have sense. However, linking phrases are optional as they only explain semantics of relations which presence is displayed by arcs. Therefore, considering constraints related to the sets of concepts and linking phrases (if linking phrases are used), it is necessary to take into account the previously specified constraints on the structure of a concept map. Then two different sets can be identified:

- the set of concepts/linking phrases already inserted in the structure of a concept map and serving as anchors/hints for completion of the task. There three values are possible:
  - an empty set. This case corresponds to "construct-the-map" tasks, because they do not offer the already provided structure of a concept map;
  - a full set. It is a case of "fill-in-the-map" tasks when all concepts or linking phrases are already inserted in the structure of a concept map;
  - a partial set. This case is also related to "fill-in-the-map" tasks when a part of concepts and/or linking phrases are already inserted in the structure of a concept map, but the other part must be filled in by students.

  Figure 4 shows the degree of directedness taking into account constraints on the set of concepts/linking phrases already inserted in the structure of a concept map.

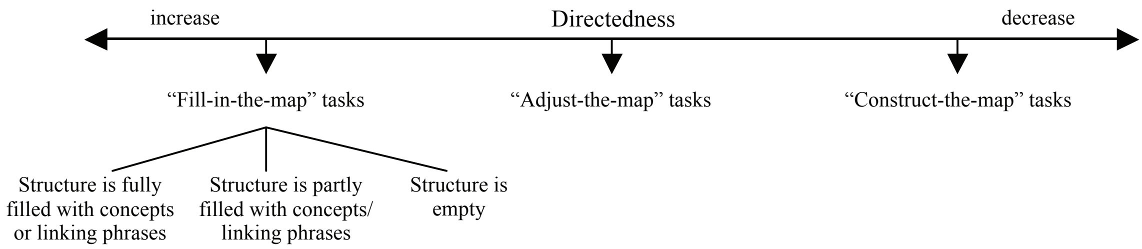

Figure 4. The degree of directedness taking into account constraints on concepts/linking phrases already inserted in the structure of a concept map.

- the set of concepts/linking phrases available to students for completion of the task. Constraints on this set can be dived into five categories (adopted from (Grundspenkis, 2011) and supplemented):
  - a full set. Students receive all concepts/linking phrases that are relevant to the task and must be inserted into the given structure of a concept map ("fill-in-the-map" tasks) or must be used for construction of a concept map ("construct-the-map" tasks);
  - an empty set. Students need to define all concepts/linking phrases relevant to the task;
  - a partial set. Students receive only a part of concepts/linking phrases as a list, the other part must be defined;
  - an overfull set. Students receive not only those concepts/linking phrases that are relevant to the task, but also additional concepts/linking phrases that are misleading, because they are incorrect or irrelevant to the problem domain;

- a hybrid set. Students receive a part of concepts/linking phrases relevant to the task and a number of misleading items as a list, but the other part of concepts/linking phrases must be defined.

Figure 5 displays the degree of directedness in relation to constraints on the set of concepts/linking phrases available to students. The degree of directedness decreases in the following order: full set→ overfull set→ hybrid set→ partial set→ empty set. However, location of overfull, hybrid, and partial sets on the directedness continuum may change according to the number of misleading and/or absent items included in them.

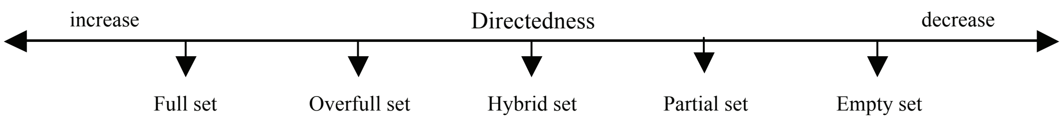

Figure 5. The degree of directedness in relation to the sets of concepts and linking phrases available to students.

Taking into account the task constraints described previously, it is possible to conclude that the degree of task difficulty in both "fill-in-the-map" and "construct-the-map" tasks is influenced by the fact what students should do and what is provided for this activity. However, the degree of task difficulty in "fill-in-the-map" tasks also depends on what is already included in the provided structure of a concept map.

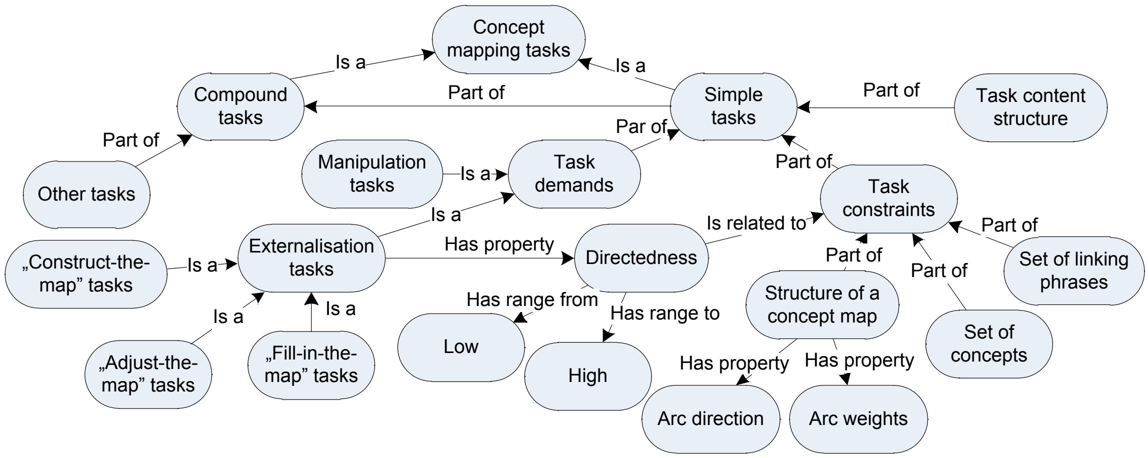

Figure 6. The general view on diversity of concept mapping tasks.

Figure 6 displays a general view on diversity of concept mapping tasks. Table 3 offers a detailed framework for identification of possible concept mapping tasks taking into account task constraints. Impossible combinations are shown as cells with grey shading. Therefore, "construct-the-map" tasks are a combination of an absent concept map structure and:

- one of constraints on the set of concepts available to students;
- one of constraints on the set of linking phrases available to students;
- one type of arc direction (from available variations);
- one type of arc weights (from available variations).

"Fill-in-the-map" tasks, in their turn, are a combination of the following items:

- one type of the full structure taking into account concepts filled in the structure;
- one type of the full structure considering linking phrases filled in the structure;
- one of constraints on the set of concepts available to students (except if the structure is "Full structure with fully filled concepts");
- one of constraints on the set of linking phrases available to students (except if the structure is "Full structure with fully filled linking phrases" and except of using "Absent set" together with any type of the full structure with filled linking phrases);
- one type of arc direction ("Undirected arcs" are used with "Absent set" of linking phrases);
- one type of arc weights.

Constraints on other elements \ Constraints on a concept map structure		Absent structure	Full structure with fully filled concepts	Full structure with partly filled concepts	Full structure with no concepts inserted	Full structure with fully filled linking phrases	Full structure with partly filled linking phrases	Full structure with no linking phrases inserted
Constraints on the set of concepts available to students	Full set							
	Partial set							
	Overfull set							
	Empty set							
	Hybrid set							
Constraints on the set of linking phrases available to students	Full set							
	Partial set							
	Overfull set							
	Empty set							
	Hybrid set							
	Absent set							
Arc direction	Undirected arcs							
	Directed arcs: direction is provided in the structure							
	Directed arcs: direction is partly provided in the structure							
	Directed arcs: direction is not provided							
	Partly directed (Novakian) arcs: direction is provided in the structure							
	Partly directed (Novakian) arcs: direction is partly provided in the structure							
	Partly directed (Novakian) arcs: direction is not provided							
Arc weights	Homogeneous weights							
	Heterogeneous weights: all weights are provided in the structure							
	Heterogeneous weights: weights are partly provided in the structure							
	Heterogeneous weights: weights are not provided							

Table 3: The Framework of Concept Mapping Tasks Taking into Account Task Constraints

5 Conclusions and Future Work

The analysis performed shows that concept mapping tasks are extremely different due to the variety of constraints that can be put on elements of a concept map. Therefore, they offer a quite broad spectrum of possibilities to support various assessment needs and peculiar students' characteristics related to construction and externalization of their knowledge structures. In future, several research tasks are planned: a) extraction from the whole set of possible concept mapping tasks a sub-set of tasks that can be processed in automatic way;

b) developing of a mathematical model for evaluation of the tasks selected; c) study on factors determining students' individual differences in construction of knowledge structures. Results of the mentioned research will be used for extending the set of tasks and providing adaptive knowledge assessment in IKAS.

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Valletta, Malta 2012

DO VIRTUAL GROUPS RECOGNIZE SITUATIONS IN WHICH IT IS ADVANTAGEOUS TO CREATE DIGITAL CONCEPT MAPS?

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Abstract. In the present experimental study, it was investigated whether virtual groups, depending on their situational circumstances, were able to decide in favor of the more suitable problem-solving procedure for their situation. The situational circumstances were to either have the possibility to create a "knowledge and information awareness" approach or not, that is, an approach that provides to the group members their collaborators' knowledge and information by means of digital concept maps. The study compared 20 triads with spatially distributed group members that were able to create a "knowledge and information awareness" approach with 20 triads collaborating without this possibility. Results showed, as expected, that the triads mostly chose the more suitable problem-solving procedure for their situation and that deciding in favor of the more suitable procedure resulted in both less time needed for solving the problems and less perceived coordination effort. However, triads that were able to create a "knowledge and information awareness" approach often did not finish their approach and could therefore not benefit from the full potential of this approach. The results are discussed.

1 Theoretical Background

1.1 The Benefits of Knowing What the Collaborators Know

Different fields of research show us the importance of knowing what the collaborators know in order to be able to communicate and collaborate effectively in group situations (Engelmann & Hesse, 2010). The research on audience design (e.g. Dehler-Zufferey, Bodemer, Buder & Hesse 2011) gives reason to believe that knowing what the collaborators know leads to changes of behavior such as writing longer texts about a topic when addressing novices (e.g., Dehler, Bodemer, & Buder, 2007). The knowledge imputing approach by Nickerson (1999) points out that knowing what the communication partner knows improves the communication by avoiding possible misunderstandings. The theory of transactive memory system (Wegner, 1986, 1995) states that group members need to know which member possesses knowledge about which topic in order as to access it through communication. An effective transactive memory system has shown to improve group performance (e.g. Liang, Moreland & Argote, 1995).

This knowledge about the collaborators' knowledge is, however, quite difficult to acquire: For example, groups need enough time to acquire it (e.g. Wegner, 1986) and many different mistakes may occur during the acquisition process (Nickerson, 1999). The acquisition of such knowledge is especially challenging for virtual groups, that is, in cases in which the spatially distributed members have to collaborate computer-supported; these groups have to struggle with reduced contextual information caused by the use of computers (cf. Kiesler, Siegel, & McGuire, 1984). The "knowledge and information awareness" (KIA) approach (e.g. Engelmann, Tergan, & Hesse, 2010; Engelmann & Hesse, 2010; Schreiber & Engelmann, 2010; Engelmann & Hesse, 2011) is a proven solution for these kinds of problems.

1.2 The KIA Approach and Coordination Theory

According to Engelmann and colleagues (e.g., Engelmann & Hesse, 2010), KIA is defined as being informed with regard to the collaborators' knowledge structures and underlying information. KIA is fostered by providing the group members with access to both their collaborators' knowledge structures and underlying information both visualized via digital concept maps. In the study these concept maps consisted of task-relevant labeled concepts as well as relations between those concepts which, as a whole, embodied both the knowledge structures and the information of the collaborators. Elements with additional information were linked to the concepts and could be opened in a small desktop window by mouse-clicking.

In several studies, this approach has been empirically proven to foster KIA acquisition of spatially distributed group members who collaborated computer-supported (e.g., Engelmann & Hesse, 2010; Schreiber & Hesse, 2010). Besides this, the KIA approach was also confirmed to improve computer-supported collaborative problem-solving: It enhanced group-performance in simulated virtual triads, meaning three persons sitting in the same room, able to speak with each other but not able to see each other because of partition walls (Engelmann et al., 2010). A follow-up study with real virtual groups, meaning groups with spatially distributed members, replicated these findings (Engelmann & Hesse, 2010). Evidence for this effect was also found with more complex tasks and different knowledge domain material (Schreiber & Engelmann, 2010).

One reason for the effectiveness of this approach is that it facilitates coordination. According to Malone and Crowston (1994), coordination is the management of dependencies between activities. Especially in the field of collaborative problem-solving and knowledge management, the management of producer-consumer relationships is very important. Producer-consumer relationships, as Malone and Crowston (1994) state, often lead to special kinds of dependencies such as 'prerequisite constraints' or 'transfer'. 'Prerequisite constraints' are activities that have to be finished before other activities can be started. For example, before person B is able to make a decision or solve a problem, person A has to provide the needed information. 'Transfer' takes place in between, when the producer communicates or 'transfers' information to the consumer. The coordination or management of these dependencies in a group problem-solving setting entails effort or costs, such as time costs for prerequisite constraints or the need to correct mistakes that appeared in the information transfer process. If the coordination costs are low, the coordination process is effectively.

It is expected that the KIA approach improves coordination: In the process of group knowledge building as a requirement for group problem-solving, the KIA approach provides the opportunity to make parts of the individual knowledge of the group members available before the individual knowledge building process is completed. Parts of the individual knowledge as a product can be used by others before the entire product is completed. This should lead to a time advantage compared to groups whose members cannot see parts of others individual knowledge before it is completed. Moreover, having the possibility to see the knowledge of the collaborators makes it possible to use this knowledge without the need to ask for it, or in return, to communicate it. This should lead to both fewer mistakes and less time needed for completing collaborative tasks. As a result of such process costs reductions, the collaborative problem-solving of groups provided with the KIA approach should be more effective and efficient.

1.3 Bringing the KIA Approach into Practice

Prior studies of Engelmann and colleagues (e.g. Engelmann & Hesse, 2010) were highly structured and the utilization of the KIA approach was predetermined because the group members worked with maps that were created by an expert (instead of by the group members themselves). These expert maps contained the complete content needed to solve the problems. Individual and collaborative work phases were separated from each other and offered enough time to accomplish each task. This design differs from real application fields in which group members need to externalize their individual knowledge by themselves. Moreover, groups need to decide in favor of a suitable, coordinated problem-solving procedure, depending on the situational circumstances (West, 1996). They also need to adapt their activities to the situational or environmental circumstances as a requirement for a coordinated procedure (Salas, Sims & Burke, 2005). Such environmental circumstances are, for example, technical characteristics and affordances. In the present study, the situational circumstances were to either have the possibility to create a KIA approach or not. This leads to our research question: Depending on whether the groups in an unstructured situation have the possibility to create a KIA approach or not, do they opt for a procedure that is suited to effective, computer-supported collaborative problem-solving?

2 Experimental Study

The present study compared a control condition with an experimental condition. The groups in the experimental condition had the possibility to create a KIA approach, meaning that each group member could first visualize his/her own knowledge and information by means of a digital concept map which afterwards was provided to the other group members during a collaborative problem-solving phase. In contrast, the groups in the control condition did not have this possibility. These group members could create individual concept maps, but these maps would not be shared with the other group members during the collaborative problem-solving phase.

We expected that groups, according to situational circumstances, would decide in favor of a suitable problem-solving procedure: The suitable procedure for the experimental groups would be that all group members, after having started to create their own concept map, continue with their individual maps before starting to collaborate, that is, to continue finishing the representation of their own knowledge and information. This is because the completed individual maps provided to the collaborators would function as a KIA approach that improves collaborative problem-solving. In contrast, the suitable procedure for the control groups would be that the group members start directly with collaboration because they cannot see the completed partner maps and, therefore, cannot create a KIA approach. Thus, we propose the following hypotheses:

- *Hypothesis 1:* Groups, depending on situational circumstances, that is, depending on the possibility to create a KIA approach, choose the more suitable problem-solving procedure for their situation, which means that groups in the experimental condition decide more often to continue first with their individual maps while groups in the control condition decide more often to start directly with collaboration.

- *Hypothesis 2:* Groups in the experimental condition that first continue with their individual maps and groups in the control condition that start directly with collaboration need less time for collaboration than those groups in the experimental condition that do not continue with their individual maps and those in the control condition that do not start directly with collaboration.
- *Hypothesis 3:* Groups in the experimental condition that first continue with their individual maps and groups in the control condition that start directly with collaboration perceive less coordination effort than those groups in the experimental condition that do not continue with their individual maps and those in the control condition that do not start directly with collaboration.

Prior studies have confirmed that a completed KIA approach, that is, having access to the concept maps of the collaborators, visualizing their complete knowledge and information, improves collaborative problem-solving. Therefore, we hypothesized the following:

- *Hypothesis 4:* Groups in the experimental condition that first continue with their individual maps outperform groups in the experimental condition that directly start collaboration and groups in the control condition that either continue or do not continue with their individual maps.

3 Method

3.1 Participants

Participants were 120 university students (94 female, 26 male) from different fields of study with an average age of 23.8 years (SD = 3.3). Both conditions consisted of 20 groups with 3 participants randomly assigned to one of the two conditions. They were rewarded with either payment or course credits. The group composition regarding gender was controlled: In each condition were three groups with one woman, seven groups with two women, and ten groups with only women. The degree of acquaintance between the group members was also controlled: Participants indicated in a questionnaire whether they knew none, one, or both of the collaborators. There was no significant difference between the conditions regarding the degree of acquaintance ($F < 1$).

3.2 Materials and Procedure

The members of every triad worked spatially distributed in different rooms equipped with a desk and a computer.

At the beginning of the empirical study, the participants filled out an online control measure questionnaire consisting of 16 multiple choice items (e.g. items regarding experience with computers, mapping techniques, and group work) designed as five-point rating scales ranging from complete agreement to no agreement. Then they were trained in how to use CmapTools (http://cmap.ihmc.us/), a digital concept mapping software.

After ensuring that all participants could handle the tool, the main phase of the study began. Group members read the instructions informing them about their role in the study: They were asked to imagine that each one of them was a different expert who had to collaborate with two other experts in order to protect a spruce forest. For this purpose two problems had to be solved: First, the group had to decide and justify which pesticide they would use to protect the spruce forest. Second, they had to decide and justify which fertilizer they would use.

The domain material used was given as a text document file (i.e. a Word document), which was presented as being a group member's own notes. It consisted of several concepts (e.g., spruce), relations between concepts (e.g., a spruce needs less nitrate) and background information (e.g., more detailed and verbal explanations of the concepts) that were evenly distributed among the three group members: Each member had several concepts, relations, and background information that were unshared, shared with one collaborator, or shared with both collaborators.

The members then had nine minutes to individually create a concept map visualizing their individual knowledge and its underlying information. However, in order to increase coordination effort in the subsequent phase, the time provided was too short for finishing one's own individual map. The groups were then informed that the problem-solving phase would start: Now they could decide whether they wanted to finish their individual maps first or to start directly to collaborate. The groups had 50 minutes to solve the two problems, which could only be solved by compiling the knowledge and information of every single member. To find the solutions, they had to create a common concept map in their shared working window. In this phase, they could communicate with each other via Skype. The control condition did not have the possibility to create a KIA approach; that is, each member could only see his/her own individual map as well as the common concept map (see Figure 1). It was expected that seeing only one's own unfinished map would have a low affordance to finish it because no one else would know that it was still unfinished. The experimental condition did have the possibility to create a KIA approach: Members of the experimental condition were not only able to see their own individual maps but also the individual maps of their collaborators. In addition, they also had access to the shared working window for creating the common concept map (see Figure 2). It was expected that seeing the three unfinished individual maps would have high affordance to complete them (cf. Suthers, 2006). Completed individual maps result in a completed KIA approach for collaboration.

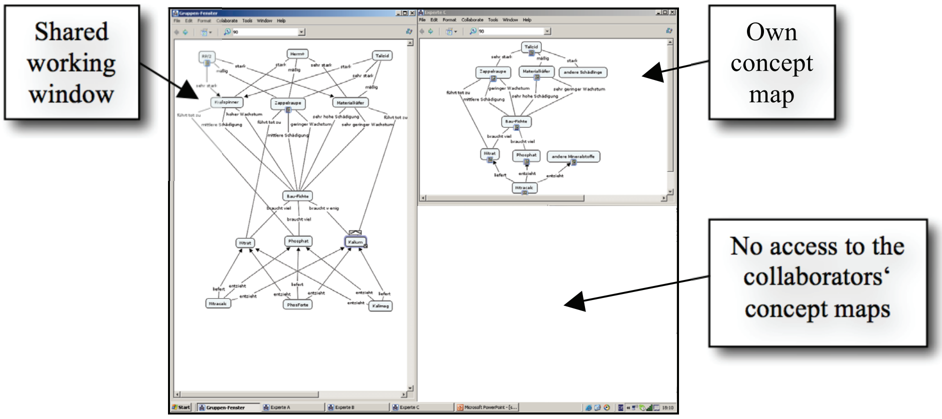

Figure 1. Screen of the control condition in the collaborative problem-solving phase

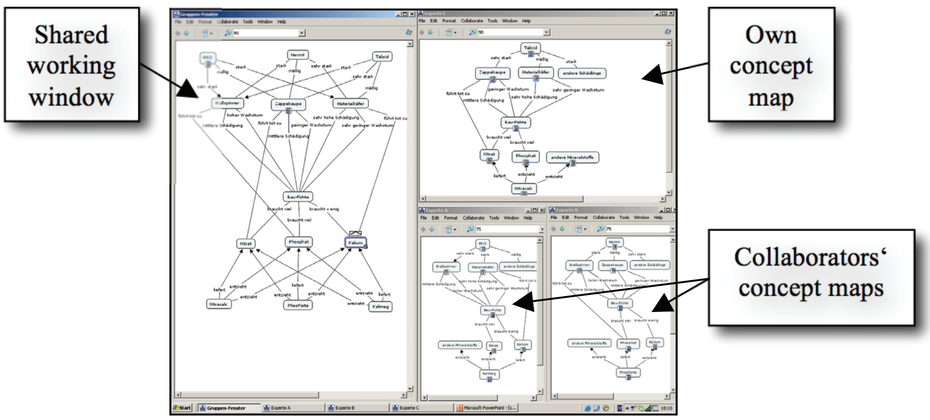

Figure 2. Screen of the experimental condition in the collaborative problem-solving phase

In this phase, log files of creating the common maps (by CmapTools) as well as video and audio files (by Camtasia) were recorded.

Following this phase, each group member worked again individually: First, they answered an online test measuring the amount of acquired KIA by means of 36 multiple-choice test items (example-item: "Please mark which expert(s) had information about the relation between RP/2 and fidget-grub - Expert A, B, or C?"). Second, each group member completed a questionnaire for evaluating the study and aspects of collaboration, coordination, and problem-solving. The items were assessed by five-point rating scales ranging from 1 point for no agreement and 5 points for complete agreement. The questionnaire contained 42 items in the control condition. There were 52 items in the experimental condition due to some additional items referring to the usefulness of seeing the collaborators' maps containing their knowledge structure and information. Participants neither had time limits nor access to the experimental environment while filling in the KIA test and the questionnaire.

In comparison to previous studies by Engelmann and colleagues (Engelmann & Hesse, 2010, 2011), the main differences in the procedure was that the participants had to create their individual concept maps by themselves. Further, the short time frame for creating the individual map and the freedom of choice in how to proceed at the beginning of the problem-solving phase forced the group members to more coordination effort.

4 Results and Discussion

All analyses presented here are based on group level data because the individuals in a group were not independent of each other. In this paper, we will report partial eta-squared values (η_p^2) as a descriptive index of strength of the association between the experimental factor and a dependent variable (Cohen, 1973). Such a value is defined as "the proportion of total variance attributable to the factor", excluding other factors' impact (Pierce, Block, & Aguinis, 2004, p. 918).

With regard to the control measure items (e.g., experience in group work), a factor analysis with Varimax rotation was conducted resulting in two interpretable factors, namely, "experience with computers" and "preference for using different information resources". For each of these factors a univariate ANOVA was performed showing that there were no significant differences between the two conditions (*F*s < 1). Therefore, the inclusion of a covariate was not necessary.

In accordance with *Hypothesis 1* (postulating that the triads of the conditions choose the more suitable problem-solving procedure, that is, that the experimental groups decide more often to continue with their individual maps first before starting to collaborate, while the control groups decide more often to start directly with collaboration), more experimental groups decided to finish the individual maps first (i.e., 12 of the 20 groups) compared to the control groups (4 of 20 groups), while most control groups started directly to collaborate (i.e., 16 of the 20 groups) (Pearson-χ^2 (1, N = 40) = 6.7, p = .01). However, in the experimental condition, only 12 of 20 groups opted for the more suitable procedure. One reason for this proportion being lower than expected could be that groups did not recognize the advantage of completed individual maps that result in a completed KIA approach.

In line with *Hypothesis 2* (postulating that groups that choose the more suitable problem-solving procedure for their situation need less time for solving the problems), the ANOVA resulted in a significant interaction indicating that continuing with the individual maps was only helpful for solving the first problem for experimental groups, while continuing with the individual maps increased the collaboration time needed for the control groups ($F(1,36) = 5.17$; $MSE = 192167.2$; $p < .05$; $\eta_p^2 = .13$). The same kind of interaction was found for solving the second problem ($F(1,36) = 3.83$; $MSE = 259092.1$; $p = .058$; $\eta_p^2 = .10$). The means are provided in Table 1. These interactions were expected because the experimental groups that continued with their individual maps could benefit from the completed KIA approach that reduces the time needed for problem-solving. Due to the fact that the control groups could not benefit from the finished individual maps, because in the problem-solving phase, the members were not provided with the collaborators' individual maps, for them the best procedure was, as expected, to start directly with the collaboration.

	Experimental groups		Control groups	
	Problem 1	Problem 2	Problem 1	Problem 2
Continued with individual maps	**26:40** (06:35)	**28:03** (09:85)	32:58 (09:23)	37:30 (06:22)
Started directly with collaboration	30:23 (07:14)	32:47 (08:05)	**24:41** (07:21)	**30:15** (07:49)

Table 1: Means (and standard deviations) of the needed time for solving problem 1 and 2

In accordance with *Hypothesis 3* (postulating that groups that opt for the more suitable problem-solving procedure perceive less coordination effort), the ANOVA resulted again in a significant interaction showing that experimental groups that continued with their individual maps and control groups that started directly to collaborate perceived less coordination effort than groups that did not opt for their most suitable procedure $F(1,36) = 4.80$; $MSE = 0.90$; $p < .05$; $\eta_p^2 = .12$, see also Table 2). Coordination effort was a factor that resulted from a factor analysis including items of the questionnaire that was answered after the problem-solving phase.

	Experimental groups	Control groups
Continued with individual maps	**-0.07** (1.50)	0.38 (1.50)
Started directly with collaboration	0.68 (1.01)	**-0.38** (0.65)

Table 2: Means (and standard deviations) of the perceived coordination effort

However, in contrast to *Hypothesis 4*, we did not find that experimental groups that continued with the individual maps outperformed the other three conditions with regard to collaborative problem-solving performance (All *F*s > 1, see also Table 3). This was unexpected because finished individual concept maps, visualizing the group members' knowledge and information, that are provided to their collaborators, result in a completed KIA approach that was proven to foster collaborative problem-solving (cf. Engelmann & Hesse, 2010).

	Experimental groups	Control groups
Continued with individual maps	**4.3** (2.2)	4.5 (2.1)
Started directly with collaboration	4.4 (2.7)	4.4 (2.6)

Table 3: Means (and standard deviations) of the collaborative problem-solving performance

Additional analyses gave an explanation for this unexpected finding: As expected, we found indeed that experimental groups that continued with their individual maps (E_con) included more correct nodes and correct relations in their individual maps, compared to experimental groups that did not continue with their individual maps, that is, that collaborated directly (E_coll) (regarding nodes: M_{E_con} = 23.00; SD_{E_con} = 4.90; M_{E_coll} = 17.75; SD_{E_coll} = 3.41; $F(1,18) = 6.89$; $MSE = 19.19$; $p < .05$; $\eta_p^2 = .28$; regarding relations: M_{E_con} = 28.33; SD_{E_con} = 7.55; M_{E_coll} = 18.88; SD_{E_coll} = 5.41; $F(1,18) = 9.30$; $MSE = 46.20$; $p < .01$; $\eta_p^2 = .34$). However, the continued maps of the experimental groups contained on average only 77% of all correct nodes and only 63% of all correct relations. That is, the experimental groups that continued with their individual maps did not finish their individual maps and therefore could not profit from a completed KIA approach.

In addition, we found that the experimental groups that continued with their individual maps did not improve the problem-solving potential of their individual maps: that is, they did not increase the problem-relevant aspects of their individual maps, compared to experimental groups that did not continued with their individual maps (M_{E_con}= 1.17; SD_{E_con} = 0.94; M_{E_coll} = 0.63; SD_{E_coll} = 0.74; $F(1,18) = 1.87$; $MSE = 0.75$; $p > .05$). This is also an explanation for the missing effect, that is, an explanation for the result that the experimental groups that continued with the individual maps did not outperform the other three conditions with regard to collaborative problem-solving performance.

A further explanation for this missing effect on the collaborative problem-solving performance is that the experimental groups that continued with their individual maps did not acquire more KIA compared to experimental groups who started directly to collaborate (M_{E_con} = 14.00; SD_{E_con} = 2.02; M_{E_coll} = 13.02; SD_{E_coll} = 2.14; $F(1,18) = 1.07$; $MSE = 4.26$; $p > .05$).

5 Summary and Implications

In the present experimental study, it was investigated whether virtual groups, depending on their situational circumstances, were able to choose the more suitable problem-solving procedure for their situation. The situational circumstances were to either have with the possibility to create a KIA approach or not, that is, an approach that provides to the group members their collaborators' knowledge and information by means of individual digital concept maps. In more detail, after an individual phase too short for creating and finishing one's own individual concept map representing one's own knowledge and information, a problem-solving phase started. In this phase, all groups could decide how to proceed, that is, to first finish the individual concept maps or to start directly with collaboration. In the problem-solving phase, each member of the control groups could only see their own unfinished concept map, while each member of the experimental groups had also access to his/her collaborators' maps; that is, they were provided with the possibility to create a KIA approach.

The study compared 20 triads with spatially distributed group members that were able to create a KIA approach (experimental condition) with 20 triads collaborating without this possibility (control condition).

Results showed, as expected, that the triads opted predominantly for the more suitable problem-solving procedure for their situation: The experimental groups that could create a KIA approach decided mostly to first continue with their individual concept maps visualizing their own knowledge and information. These maps were provided to their collaborators and could be used as a KIA approach. In contrast, the control groups, which were not able to create a KIA approach, decided mostly to start directly with collaboration instead of continuing with their individual maps that could not be provided to the collaborators.

As expected, opting for the more suitable procedure resulted in both less time needed for solving the problems and less perceived coordination effort. Therefore, this study demonstrated that also in unstructured situations having access to the collaborators' knowledge structures and underlying information (or to parts of these structures) helps to reduce the needed collaboration time and the perceived coordination effort.

However, groups having the possibility to create a KIA approach often did not continue to finish their individual maps and – if they did – they discontinued the task too early; that is, they did not finish the individual maps. As a result, they could not profit from a completed KIA approach that would improve their collaborative problem-solving performance. A possible explanation could be that they did not recognize the potential of a completed KIA approach and did not expect that the needed time for finishing the maps is time that reduced the collaboration time.

Currently, we are planning a follow-up study with a focus on motivating group members to complete their individual maps so that they could benefit from a completed KIA approach that is expected to increase their group performance.

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EL MAPA CONCEPTUAL COMO INSTRUMENTO DE INVESTIGACIÓN: CONSTRUCCIÓN Y REPRESENTACIÓN DE UN MODELO DE TUTORÍA VIRTUAL

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Abstract. Se presenta una propuesta de uso de los mapas conceptuales como herramienta de representación en un proceso en curso de construcción de un modelo de tutoría para la dirección de proyectos de investigación. Se utiliza el mapa conceptual, ya que contribuye a la representación visual de conceptos y las relaciones entre ellos. De la primera revisión de la literatura sobre el tema se diseñó un primer mapa conceptual. Este fue modificado en base a los aportes realizados por un grupo de tutores de máster que forman parte de un grupo de trabajo sobre el tema. Este mapa está en proceso de transformación debido a una segunda revisión de la literatura, que posteriormente se presentará a un grupo de tutores que estén dirigiendo proyectos en este momento, que mediante la técnica de grupo de discusión, contribuyan a construir un mapa experto final de forma colaborativa sobre dicho mapa conceptual.

1 Introducción

Esta propuesta se enmarca en un proyecto de investigación que se ocupa de estudiar la relación del estudiante de doctorado o de máster con el tutor o director de tesis, es decir, del 'supervisor' con el 'investigador en formación', caracterizar al tutor de proyectos de investigación, sus funciones, competencias y necesidades, la relación e importancia de la socialización y el apoyo y proponer pautas de trabajo para mejorar la práctica. Nos ocupamos de un tipo de tutoría concreto orientado al desarrollo de competencias de investigación, de organización y desarrollo de proyectos en los estudiantes, a la que llamamos tutoría de proyectos de investigación o simplemente tutoría de investigación. Una de las primeras actuaciones del proyecto fue generar un modelo de tutoría, que contemple los principios generales del proceso de supervisión de proyectos e investigaciones. El proceso de construcción del modelo se inició con un mapa conceptual surgido de la revisión de la literatura, y que se ha ido transformando en las diversas iteraciones que han funcionado como fases de validación del mismo, mediante un grupo de trabajo con tutores de máster, y las sucesivas reestructuraciones a partir de revisiones de los materiales disponibles sobre este tema.

De esta forma, presentamos una investigación que está en proceso, en la que se pretende validar el modelo en forma de mapa conceptual utilizando un grupo de discusión, para identificar y formular cuáles son las necesidades de los directores y de los alumnos, conocer experiencias prácticas y posibles situaciones problemáticas surgidas de esta práctica, describir los diferentes perfiles de tutoría y dar respuesta a estas situaciones. Al darle forma de mapa conceptual se representan de forma visual las relaciones entre estos factores: el tutor y las funciones que debe desarrollar, la importancia de la relación individualizada con el director, y grupal con el resto de compañeros, y todo ello describiendo unas pautas de trabajo para la mejora de la práctica de este tipo de tutoría.

En este mapa conceptual se representan todos estos factores que influyen y las relaciones anteriormente mencionadas. Sirve como punto de referencia para conocer la experiencia, validarla y obtener resultados que sirvan para cubrir las necesidades detectadas de los directores y los investigadores en formación a través de un grupo de discusión, así como, se pretende conocer el uso de los mapas conceptuales como herramienta para reorganizar y completar en base a la discusión la representación de una realidad y las relaciones que se derivan de esta.

2 Marco conceptual y metodológico

La investigación en curso que se presenta, encuentra sus fundamentos en trabajos que se ocupan de una nueva concepción de la supervisión de trabajos de investigación. Para llegar a nuevas concepciones de cómo puede ser este modelo de supervisión desde la perspectiva de tutoría de proyectos de investigación, entendemos que la investigación basada en diseño aporta herramientas y procedimientos para una construcción participativa en su construcción, y que los mapas conceptuales constituyen una valiosa herramienta para la construcción colaborativa, la discusión y el intercambio de conocimiento en un entorno virtual.

2.1 *Supervisión de proyectos de investigación como tutoría*

Entendemos que el marco que analiza la relación entre supervisor y estudiante en trabajos de investigación es la tutoría. Si ésta es una acción necesaria y muy importante para el desarrollo del proceso de aprendizaje del estudiante en todos los niveles de estudios, en el caso de proyectos de investigación, por sus especiales características lo es más.

Avanzar en la definición de dicha relación requiere indagar sobre un modelo específico de tutoría orientada a la supervisión y orientación de trabajos y proyectos de investigación. ¿Cuál es una buena práctica de supervisión? La supervisión efectiva de los investigadores en formación es un complejo proceso con múltiples factores que abarca cuestiones como la relación de los estudiantes y supervisores a todos los niveles, la infraestructura disponible, las políticas institucionales y gubernamentales, estructuras y procedimientos. Todas estas cuestiones han sido objeto de investigación. Seagram et al (1998), Dinham y Scott (1998), Knowles (1999), Taylor y Beasley (2005) y Unwin (2007) se han ocupado de la actuación de supervisión desde distintas perspectivas. También es objeto de preocupación en las distintas propuestas sobre doctorados de Delamon, Atkinson y Parry (1997); Taylor y Beasley (2005), Park (2007) o Lee (2008 y 2009).

Por otra parte, al ocuparnos de procesos que se desarrollan total o mayoritariamente online, los enmarcamos dentro de los nuevos escenarios de aprendizaje surgidos por el desarrollo que está llevando en los últimos años las tecnologías de la información y la comunicación, abriendo nuevas posibilidades de comunicación entre el tutor y el alumno, de búsqueda y organización de la información, de desarrollo de trabajo colaborativo, de compartir conocimiento, de organización del tiempo, etc. En esta línea, encontramos distintas propuestas orientadas a proporcionar recursos y apoyo a postgrados desarrollados en entornos virtuales (Salinas et al., 2010; Moreno y Salinas, 2011).

Uno de los aspectos más señalados en los nuevos entornos orientados a estudios de postgrado es la relación supervisor – estudiante, y especialmente el rol del tutor. En la actualidad, no es suficiente estar activo en la investigación para desarrollar una supervisión adecuada. Es necesario repensar las relaciones y responsabilidades de supervisión, ya que es percibida cada vez como más una forma de enseñanza, de hecho, probablemente la más sutil y compleja en el que estamos involucrados (Taylor y Beasley, 2005).

Aceptar que la supervisión es, en todo o en parte, una forma sofisticada de enseñanza, implica que para ser un supervisor efectivo, se tiene que ser un tutor eficaz. Y esto nos lleva a nuestra pregunta de en qué constituye una enseñanza efectiva en el contexto de la supervisión, especialmente en la relación tutorial entre supervisor y estudiante.

2.2 *Investigación basada en diseño*

Responder a dicha pregunta tiene un componente que involucra a la práctica, pero al mismo tiempo a la importancia de proponer principios de acción. Esto puede abordarse mediante la construcción colaborativa de un modelo, en este caso del Modelo de Tutoría para la Maestría en Educación en Entornos Virtuales, orientado a aportar soluciones para la praxis de los tutores, y al mismo tiempo a desarrollar de manera reflexiva y colaborativa unos principios de actuación. Puede aplicarse a nuestro caso lo que Juuti y Lavonen (2006) definen como aspectos constitutivos de la investigación basada en el diseño: “un proceso de diseño que es esencialmente interativo, que parte del reconocimiento del cambio en el entorno de la praxis, que genera un artefacto ampliamente utilizable y proporciona conocimiento educativo para una praxis más inteligible”.

Efectivamente, nuestra investigación responde muy bien a las características esenciales de la investigación basada en el diseño (Reeves, 2000):

- Aborda problemas complejos en contextos reales, en colaboración con los profesionales.
- Integra principios de diseño conocidos e hipótesis con los “affordances” tecnológicos para ofrecer soluciones a problemas complejos.
- Realiza una indagación rigurosa y reflexiva para probar y refinar los ambientes de aprendizaje innovadores y definir nuevos principios de diseño.

Se trata de un conjunto de actividades de investigación en el proceso de desarrollo de varias intervenciones centradas en la articulación y especificación de los principios de diseño. Su énfasis, por tanto, está en la producción del conocimiento con el objetivo último de mejorar los procesos de diseño y desarrollo y evaluación educacional (Richey y Klein, 2007).

Este proceso hay que considerarlo desde los principios de la investigación en diseño y desarrollo: ser recursiva (iterativa), reflexiva y participativa (van Akker, 1999). La iteración, en efecto, supone un proceso de diseño y desarrollo que permite tanto a los usuarios como a los expertos participar completamente del proceso de revisión y reformulación. Al ser reflexiva, se opone al enfoque de la racionalidad técnica y asume que muchos, si no la mayoría, de los problemas importantes en la práctica profesional no pueden definirse y resolverse con soluciones preconcebidas. Al ser participativa, refleja el cambio de perspectiva de considerar como experto a uno en el que el diseñador es parte de un equipo.

Para llevar a cabo el proceso de reflexión y construcción colaborativa del modelo se ha considerado que los mapas conceptuales constituyen un instrumento adecuado para captar y compartir conocimientos de los expertos.

2.3 Mapas conceptuales

Consideramos que el mapa conceptual es una herramienta que responde bien a nuestros propósitos ya que permite la representación del conocimiento y muestra los conceptos y sus relaciones a través de una jerarquía. De acuerdo con Coffey, Hoffman, Cañas y Ford (2002) es una herramienta que ayuda a facilitar la comprensión de las relaciones conceptuales y la estructura del conocimiento. A través de las proposiciones o palabras de enlace se van representando las relaciones significativas que se van entrelazando, además de presentarlo de forma visual, lo que simplifica el sistema o pregunta objeto de estudio (Arellano y Santoyo, 2009).

Cañas et al (2000) hacen referencia a los mapas conceptuales como herramientas para representar y publicar modelos de investigación con el fin de promover la colaboración de otros investigadores. Así, al hacer referencia a mapas creados por expertos, especifica que no solo sirven para facilitar el acceso a la información como un índice, sino que representan el conocimiento que permite la navegación sobre el modelo de conocimiento experto. En nuestro caso, se trata de un mapa conceptual teórico, basado en una búsqueda y recogida de información, que pretende transformarse en experto mediante la reflexión y colaboración, a través de la dinámica propuesta para este estudio.

La representación del conocimiento experto como técnica de recogida de información para la investigación incluye la obtención de datos a partir de la entrevista o la observación directa de procedimientos y la posterior representación de los datos en forma de mapa conceptual. En nuestro caso la obtención de información se realiza en grupos de discusión y la representación se lleva a cabo de forma colaborativa. Al ser una representación explícita y manifiesta del conocimiento, tal como afirman Novak y Gowin (1988), los mapas permiten generar la discusión e intercambiar diferentes puntos de vista entre un grupo de personas referente a las relaciones entre conceptos o denotar la falta de conexiones entre estos. A partir del estudio de un mapa inicial y la entrevista semiestructurada en forma de grupo de discusión, se pretende compartir el conocimiento a través de esta dinámica y representarlo a través del mapa como elemento para la discusión.

La utilización del software CmapTools, desarrollado por el Institute for Human & Machine Cognition, contribuye a desarrollar todo el proceso en un entorno virtual, ya que apoya la colaboración y del intercambio y puede ser utilizada tanto en actividades cara a cara, como en situaciones de distancia (Novak y Cañas, 2006).

3 Proceso de investigación

Como se ha comentado, para dar respuesta al problema planteado se procedió a la realización de un modelo de supervisión, centrado en la tutoría de proyecto de investigación que identificara los elementos, sus relaciones aportara soluciones para mejorar la praxis. El modelo se representa en forma de mapa conceptual debido a las potencialidades que esta herramienta nos ofrece. Para la creación del modelo se han definido diferentes momentos de recogida de información (fig.1) a partir de la propuesta de Reeves (2000).

Cabe señalar que estos momentos no son independientes, ni consecutivos, sino que pueden desarrollarse en algunos casos superpuestos.

3.1 Primera revisión de la literatura sobre el tema

A partir de los hallazgos de la primera revisión bibliográfica, se diseña un primer mapa del modelo, que representa los elementos de la tutoría de proyectos, entendida como un proceso de enseñanza-aprendizaje para desarrollar la competencia investigadora. Este mapa es utilizado como elemento de análisis y valoración en el segundo momento.

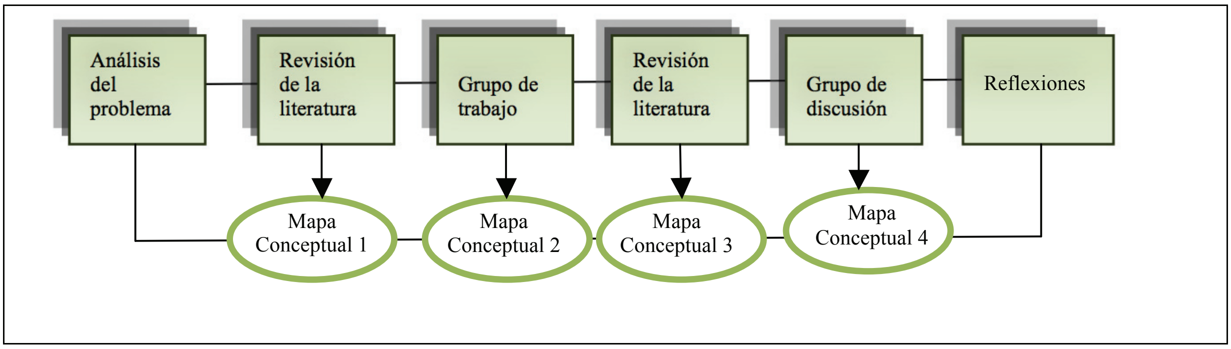

Figura 1. Fases para la recogida de información en la investigación

3.2 Creación de un grupo de trabajo con tutores en activo y puesta en práctica del modelo

Con el objeto de realizar una primera validación del modelo se desarrolla un grupo de trabajo con los posibles tutores de la Maestría. Se pretende que los tutores participen de la construcción y validación del modelo y de su implementación práctica. Por ello se somete a discusión el modelo teórico y se realiza una simulación de la implementación del sistema de forma online, poniendo a disposición de los tutores la herramienta considerada más adecuada para la realización de esta práctica de tutoría: un e-portfolio de tutoría, gestionado mediante el software Mahara. Para ello:

- Se parte de los conocimientos y experiencias previos de los participantes para la reflexión sobre conceptos, elementos y funciones a incorporar.
- Se planifica todo el trabajo a ser llevado a cabo a través del e-portafolio, con el objetivo de que los supervisores se familiaricen con el mismo.
- Se crean espacios de trabajo para el propio trabajo del supervisor, para compartir con sus alumnos y colectivos, ya que lo que se pretende son actividades individuales y grupales, con el fin de aplicar el modelo teórico de tutoría orientado hacia la mejora de la práctica de tutoría y al mismo tiempo conozcan las posibilidades que el e-portfolio ofrece como herramienta de tutoría.

Debemos tener en cuenta que este grupo de trabajo está en proceso de finalización, quedando pendiente el proceso de seguimiento sobre la práctica desarrollada.

En cuanto a la validación del modelo, el proceso ha consistido en:

- Los aportes que se han ido haciendo han contribuido a la transformación y evolución del primer mapa conceptual
- El mapa conceptual modificado se ha presentado al grupo participante para que observen, reflexiones y critiquen la forma jerarquizada y organizada en que aparecen sus ideas, aportes y trabajos y la relación con el marco conceptual de referencia que se realizó en la primera etapa.

3.3 Segunda revisión de la literatura

Con el fin de culminar el trabajo con el grupo de trabajo se plantea una segunda revisión bibliográfica, a partir de elementos aportados, de tal forma que se complete el mapa creado en la etapa anterior con recursos y materiales para consulta por parte de los tutores participantes y por tanto, el mapa y el modelo siga evolucionando en base a sus aportes sobre la práctica.

3.4 Grupo de discusión

Paralelo a este grupo de trabajo se planifica un grupo de discusión en el que se presenta el modelo en forma de mapa conceptual evolucionado de las tres etapas anteriores. Según Ballester (2001) los grupos estructurados se basan en un modelo metodológico sencillo, reuniendo a un grupo de personas para pedir opinión y que aporten información. Dentro de los grupos estructurados encontramos de tres tipos: grupos de discusión, grupos nominales y paneles Delphi.

En nuestro caso hemos considerado que el que más se adaptaba a los objetivos planteados y la recogida de información es el grupo de discusión, ya que permite analizar la información en una situación de comunicación controlada. La interacción está determinada y controlada por el coordinador del grupo (horario pactado, selección de participantes, etc.) y se recogen datos cualitativos, ya que éste va solicitando información mediante preguntas e intervenciones.

Se cuenta con un grupo de discusión creado para trabajar sobre el modelo de tutoría de proyectos de investigación que se representa a través de un mapa conceptual. En este sentido la finalidad del grupo de discusión es conocer la opinión experta (adecuación, suficiencia y calidad técnica) y recoger información para tomar decisiones de mejora. Con este se pretende:

- Validar un modelo teórico de tutoría de proyectos de investigación en base a los conocimientos y experiencias previas de supervisores.
- Averiguar si el objeto de estudio (modelo) se adecua a las necesidades de los supervisores y al contexto en el que se desarrolla.
- Conocer la opinión de los supervisores sobre los instrumentos y pautas planteadas en el modelo y averiguar así, su suficiencia.
- Recoger información sobre la calidad técnica del modelo.
- Recoger información sobre casos prácticos y situaciones conflictivas habituales ante los que se encuentran los supervisores a la hora de dirigir un proyecto.

La selección de los participantes procederá de una población-objeto de doctores ejerciendo en la actualidad de supervisores de tesis y puedan asistir de forma presencial a la sesión planificada para el grupo de discusión.

Previo a la sesión del grupo que aquí planteamos se les enviará a cada uno de los participantes el mapa conceptual resumen del modelo objeto de estudio, con el fin de que los participantes hayan podido conocer lo que aquí planteamos y se pueda desarrollar la sesión de forma más fructífera. El mapa conceptual será modificable e individual, de esta forma cada uno podrá reordenarlo y transformarlo como crea conveniente. Al inicio de la sesión se hará una breve exposición del modelo y de las modificaciones planteadas por cada uno de los participantes y se plantearán dudas que hayan ido surgiendo durante la lectura del modelo. Una vez planteadas y resueltas las dudas se desarrollará el grupo de discusión.

Durante la sesión, la estrategia utilizada para desarrollarla será una discusión progresiva y de co-construcción mediante preguntas abiertas. Se pretende recoger información sobre el modelo, los elementos constituyentes, las conexiones entre éstos y la relación con las necesidades. Si existen carencias, demandas o expectativas que no se ven contempladas. Se pretende extraer problemas sobre la práctica con el fin de diseñar soluciones en el resultado final.

4 Resultados y conclusiones

Tanto el modelo, como su representación mediante el mapa conceptual lo consideramos como un proceso vivo, ya que está en constante evolución debido a los diferentes procesos de validación que está experimentando, en espera de obtener un modelo representativo que aporte soluciones de la relación alumno-director, de apoyo, de procesos, de herramientas e instrumentos, de competencias y funciones, de organización, etc.

Los resultados que se obtuvieron de la primera etapa, tras la revisión de la bibliografía fue, más que un mapa conceptual en sí, un esquema de los principales aportes recogidos durante la revisión, y que se consideraron los principios básicos de la tutoría (mapa conceptual como sistema de toma de notas). Está basado en tres líneas principales, la socialización, las fases de trabajo y las funciones de un supervisor. A la vista de la fase más avanzada en la que nos encontramos en este momento, puede concluirse que se trataba de un primer esbozo, un borrador sobre el problema al que queremos dar solución (Fig. 2).

El grupo de trabajo utilizó este primer mapa (Fig. 2) como punto de apoyo para la realización de toda la tarea durante la segunda fase. Sobre el mismo se aportaron nuevas ideas y experiencias de trabajo que sirvieran para la modificación del mismo, con el fin de validar el modelo teórico. A pesar de que el grupo de trabajo aún no ha concluido, los aportes realizados hasta el momento han sido importantes para la evolución del mapa (Fig. 3).

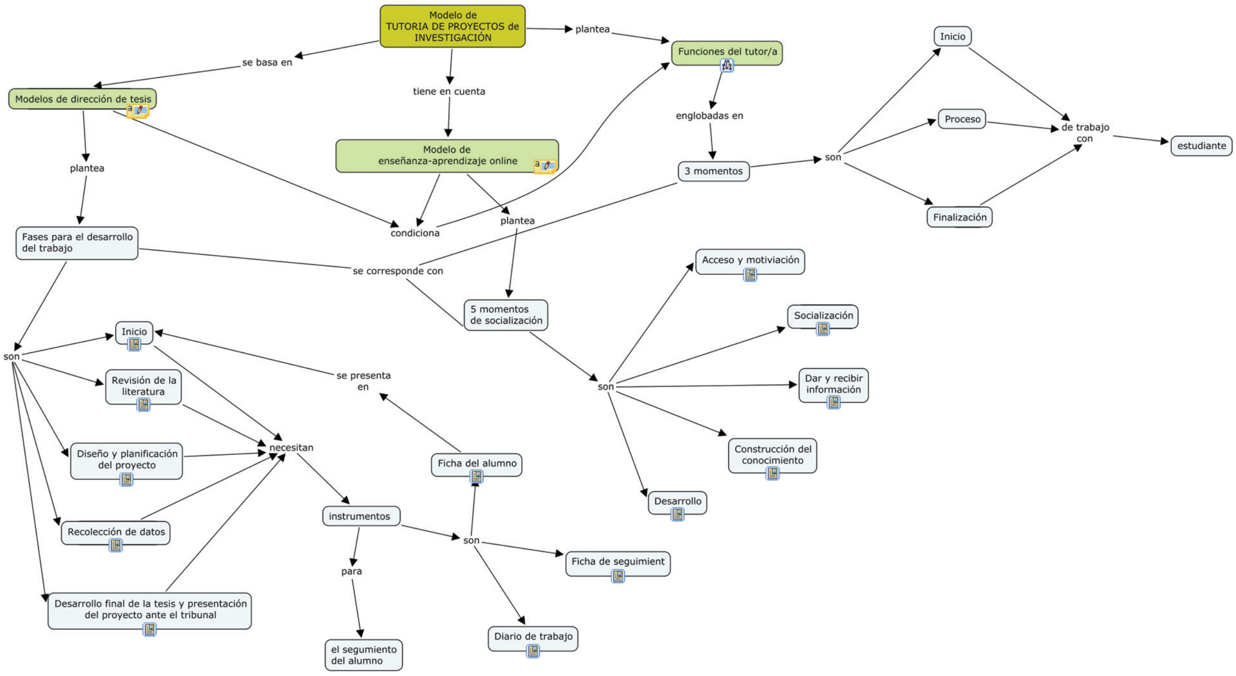

Figura 2. Mapa conceptual sobre el modelo de relación supervisor-investigador en formación como resultado de la primera fase de la investigación.

Es por este motivo, la continuidad del trabajo con el grupo, que en dicho mapa no se ven reflejadas las fases de desarrollo de trabajo, aunque sí se puede intuir una evolución del primero a éste, que contempla la figura del tutor, y las funciones, aunque siguen ubicándose en tres momentos, se dividen en este caso en: pedagógica, técnica, organizativa, orientadora y socializadora. También toma importancia la socialización, que aunque no varíe en los cinco momentos de socialización de Salmon (2000), sí que añade dos líneas a tener en cuenta: el alumno-director y el alumno-alumno.

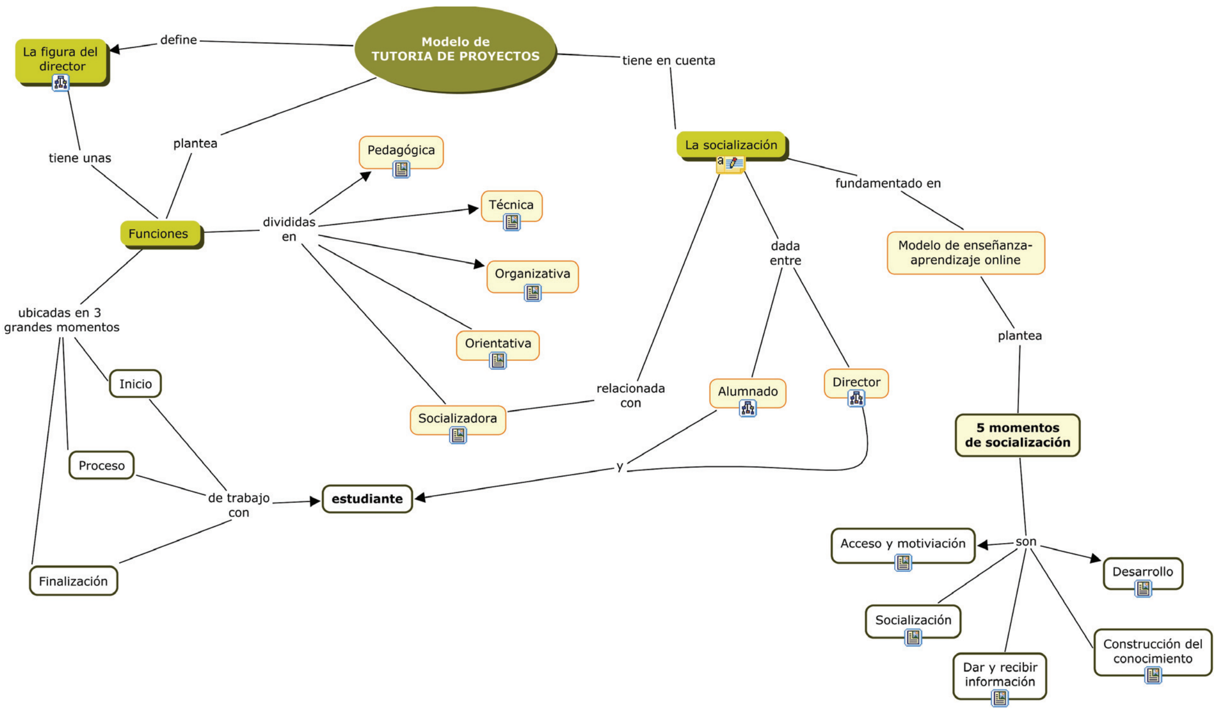

Figura 3. Mapa conceptual sobre el modelo de relación supervisor-investigador en formación como resultado de la segunda fase de la investigación

A partir de los distintos aportes de este grupo, de la segunda revisión de la bibliografía y de la reflexión del equipo, se elabora un mapa conceptual sobre el modelo de tutoría más maduro y evolucionado que tiene por objeto su utilización en la fase final del grupo de trabajo y como mapa inicial para el grupo de discusión (Fig 4).

En esta versión del mapa, ya se observan las relaciones existentes entre los conceptos claves que tiene este modelo de tutoría. El mapa se ha simplificado con el fin de facilitar la comprensión de los usuarios y la navegación por él. Como puede observarse cada concepto clave tiene un objeto enlazado, en la gran mayoría otro mapa conceptual que desarrolla el concepto de forma más detallada, y a su vez, estos tienen enlazados otros objetos generando una representación jerárquica, ordenando y relacionando la información. De acuerdo con la fase 4, el mapa se presentará al grupo de discusión a fin de obtener resultados y reflexiones sobre la relación entre el supervisor y el investigador en formación, sobre los instrumentos y herramientas necesarios para llevar a cabo esta supervisión y si las pautas de trabajo se adecuan a los directores, y por consiguiente, una nueva versión del mapa conceptual y del modelo.

Dentro de la discusión se pretende que se evidencien las necesidades de los tutores a la hora de dirigir un proyecto de investigación, los posibles problemas o supuestos prácticos con los que se encuentran, si es posible la adecuación de un único modelo a un grupo de supervisores con estilos de tutoría diferentes. Y por tanto, la validación del modelo presentado en forma de mapa conceptual.

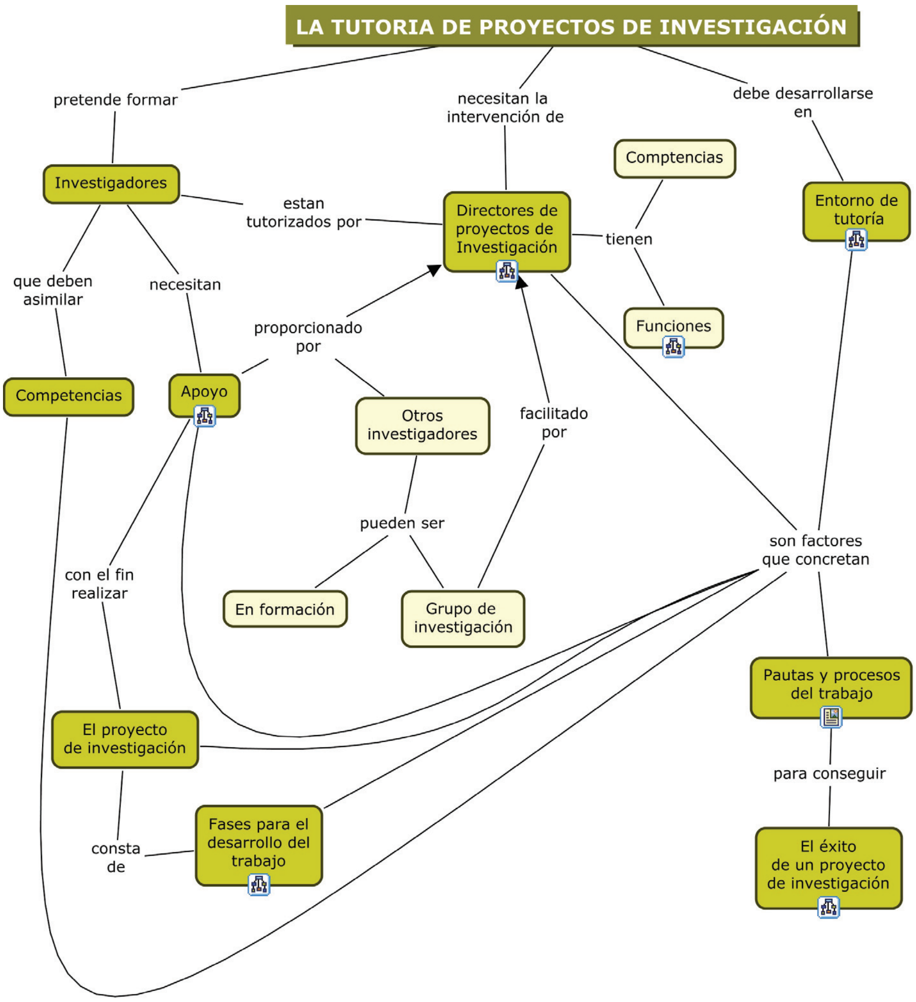

Figura 4. Mapa conceptual sobre el modelo de relación supervisor-investigador en formación como resultado de la tercera fase de la investigación

En conclusión, esta forma de presentar el modelo, a través de un mapa conceptual, confirma la idea de que el conocimiento puede presentarse de tal forma que el usuario interactúe con la información, pueda ver las relaciones existentes entre los conceptos e ideas claves que confluyen cuando hablamos de la relación supervisor – investigador en formación e interiorice las pautas y procedimientos allí expuestos. En este sentido tenemos los primeros resultados para continuar con la investigación, repitiendo la experiencia con un mayor número de directores, con el fin de abrir nuevas vías de investigación.

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EL MAPA CONCEPTUAL COMO UN RECURSO DIDÁCTICO EN CONSTRUCCIÓN DE LOS CONCEPTOS DE LA ASTRONOMÍA

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Abstract: Este artículo presenta resultados parciales de una investigación que estudia el papel del Mapa Conceptual (MP) como recurso didáctico para facilitar el aprendizaje significativo de los conceptos científicos de temas astronómicos, desarrollada en el 6 º grado primario, en una escuela pública de São Paulo, Brasil. Más allá de la investigación, también se busca formar conceptos subsumidores con el fin de comprender conceptos básicos de astronomía. Para lograr la meta trazada se ha utilizado, en la colecta de los datos, una metodología casi-experimental. El tratamiento y análisis se muestran a través del estudio descriptivo y analítico del rendimiento de los estudiantes y, también, del análisis de los contenidos de los mapas producidos durante la investigación. A modo de conclusión se pueden hacer algunas consideraciones, por ejemplo, que es en el proceso de elaboración, discusión y reflexión de registro, debido al desarrollo de mapas conceptuales, que los estudiantes pueden desarrollar interacciones positivas entre el conocimiento previo y los nuevos conocimientos y, así, validar el uso de MC en las clases.

1 Introducción

En el primer contacto con los estudiantes del 6 º grado de la escuela primaria, ya conseguimos percibir las debilidades de comprensión conceptual en los temas de Astronomía. Estas debilidades ya eran apuntadas en investigación específica de la enseñanza de astronomía y fue confirmada por el sistema de evaluación de aprendizaje, tanto a nivel estatal, como nacional. La debilidad conceptual encontrada en ese nivel de escolaridad era un problema educacional para ser investigados en la rutina de la sala de clase, ya que la fragilidad conceptual acaba comprometiendo la adquisición de nuevos conceptos científicos, base para la comprensión e interpretación de los fenómenos astronómicos correspondientes a cada nivel a lo largo de la escolaridad básica (Leite y Hosoume, 2008).

En la concepción de aprendizaje significativo, los conceptos científicos sobre astronomía, a pesar de estar implícitos, servirían como motivación para adquirir nuevos conceptos subsumidores, proporcionando oportunidades de aprendizaje significativo en la serie posterior. Sin embargo, en la educación formal, proporcionar el significado conceptual de contenidos de Astronomía, no es tan fácil (Langhi y Nardi, 2009).

Por esta razón, es necesario, que el maestro, para llevar a cabo formas innovadoras para identificar las debilidades, y también las potencialidades de sus alumnos, debe asignar significados a los conceptos científicos que quiera enseñar, esto, con base en su estructura cognitiva, presuponiendo de que estos conceptos cuando significados puedan llegar a ser subsumidores que interactuaran con los nuevos conceptos de la materia.

De acuerdo con Novak y Gowin (1999), el Mapa Conceptual (MC) ha sido desarrollado para asegurar la participación y negociación de significados, por lo que favorece el concepto ausubeliana de aprendizaje significativo. También se recomienda como potencializador de datos o conocimientos de los conceptos investigados por Novak (2000) y Moreira (2003). Puede ser utilizado en otras formas, en diferentes disciplinas y con diferentes enfoques, según un estudio presentado en conferencias nacionales e internacionales sobre el tema. Suponemos que el MC es un recurso didáctico para potencializar el aprendizaje, esta investigación pretende responder la siguiente pregunta: ¿El uso de MC como herramienta de enseñanza facilita el aprendizaje significativo de los conceptos científicos en el contexto de la sala en la escuela primaria? Junto a la respuesta de la pregunta formulada queremos comprender cómo los mapas conceptuales (MC) contribuyen al proceso de adquisición de conceptos de Astronomía, que actúan como facilitador del aprendizaje de los alumnos, en la dinámica del aula durante la enseñanza de Ciencias Naturales.

Para lograr esto se diseñó una investigación, con enfoque cualitativo y cuantitativo para colecta, procesamiento y análisis de datos, con dos grupos de alumnos de sexto grado de una escuela pública de São Paulo, Brasil. Junto a esta investigación tratamos de formar conceptos subsumidores para la comprensión de los contenidos básicos de astronomía, tales como elementos astronómicos visibles en el cielo y elementos del Sistema Solar.

Este artículo presenta resultados parciales de una investigación por medio de estudio descriptivo y analítico de la actuación de los grupos, además de ejemplos de análisis de contenido de Mapas Conceptuales (MCs) producidos durante el proceso de intervención. Varias consideraciones pueden hacerse a partir del estudio, por ejemplo, es en el proceso de elaboración, discusión y registro de la reflexión, debido al desarrollo de MCs, que los estudiantes pueden desarrollar interacciones positivas entre el conocimiento previo y los nuevos conocimientos, validando así, el uso MC en la sala de clases.

2 Fundamentos teóricos

En lo que respecta a la investigación en la enseñanza de materias científicas, Novak (2000) y Moreira (2003) recomiendan una metodología inversa a la tradicional, con el fin de recoger y disponer los datos, el MC. Dicha herramienta puede reemplazar las entrevistas transcritas en trechos organizados por el investigador con el fin de convencer al lector de que el investigado tiene ciertas ideas o ciertos conocimientos previos. La constitución de rigor científico se asocia tanto a procedimientos estadísticos, como interpretativos. Herramientas indispensables para la investigación en educación, ya que ayuda al investigador a exponer sus datos, hacer inferencias e investigar las relaciones causales. Además de estos factores, estos procedimientos son recursos utilizados por los investigadores con el fin de analizar, interpretar, relacionar, inferir, explicar, asumir y representar los datos registrados en los eventos. A partir de estas mudanzas el investigador, de acuerdo a Gowin y Alvarez (2005) las afirmaciones de conocimiento y el valor proporcionado por el estudio, genera informaciones relevantes provenientes de la acción de la investigación.

También encontramos, entre las contribuciones de los autores y los argumentos, la necesidad de organizar la educación destinada a un estudio más exploratorio del conocimiento previo del estudiante, si el objetivo es lograr el aprendizaje significativo sobre cualquier tema. Como Ausubel (2002) y Moreira (2006), el aprendizaje significativo sólo será posible desde el momento en que el profesor como investigador, pase a conocer no sólo las debilidades sino también las potencialidades de sus alumnos para asignar significados a los conceptos que se quiera enseñar, sobre la base presente en su estructura cognitiva. Estos conceptos, según los autores, pueden llegar a ser subsumidores que interactúen con los nuevos conceptos de la disciplina.

Por esta razón, Ausubel (2002) recomienda que el maestro recopile información sobre el conocimiento previo de los estudiantes, de modo que pueda de alguna manera, analizarlos y complementarlos de forma adecuada. Moreira (2006) reitera la propuesta de Ausubel (2002) al argumentar que ese conocimiento previo parece ser el factor que más influye en el aprendizaje posterior (pág. 19) y señala también, que este conocimiento no es necesariamente sólo un concepto, puede ser una idea, una proposición o una representación que puede ser reconocida por el profesor en la sala y (re) significada por el alumno, es decir, dar un nuevo significado, nueva interpretación y una nueva comprensión de los conocimientos previos, lo que permite al estudiante desarrollarse conceptualmente desde lugares diferentes de etapas de aprendizaje.

Los criterios propuestos por Novak y Gowin (1999), revela que el modelo puede mostrar el aprendizaje conceptual y propositiva en relación a la disciplina de acuerdo al punto de vista ausubeliano, desde que los conceptos provengan de situaciones de aprendizaje y de la relación de características específicas, potencialmente significativas, de estos conceptos con las ideas relevantes existentes en la estructura cognitiva del alumno de forma no-arbitraria y sustantiva, rindiendo un aprendizaje proposicional correlativo (Ausubel, 2002). El orden jerárquico vertical de los conceptos en el mapa muestran las de orden superior (muy general e inclusiva), subordinados (intermedio) y los ejemplos específicos y poco o inclusiva, que indica las relaciones de dependencia entre los conceptos (Moreira, 2006). Este orden jerárquico es vertical, también llamado por Novak y Gowin (1999), Gowin y Alvarez (2005) de los niveles jerárquicos.

De este modo, las jerarquías indicadas, definen claramente las propuestas aceptables y posibles, subcontratadas por el estudiante durante el proceso de elaboración de su MC. Esta forma de análisis no es el único, pero se adoptó por permitir que las discusiones sobre la relación de subordinación entre los conceptos descritos en los niveles verticales. Al mismo tiempo, permite elaborar poco a poco, una explicación coherente del proceso de enseñanza y aprendizaje en tiempo real en el aula, lo que valida el uso de MC como un recurso, potencialmente significativo para el grupo investigado.

3 Metodología

Basado en el enfoque cuantitativo y cualitativo, se diseñó un estudio cuasi-experimental, debido a la falta de un control total sobre todas las variables (Moreira y Rosa, 2007). Se escogieron dos grupos de estudio, el grupo experimental, grupo A (6º grado A) y el grupo de control, grupo B (6º grado B), con estudiantes de la Escuela Estadual en la ciudad de Guarulhos, São Paulo, Brasil, entre 11 y 12 años de edad. Inicialmente, los datos fueron obtenidos a través de una evaluación diagnóstica (AD), sobre el tema (Meneses Villagra, 2001). El AD estaba constituido por 20 preguntas. A partir del análisis de los datos obtenidos, fue posible pensar en una intervención planificada mediada por una estrategia de enseñanza (ED). Este fue dividida en unidades de aprendizaje potencialmente significativas (UEPS) atendidos por varios recursos, entre ellos, el MC (Moreira, 2010), durante la intervención, sólo la clase experimental produjo los mapas conceptuales.

En la etapa final de la intervención tuvo lugar la evaluación del aprendizaje (AP), utilizando el mismo instrumento aplicado en la AD. Esta evaluación se caracterizó por ser un instrumento de recopilación de datos, tanto la AD como en la AP, debido a la naturaleza de la investigación y a su diseño, las recomendaciones de autenticidad y validez del contenido fueron atendidas (Carvalho, 2006; Laville y Dionne, 1999).

Después de la validación, aplicamos la herramienta en la clase, B del 6 º grado, formado por 34 estudiantes e hicimos la corrección, utilizando una escala de 0,0, 0,25 y 0,5 sobre la base de aciertos y errores de los contenidos de las preguntas, aceptadas por la comunidad científica.

Con el fin de verificar la fiabilidad del instrumento de recolección de datos (AD), se calculó el coeficiente alfa de Cronbach (Cronbach, 1951 apud Moreira y Veit, 2007) Este coeficiente varía entre o a 1, cuanto mayor es el valor, mayor es la consistencia del instrumento. La literatura indica que cuando grupos son evaluados, los valores alfa aceptables son igual o mayor a 0,7. El coeficiente alfa calculado a partir de las respuestas del grupo B fue de 0, 748. Por esta razón, creemos que el instrumento tiene validez y es también confiable, es decir, cuando se aplica a otras clase de 6º grado, puede ofrecer los mismos datos y obtener los mismos resultados (Laville y Dionne, 1999; Moreira 2003; Carvalho, 2006). Basándose en esos resultados, aplicamos el mismo instrumento (AD), también a la clase de 6º grado A, que consta de 31 estudiantes, y las respuestas fueron corregidas con base en el mismo parámetro para la clase de 6º grado B. Cabe señalar que efectivamente participaron en el proceso de 21 estudiantes en la clase A y 26 estudiantes en la clase B.

Al comparar el rendimiento en las evaluaciones de AD y AP de ambos grupos, se utilizó la prueba t para muestras apareadas, a través del cual nos aseguramos de que las calificaciones promedio, con un grado de seguridad, son estadísticamente diferentes. En la prueba t apareadas s la misma muestra sirve en diferentes momentos, por ejemplo, antes de la operación y después de la intervención. Se define como hipótesis nula (H0) de que el "uso de la MC no tiene ningún efecto en el aprendizaje", es decir, los promedios de antes y después del uso de la MC son iguales. El MC sólo, se utilizó en el grupo experimental, sin embargo, la hipótesis H0 fue probado en las dos clases.

Los MCs producidos por el grupo experimental fueron sometidos a un análisis cualitativo (Novak y Gowin, 1999). El análisis del contenido del mapa, no se basó en proceso de clasificación de los modelos, sigue, sí, un enfoque cualitativo a la interpretación interactiva defendida por Laville y Dionne (1999). Debido a su característica, peculiaridad y al contexto en el que se produjo (Moreira, 2008). Con el fin de resaltar la evolución conceptual, a partir de elaboración de MC, hacemos análisis de de contenido de los mapas producidos por los alumnos de 6° serie A durante el proceso de intervención. Hemos adoptado como criterio de referencia establecido inicialmente por Novak y Gowin, 1984 en la edición original del libro "Aprender a Aprender", cuando se discute la naturaleza y usos de los mapas conceptuales con el fin de aprendizaje significativo. La interpretación ha dado lugar a una inferencia o conclusión basada en los indicadores de aprendizaje.

4 Resultados y discusión

Desde el punto de vista cuantitativo, los resultados descriptivos y analíticos, tenían la intención de llegar a la comprensión del problema y hacer un juicio de valor más fiable, (Novak y Gowin, 1999; Moreira, 2003). De este modo, la Figura 1 ilustra, respectivamente, el rendimiento de los estudiantes en los grupos experimentales (grupo A) y de control (grupo B) en la evaluación diagnóstica (AD) y la evaluación del aprendizaje (AP).

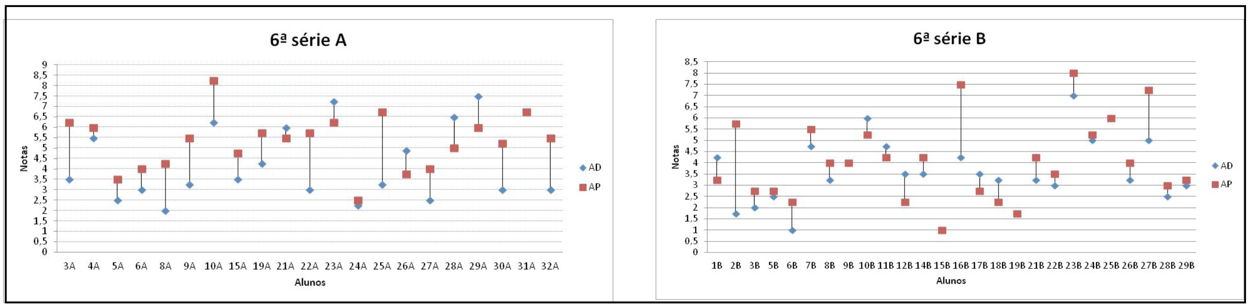

Figura 1: Las notas de los alumnos de 6 º grado A y B de la evaluación diagnóstica (AD) y el aprendizaje (AP)

Para la disposición de los resultados de las evaluaciones numéricas de las notas del grupo A (Figura 1), se puede ver una evolución en el aprendizaje de la mayoría de los estudiantes, a partir de sus conocimientos previos. La mayor parte de ellos los hemos identificado en tres grupos: aquellos con una mayor amplitud, 3A, 8A, 9A, 10A, 22A, 25A, 30A, 32A, otros con amplitud regular, 5A, 6A, 15A, 19A, 27A, y por último aquellos con menor amplitud, 4A, 24A, y aquí también se encuentran los alumnos, 21A, 23A, 26A, 28A y 24A, con notas inferiores en la evaluación AP, o sea que la nota de evaluación de aprendizaje fue menor de la que había obtenido durante el diagnóstico, y también, el alumno del grupo 31A, que se mantuvo en el mismo nivel de conocimiento previo, es decir, Nota de AP fue igual a AD.

Con respecto a la grupo B (Figura 1), se puede visualizar algo, semejante, sin embargo, en mayor o menor medida dependiendo de la nota de cada grupo analizado, en comparación con el grupo A. En el grupo que alcanzó una mayor amplitud, encontramos los estudiantes 2B, 16B, y 27B. En amplitud regular encontramos los estudiantes 3B, 6B, 7B, 8B, 14B, 21B, 22B, 23B, 26B y 28B y en los de menor amplitud, los estudiantes 5B, 24B, 29B. Ya en esta clase, se identificaron seis estudiantes con más baja calificación en la evaluación de AP, es decir, la nota de la evaluación del aprendizaje fue inferior a la que el estudiante había obtenido en la evaluación diagnóstica, son ellos 1B, 10B, 11B, 12B, 17B y 18B. Los estudiantes que permanecieron en el mismo nivel de conocimiento previo, es decir, que la nota de AP fue igual a AD, en este grupo tenemos 25B, 19B, 15B y 9B.

En el estudio analítico, se utiliza como referencia el promedio de las evaluaciones finales, y se comparó el desempeño mediante el test t pareado con un nivel de significación del 5%. El resultado prueba t se puede ver en la Tabla 1. Sólo el grupo experimental (grupo A) mostró un incremento significativo (p = 0,04). Podemos concluir que el uso de MC contribuyó para aumentar el nivel de aprendizaje de los estudiantes de la clase A, pero no fue posible establecer esta hipótesis para los estudiantes de la clase B.

Tabla 1 - Resultado de la t-test para la puntuación media final de la evaluación diagnóstica (AD) y evaluación el aprendizaje (AP) para el grupo experimental (6a) y control (6b).

Grupo		Experimental (A)	Control (B)
AD	Media	4,26	3,57
	Desviación Estándar	1,79	1,31
AP	Media	5,29	4,07
	Desviación Estándar	1,51	1,81
Valor de t		-2,11	-1,08
Grados de liberdad		36,66	48,05
Valor de p		0,04	0,28

Cuando analizamos los valores de las muestras evaluadas por pregunta, agrupamos los valores de cada pregunta en sus respectivas categorías de indicadores de aprendizaje (Tabla 2), se observaron diferencias en la evolución del aprendizaje en el grupo A, también, a partir de cada indicador. En este sentido, se identificaron los indicadores de mayor y menor amplitud para cada clase tomando en cuenta la cuestión de mayor alcance, o sea, aquella que define la habilidad deseada.

A partir del análisis de los datos de la evaluación, se puede concluir con un 95% de confianza, que el uso de MC contribuyó al mayor nivel de aprendizaje de los estudiantes en la clase A. Este análisis muestra que el conjunto de habilidades ofrecida por los quince indicadores de aprendizaje tampoco fueron contemplados.

Cada conjunto de indicadores incluye de uno a tres preguntas que proporcionan referencias sobre el contenido científico. Juego de cinco de ellos fueron atendidos por la clase A y clase B por sólo dos (Tabla 2). Cuantitativamente, estos valores se consideran insuficientes en el contexto de la enseñanza. Sin embargo, en el contexto del aprendizaje son pertinentes y cumplen con algunos objetivos básicos enunciados en el UEPS, tales como: conceptos de construcción para la comprensión de los elementos astronómicos visibles en el cielo, identificación de los elementos del Sistema Solar y la interpretación de algunos fenómenos que implica el conocimiento sobre el cielo, como por ejemplo, las fases de la luna.

Por los indicadores, es evidente que la clase A podría ir más allá en el aprendizaje que la clase B. Se encontró que las cinco preguntas de evaluación mostraron diferencias significativas, es decir, valor de p menor de 0,05 para la clase A, sólo la pregunta tres fue considerada de nivel bajo o básico para los estudiantes (6 º grado), mientras que otros muestran un nivel considerado regular o adecuada. En este aspecto, también, el grupo A mostró mejor evolución que el grupo B anterior, ya que obtuvieron valores más bajos en cuatro preguntas (7, 8, 14, 17) de medio o adecuado, mientras que el grupo B, sólo en una pregunta (12).

Sin embargo, la única cuestión que cayó a la clase B (12), requería un nivel de abstracción y más conocimiento, porque exige el desarrollo de hipótesis para identificar el movimiento aparente de la Luna y su explicación, utilizando la terminología científica. En este caso, hablando de la importancia potencial dado al tema, justificativa de esto en Ausubel (2002) muestra que cuando disponibilidad y otras cualidades importantes existentes en las estructuras cognitivas de estudiantes diferentes, son factores importantes en la determinación de la significación potencial. Como recursos de aprendizaje se utilizaron una mayor o menor importancia potencial en relación a ellos, en la clase B.

Tabla 2 - Valores de los medios, el valor de t, los grados de libertad y el valor de "p" como una cuestión evaluada agrupan los indicadores de aprendizaje.

	Grupo A – 6º grado A (experimental)					Grupo B – 6º grado B (control)			
Indicadores de Aprendizaje	**Preguntas**	**Medias**	**Valor t**	**Grados de libertad**	**Valor de p**	**Medias**	**Valor t**	**Grados de libertad**	**Valor de p**
Identificar los elementos astronómicos y diferenciarlos de los demás.	3AD	0,39	-2,42	20	**0,02***	0,43	-0,98	42,81	0,32
	3AP	0,5				0,47			
	7AD	0,14	-1,95	39,09	**0,05***	0,14	0,64	49,41	0,52
	7AP	0,28				0,1			
Identificar el movimiento aparente, y hacer uso de la terminología científica.	12AD	0,1	-0,57	40	0,57	0,009	-2,07	31,63	**0,04***
	12AP	0,14				0,06			
Identificar las distancias astronómicas.	8AD	0,16	-2,45	39,9	**0,01***	0,21	0	50	1
	8AP	0,34				0,21			
Identificar las fases de la luna.	14AD	0,26	-3,14	36,94	**<0,01***	0,14	-3,82	**49,58**	**<0,01***
	14AP	0,4				0,3			
Representar y describir los elementos del Sistema Solar	17AD	0,19	-2,78	37,68	**<0,01***	0,12	-1,01	49,07	0,31
	17AP	0,34				0,18			

5 Interpretación de los mapas conceptuales

Los mapas producidos fueron analizados e interpretados de acuerdo a la coherencia semántica presentada por el autor, es decir, conforme significado lógico asignado por él. Por esta razón, no tenemos la intención de inferir acerca de la legitimidad de la estructura de MC construido. Estamos de acuerdo con la idea de Novak y Gowin (1999), reiterada por Moreira (2006) declaración de que no hay mapa correcto o incorrecto, sino una representación de pensamiento de los estudiantes en su esfuerzo por aprender, en comparación con nuevos conceptos y nuevas habilidades. Por lo tanto, las jerarquías que se indican, definen claramente las proposiciones aceptables y posibles subcontratadas durante el proceso de elaboración del mapa.

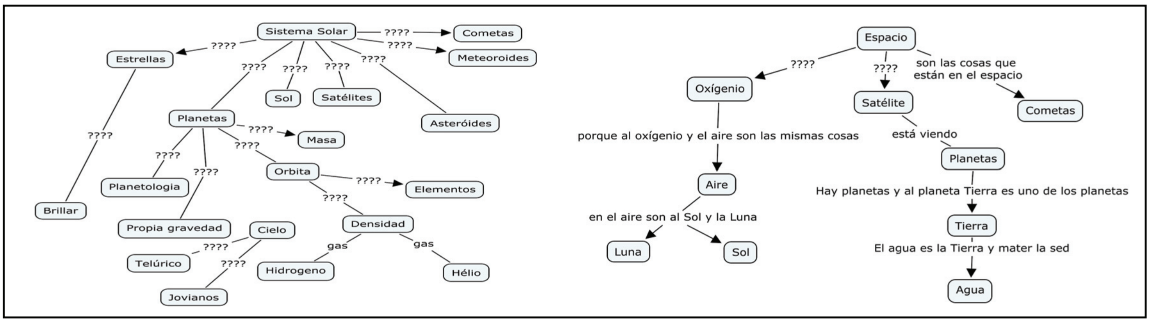

Figura 2: MC preparados por el estudiante19A

Al analizar la construcción del mapa, nos encontramos con que los conceptos fueron seleccionados y dispuestos sin repetición dentro de una jerarquía más compleja, lo que implica diferentes niveles. La diversidad de los conceptos presentados ha contribuido al enriquecimiento del mapa. Varias situaciones fueron identificados según los casos: la elección del concepto superordenado de Sistema Solar, el concepto de orden superior, conectados por líneas a sus subordinados, representado por el Sol, las estrellas, satélites, asteroides, cometas y meteoroides. Varias indicaciones de los planetas fuera de las relaciones que podrían ser válidas cuentan como palabras de enlace, por ejemplo, "los planetas tienen una masa", "los planetas están en órbita", "los planetas son estudiados por la planetología", etc. En cuanto a las situaciones inapropiadas, se destaca la ausencia de palabras de enlace en casi todas las líneas. Además, el mapa refleja una organización que caracteriza mapa lineal vertical como unidireccional.

Por otro lado, el trazado del mapa también muestra la expansión del repertorio conceptual del estudiante, cuando muestra los conceptos científicos estudiados en clase, por ejemplo, densidad, terremotos, planetología, auto gravedad, y masa joviana que forma parte de la disciplina enseñada, del conocimiento introducido durante el semestre. De esta forma, hemos demostrado la formación de nuevos conceptos “subsumsores”, representados, negociados y significados por el estudiante en el contexto del aula.

En otro MC del mismo alumno identificamos las mismas características estructurales de la anterior. Sin embargo, podemos ver algunas de las descripciones de relaciones válidas que se combinan con las líneas ya existentes indicativas de un concepto a otro. A diferencia del otro mapa, la organización tiene relaciones representadas por largas frases que representan un verdadero trabajo cognitivo, del estudiante, para superar o mejorar su mapa en función de lo que no fue capaz de presentar en el mapa anterior.

En la lógica de los estudiantes, los significados atribuidos a las relaciones conceptuales se pueden explicar de la siguiente manera: ". El oxígeno, satélites y cometas son algo que están en el espacio". Señalan "espacio" como un concepto de orden superior, porque es en el espacio que se contienen "otras cosas" además del espacio que es "muy grande y representa nuestro universo." En el espacio, "sólo los satélites están mirando los planetas", explica además que "hay múltiples planetas y la Tierra es uno de ellos." Y continúa: "El único que tiene el agua es la tierra", es decir, "el agua está en la Tierra" y el agua "mata nuestra sed." En cuanto a las relaciones establecidas a través del concepto de "oxígeno", presenta la siguiente explicación: "el espacio está lleno de aire", "el aire y el oxígeno son la misma cosa", "en el espacio aéreo no existen el Sol y la Luna".

En particular, la construcción de los significados diferentes de los establecidos por el material de enseñanza, y tomando en cuenta el desarrollo de estrategias de enseñanza que están a favor de la identificación de los elementos astronómicos (sol, la luna) y de la diferenciación de los elementos atmosféricos (aire, oxígeno). La construcción de nuevos significados sobre un evento o un objeto, en referencia al contenido de la materia, no es una tarea trivial, y depende, como argumenta Novak (2000), de lo que el estudiante ya sabe acerca de este evento u objeto que se requiere para establecer la etiqueta (conceptos) para las regularidades de la experiencia vivida, por lo general provienen de sus acciones personales e idiosincrásicas.

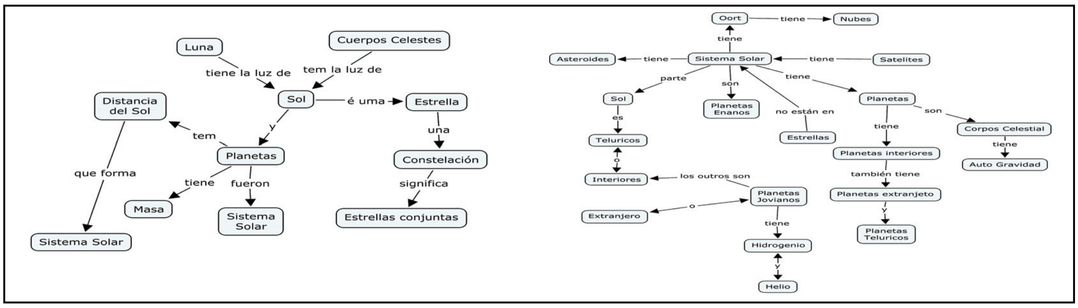

Figura 3: MC preparados por el estudiante 32.

El primer MC del alumno 32 presenta una estructura espacial organizada y tiene diferentes niveles. Hay cinco niveles jerárquicos considerados. El concepto más inclusivo Cuerpos Celestes, está vinculado al sol y a la estrella. El concepto subordinado se dirige a los conceptos específicos, los planetas y las constelaciones. Estos siguen hacia el menos inclusivo representados por masa, Sistema Solar y conjunto de estrellas. Cada concepto se conecta por medio de flechas de entrada y salida a otros conceptos considerados, identificando relaciones conceptuales que se traducen en proposiciones válidas, por ejemplo, el Sol es una estrella, el planeta tiene masa, los planetas forman el sistema solar; constelación significa conjunto de estrellas; planetas están distantes del Sol, la Luna tiene la luz del sol, los cuerpos celestes tienen la luz del sol Todas las líneas de conexión son nombrados por palabras clave, que representan a la naturaleza de la relación. Así, encontramos que varias relaciones son válidas para el estudio de la disciplina. El MC tiene una semántica basada en perceptibilidad, es decir, puede ser entendido por los significados previamente presentados. Sin embargo, el concepto del sistema solar, entendido como mucho más inclusivo, se coloca dos veces en la base de la MC. Siendo una vez como un concepto inclusivo y otro como ejemplo.

La disponibilidad de las ideas sobre el tema enseñanza, cuando bien organizado en la estructura cognitiva, es esencial para la comprensión y la manipulación de las ideas nuevas (Ausubel, 2002). Por lo tanto, la articulación de las ideas de los estudiantes, ha sido objeto de pruebas de aprendizaje cuando el MC muestra: "los cuerpos celestes son la luz del sol ... sólo aquellos que son los cuerpos celestes del Sistema Solar ... el conjunto de todos los cuerpos celestes es el Sistema Solar ... la luna tiene la luz del sol ... que realmente brilla ... la luz es directamente en la luna ... no tiene luz y tiene que recibir la luz del sol ... Parece que el tiempo no se quedó iluminado ... Más es ... es que a medida que la luna gira alrededor de la Tierra gira en torno a hacer sombra ... se forman las fases de la luna .. nueva, creciente, menguante y llena ... Luna es un satélite natural de la Tierra ... el cuerpo celeste más importante está en el sol ... tenemos que poner aquí un poco más abajo ... el Sol es una estrella de quinta magnitud y es la estrella más cercana a la Tierra ... está mucho más cerca ... que las otras estrellas... estrella de la constelación llamada aquí con ... significa conjunto constelación de estrellas... tiene muchas constelaciones en el cielo ... que no pongan esas cifras ... es la gente que piensa ... viendo aquí en la Tierra parece que cruzar, el escorpión, de arranque, el león, el toro, cacerola con mango y muchas otras cosas que la gente se preguntará ... así que junté todo para explicar mejor." La comprensión de los contenidos de las clases es cada vez más evidente, desde que el estudiante afirma haber colocado planetas en la posición específica, debido a su relación con el Sol, es decir, mostró una relación de dependencia con el desempeño de algunos fenómenos Por ejemplo: "los planetas y el sol forman el Sistema Solar ... que están en órbita alrededor del sol ... cada uno en su órbita ... porque el Sol atrae a muchos cuerpos celestes: planetas, satélites, asteroides, cometas ... los planetas tienen masa ... la masa es lo que da fuerza para que cada uno sea atraído ... tiene una gran cantidad de fuerza de la masa es grande ... cada planeta está a una distancia del sol. La Tierra es de 150 millones de kilómetros de la otra ... Todavía no sé ... todos los planetas forman el sistema solar ... la única estrella que se encuentra en el Sistema Solar es el Sol ... las otras estrellas no son ... obtiene un frente de poco más de práctica del Sistema Solar ... Creo que puse todas las palabras en el MC".

En el segundo MC, los estudiantes, muestran la posición de los diferentes conceptos de los demás, sin dejar de lado la jerarquía conceptual. El concepto clave inclusive se posiciona más en el centro. Tiene diferentes niveles y formas de un concepto más inclusivo para el menos inclusivo. Cada concepto se conecta por medio de flechas unidireccionales en algunos casos, las bi-direccionales de uno o más conceptos para indicar un significado válido, en su mayoría que caracterizan a una proposición. Por ejemplo, los planetas son cuerpos celestes del Sistema Solar tienen asteroides, cuerpos celestes tienen autogravedad. Por lo tanto, las ramificaciones se constituyen entre conceptos subordinados a los más específicos. El aprendizaje se demostró cuando el estudiante siguió compartiendo su significado y se explican en los asteroides del Sistema Solar , tienen planetas ... los planetas son cuerpos celestes que la gravedad tiene auto ... es debido a la gravedad propia de los planetas están en órbita alrededor del sol .. cada uno en su órbita ... que giran en la órbita debe tener un montón de pasta ... y estar bien ... bastante limpio a su alrededor, sin polvo cósmico mucho más ... de lo contrario, es el planeta ...". Explicó que Plutón no es planeta más tiempo y se refirió a una de las condiciones que hicieron de Plutón ser considerado un planeta enano", debido a que el planeta Plutón ya no es ... él tiene mucho que el polvo cósmico alrededor de ellos ... y esto dificulta ... que no podía quitar la suciedad que tiene en su órbita".

Durante la explicación debería haberse dado cuenta de que sólo se conecta con el interior de la tierra, considerada nombres sinónimos para los grupos de planetas. Por lo tanto, hizo la siguiente observación: "Ahora veo que no era el adecuado para poner en orden ... telúrico no era necesario ... podría poner en interiores o terrestres ... es lo mismo", fue la identificación de errores en la estructuración del MC un punto positivo en la negociación de significados. Como el primer plano justificaciones ocurrió en la formación profesional terminó de ser negociado. El estudiante se dio cuenta de que no habría necesidad de hacer conexiones con tantos términos terrestres, interiores y exteriores.

En cuanto a la conexión del sistema solar con Sun, dijo: "el Sol es parte del sistema solar no es más igual que otros cuerpos celestes del Sistema Solar ... es el más importante ... de todos los que han mencionado ... todo gira alrededor de él ... cuando la tierra gira alrededor del sol .. como las estaciones ... Creo que los otros planetas también tienen estaciones de ... porque ellos también giran alrededor del sol .. al igual que la tierra ... Ahora las estaciones de otros planetas, creo que son diferente ... No lo puedo explicar ... "varias hipótesis sobre la veracidad de la declaración fueron puestos en ese momento por otros estudiantes. La discusión dio lugar a un comentario de otro estudiante", los científicos dicen que tienen mucho más en el cielo que no nos da el conocimiento práctico ... es difícil llegar a lugares tan lejos que es ... va a encontrar las cosas ... ", concluyó un error más que se rectifica la identifica por él en su MC: La nube de Oort es en el Sistema Solar ... y más lejano de los planetas ... Pongo aquí ... es el lugar que ocupa cometas ... cometas es el mismo garaje, en el Universo." Los significados atribuidos a los contenidos de las proposiciones ofrecen Astronomía varios ya han aprendido y experimentado que posiblemente constituyen la estructura cognitiva estudiante, con el aprendizaje significativo.

6 Consideraciones finales

El resultado, en general, se considera pedagógicamente adecuado tanto para la clase A, como para la clase B. Tanto en la atribución de significado, como en la forma de expresarse sobre el tema de educación y como las nuevas acciones favorecen la enseñanza-aprendizaje. Incluso los grupos que presentan diversas amplitudes con respecto a las notas, que no podía ser de otra manera, es innegable que todos ellos están en un proceso activo de adquisición de conocimientos. Sin embargo, para estos resultados e incluso al hacer uso de análisis cuantitativo en el proceso de investigación, varias consideraciones se pueden hacer en un intento de justificar la diferencia en la evolución de la clase A con respecto a la clase B, independientemente de la utilización de MC.

La primera es sobre el nivel de conocimiento previo proporcionado por cada una de ellas por medio de la evaluación diagnóstica. Suponiendo que la clase A poseía un promedio superior en AD, como resultado, los titulares de subsumidores serían más elaborados sobre los conceptos de la materia, así, sería natural que el avance en el aprendizaje fuese mayor. Sin embargo, las condiciones favorables al aprendizaje significativo, fueron encontradas en ambas clases en función de lo que la categorización de las respuestas apuntaban: ambos grupos exponían las debilidades sobre los conceptos científicos de temas astronómicos.

La preparación de los MCs consistió en una serie de condiciones para la construcción de conocimiento efectivo que no exime el ejercicio de la crítica y la creación por parte del aprendiz. Así, la enseñanza, centrada en la negociación de significados, desafió a los estudiantes a presentar nuevos problemas que requiriesen un posicionamiento en contra de su aplicación, destacando las debilidades y fortalezas inherentes en el proceso de aprendizaje que sobresalieron en la preparación y presentación de los mapas conceptuales durante la intervención. Por último, el MC, cuando se adoptó como un recurso potencialmente importante en el aula del 6 º grado provocó una subversión cognitiva individual y colectiva, generada por los obstáculos y desafíos que deben ser superados durante su preparación y presentación. Por esta razón, el recurso facilita el aprendizaje significativo. Este estudio, al igual que otros, valida el uso de MC en este nivel de educación.

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EL USO DE VIDEO-PRESENTACIONES CREADAS CON CMAPTOOLS EN LA MODALIDAD DE FORMACIÓN ON-LINE: UN ESTUDIO PRELIMINAR

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Abstract. En este trabajo presentamos una experiencia de formación permanente del profesorado en un actividad de e-learning, cuyo contenido se centraba en los mapas conceptuales y su aplicación en la educación. La organización de toda ella se hizo a partir de mapas conceptuales elaborados con CmapTools. Los recursos se presentaban todos en forma de mapa conceptual y los contenidos de la actividad de basaban en el uso de video-presentaciones, creadas todas ellas con el creador de presentaciones del referido programa. Si bien es habitual la utilización de video-tutoriales para explicar determinadas funciones de un programa, no hemos encontrado aplicaciones previas sobre el uso de video-presentaciones con CmapTools. Los destinarios de la actividad eran formadores de formadores, por lo tanto, docentes con una formación previa importante. Como herramientas de comunicación asíncrona se emplearon los foros del EVA y para la comunicación síncrona el chat del entorno y la red de micro-blogging Twitter. La valoración de la actividad se ha hecho a partir de un cuestionario que han cumplimentado los participantes. Como principales conclusiones podemos apuntar que el grado de satisfacción con los contenidos y el desarrollo de la actividad ha sido elevado, y que el apartado más bien valorado han sido las video-presentaciones, que eran el recurso que queríamos evaluar.

1 Introducción

La formación permanente del profesorado, entendida como aquella que tiene como destinatarios a docentes en activo, consideramos que es una de las mayores prioridades que debería tener cualquier sistema educativo. Si cada vez se hace más necesario un aprendizaje a lo lago de toda la vida (*LifeLong Learning*) en todas las profesiones, en el caso de los docentes esta necesidad es todavía mayor.

A raíz de una petición de organizar un taller en modalidad de formación on-line dedicado al uso de los mapas conceptuales en educación y su aplicación a partir de CmapTools (programa diseñado por el IHMC), nos vimos ante la necesidad de realizar diferentes video-presentaciones. A través de ellas, se pretendía realizar una explicación de los contenidos, que iba complementada por los recursos que se incluían. Para ello, optamos por utilizar el creador de presentaciones de CmapTools. Consideramos que el creador de presentaciones de CmapTools es una herramienta muy potente, que puede substituir, en muchos casos, a aplicaciones específicas, como puede ser PowerPoint u cualquier otro programa de presentaciones. Al analizar los estudios previos existentes, descubrimos que no existían investigaciones o experiencias previas que aunasen el uso del referido creador de presentaciones con el formato de vídeo.

La experiencia se ha realizado en una actividad a distancia, una modalidad sobre la que si bien existen algunos estudios sobre el uso de los mapas conceptuales en ellas, éstos tampoco son muy numerosos,. La particularidad de esta modalidad obliga (y permite) a hacer un uso distinto de los mapas conceptuales creados con CmapTools que el que se utiliza en las de tipo presencial.

2 La herramienta de presentaciones de CmapTools

Al tener que explorar a fondo CmapTools, el año 2006, para realizar su traducción al catalán (proceso a lo largo del cual siempre tuve el soporte del IHMC), y también al elaborar unos materiales de formación para una actividad en formato e-learning de los que se hablará más adelante, profundicé en el creador de presentaciones, y las múltiples posibilidades que ofrecía.

Después de haber estado examinando sus potencialidades, y haber visto a diferentes especialistas utilizarla con éxito en sesiones presenciales, pensamos que ofrece muchas más posibilidades y usos de las que se le están dando actualmente, como mínimo si se examina la bibliografía existente relacionada con los mapas conceptuales en general, y CmapTools en particular.

A veces, cuando explicamos a partir de un mapa conceptual, suele ser muy útil ir mostrando los elementos que nos interesa resaltar en un determinado momento, para focalizar la atención en ellos, y eliminar otros que podrían distraer. Al mismo tiempo, es el creador de la presentación el que marca la secuencia en la que se hace la lectura del mapa conceptual, y el usuario puede detenerse y explicar con detalle los conceptos y las proposiciones que se consideran relevantes.

El diseño de la presentación se hace con relativa facilidad, a partir de las herramientas disponibles en el propio creador de presentaciones. Con ellas podremos corregir con facilidad errores, copiar elementos de una diapositiva a otra, variar su orden... Al mismo tiempo, en un Cmap concreto pueden crearse diferentes presentaciones, para adaptar el mismo mapa a diferentes auditorios, de forma semejante a la que se pueden presentar y ocultar diapositivas con un programa ordinario de presentaciones.

La pregunta tópica que a veces en cursos dedicados a CmapTools, o en los mismos foros del *CmapSupport* es si existe la posibilidad de "exportar" una presentación creada con el programa a PowerPoint. La respuesta es siempre la misma: no se puede exportar. Si alguien quiere hacerlo, debe convertir a formato imagen cada uno de los pasos de la presentación a formato gráfico y luego importarlas en PowerPoint. Aunque visto cómo funciona en CmapTools, consideramos la exportación innecesaria.

Cuando uno se plantea el uso de la herramienta de presentaciones de CmapTools en situaciones de educación no presencial el inconveniente es que ésta sólo puede reproducirse, a partir de propio Cmap en el mismo programa. Además, la gran ventaja de la presentación es la existencia de una comunicación oral por parte del ponente hacia los oyentes, y esto se pierde completamente. De todas maneras, más adelante haremos una propuesta, que es uno de los núcleos centrales de esta comunicación, que permite solucionar, aunque sea sólo de formar parcial, el problema. En resumen: podríamos decir que el creador de presentaciones de CmapTools nos permite conseguir una *visión dinámica del mapa conceptual*, frente a otra más *estática* que ofrecen otras modalidades de mostrar el Cmap.

El problema que nos hemos encontrado al intentar estudios previos sobre el uso de las presentaciones con CmapTools es que éstos son más bien escasos: así tendríamos como destacable el de Moon et al. (2008), donde se establece una comparación entre el uso las presentaciones con CmapTools con otros medios de presentación de la información. También cabría citar el estudio de Orúe, Álvarez & Montoya (2008), centrado en el uso de los mapas conceptuales para mejorar las presentaciones científicas. Una comparación sobre el uso de CmapTools y PowerPoint para presentar la información la encontramos en el de Demirdover et al. (2008), si bien en este caso se parte del uso de mapas conceptuales estáticos. Para finalizar esta breve relación de estudios, quisiéramos mencionar el de Walsh (2010), que analiza las posibilidades del uso de CmapTools y PowerPoint para mejorar la transferencia del conocimiento.

3 CmapTools y e-learning

La profesión docente implica una constante actualización, para adaptarse a toda clase de cambios, y mucho más en los tiempos actuales. Es por ello que las administraciones educativas deben (o deberían) velar por su formación continua, para conseguir una mejora en el sistema educativo. Uno de los problemas que surgen en estas actividades cuando se realizan en modalidad presencial, es que pueden surgir diferentes tipos de dificultades, que limiten la accesibilidad a las mismas: problemas de distancias, de horarios, de circunstancias personales de los docentes… En base a lo expuesto, consideramos que las actividades en formato on-line las consideramos muy apropiadas para la formación permanente del profesorado.

Las características definitorias de esta modalidad formativa, y sus peculiaridades respecto a otras, han sido establecidas por Cabero (2006). Este autor señala, como a variable crítica, a los *contenidos*, en su triple vertiente: *calidad, cantidad y estructuración*. Estos tres aspectos, especialmente el de la estructuración, pueden mejorarse mediante el uso de los mapas conceptuales.

Queremos destacar aquí el concepto de *educación flexible*, expuesto por Salinas (2005). Si bien es aplicable a cualquier tipo de formación, en el caso de las actividades on-line adquiere una especial importancia: el alumnado adquiere un papel protagonista y le ofrece la posibilidad de tomar sus propias decisiones en lo que se refiere a su aprendizaje. Y volvemos a mencionar el papel que en este caso pueden tener los mapas conceptuales, como *organizadores del aprendizaje* y especialmente de los itinerarios del aprendizaje del alumnado, tal como explican Salinas, de Benito & Darder (2011).

La combinación de mapas conceptuales y e-learning ha dado lugar a diferentes estudios. En muchos de ellos, es habitual encontrar referencias al uso de los mismos como una herramienta o recurso más del aprendizaje. Es decir, o bien se presentan mapas conceptuales sobre determinados temas, o se pide su elaboración al alumnado.

Cañas & Novak (2010) proponen su uso como *organizadores de objetos de aprendizaje*, o sea, aquellas "unidades de información", recopiladas en repositorios, y que pueden ser usadas en actividades, especialmente en Entornos Virtuales de Enseñanza y Aprendizaje (EVA, EVEA o LMS). Al mismo tiempo, los mapas conceptuales que recogen estos *objetos de aprendizaje* permiten una *flexibilización* de los itinerarios del alumnado.

Pero la aportación al tema en la que nos vamos a centrar es la González (2008). En ella se proponen cinco usos distintos de los mapas conceptuales en entornos e-learning:

a. Como guía virtual de los contenidos del curso
b. Como actividad de aprendizaje
c. Como modelo de experto
d. Como herramienta de evaluación
e. Como herramienta para producir conocimiento compartido

En nuestra condición de formador de formadores siempre hemos participado, desde diferentes roles, en el Programa de Formación a Distancia del *Servei de Formació Permanent del Professorat* de la *Conselleria d'Educació del Govern de les Illes Balears*. Dentro de este programa, elaboramos ya hace algún tiempo un curso que tiene como título *Elaboració de mapes conceptuals amb CmapTools* (Prats, 2007). Se trata de un curso sobre mapas conceptuales y CmapTools, no un actividad que emplee como recurso los mapas conceptuales.

4 Diseño de la experiencia: el uso de video-presentaciones

4.1 Video-tutoriales y video-presentaciones

Antes empezar con el desarrollo de este apartado, quisiéramos establecer una diferenciación entre dos términos, semejantes per no iguales, que utilizaremos a partir de ahora. Para los propósitos de este estudio se utilizarán las siguientes definiciones

Video-tutorial: Material en formato de vídeo, normalmente con una locución explicativa, donde se explican determinadas funciones de un programa informático, o de cualquier otra cosa. Una simple visita a YouTube nos permitirá encontrar multitud de ellos.

Video-presentaciones: Material en formato de vídeo, donde el contenido que se presenta puede ser temática variada, y lo que se muestra en pantalla es, normalmente, la exposición de un terminado tema utilizando una herramienta que permita realizar presentaciones. Lo habitual es que para la mayoría de las video-presentaciones se utiliza como herramienta PowerPoint u otros programas similares.

4.2 Video-tutoriales de CmapTools

El uso del video-tutoriales para explicar determinadas funciones de CmapTools está muy difundido, y existen numerosas experiencias previas. Sin entrar a analizar los que podríamos encontrar en redes sociales de vídeos, como YouTube o Vimeo, podríamos citar los que se encuentran en la ayuda de CmapTools, o los propuestos por el grupo Orión, de la Universidad de Extremadura. En ambos casos, se trata de video-tutoriales cortos, que tienen como finalidad mostrar determinadas funciones del programa. Tomemos, como ejemplo, el primero de los vídeos que forman parte de la ayuda de CmapTools (Carvajal, 2008). En él se nos presentan las principales características de la Ventana Vistas del programa. Otro caso semejante serían el del Grupo Orión de la Universidad de Extremadura (Martínez, 2006), que nos presentan, a partir de 29 video-tutoriales una visión muy completa de los diferentes aspectos del programa, desde su instalación hasta la sopa de conocimiento, incluyendo uno dedicado al creador de presentaciones. Existen casos con una mayor complejidad técnica en su desarrollo, como las propuestas de EducaconTIC (2009). Nosotros mismos, como herramienta puntual de soporte a un curso en modalidad de educación a distancia, hemos hecho uso de ellos, y de otros que hemos creado para la resolución de dudas puntuales de alumnos.

4.3 Las video-presentaciones con CmapTools

De todas formas, la experiencia que pasaremos a describir es diferente, y por ello no hablaremos de video-tutoriales, sino más bien de video-presentaciones.El diseño de éstas video-presentaciones nace de una petición de formación en modalidad a distancia que nos hace el ICE de la Universitat Rovira i Virgili y que explicaremos en detalle más adelante.

En esta ocasión, el planteamiento ha sido muy distinto, por diferentes motivos: El medio utilizado para la realizar de los vídeos ha sido, en todos los casos, el creador de presentaciones de CmapTools. Todos ellos empiezan por la pregunta de enfoque (que aparece implícita en el mismo), y, a partir de aquí, se van mostrando los conceptos. Al mismo tiempo que van apareciendo, se hace una explicación para una mejor comprensión de los contenidos del mapa, y para enriquecerlo. En aquellas proposiciones o conceptos que se consideran más importantes, los comentarios se hacen con un mayor nivel de profundidad.

La grabación se realizó con la herramienta SreenRecord Pro para MacOsX. Su precio es muy bajo, ofrece buenos resultados, y el video grabado se muestra de forma inmediata en pantalla. A pesa de ello, tiene como inconveniente que no permite la edición directa del material grabado, o añadir efectos, como otras aplicaciones especializadas. De toda manera, queremos hacer notar que la herramienta para la edición de video no es un factor critico para el desarrollo de la experiencia: sirve cualquiera que permite capturar las acciones en pantalla y añadir una locución. Para una correcta edición de video-tutoriales o video-presentaciones, será necesario plantearse el uso de una herramienta más potente, que permita mejorar la calidad del producto final.

Los vídeos grabados se podrían haber colocado directamente como un recurso más de los Cmaps, pero se optó por otra vía, para minimizar los problemas de accesibilidad que podrían surgir por la existencia de tantos formatos de video. Por ello, se decidió colocar éstos en la red social de videos Vimeo, por ser de muy fácil acceso, que reproduce los videos en streaming, lo que facilita su reproducción inmediata, sin crear retardos en la reproducción o la necesidad de descargar los videos en nuestro ordenador.

Para facilitar todavía más su integración en los Cmaps como objetos, se aprovechó el código *embed* que proporciona Vimeo, y se añadió como recurso al mapa, en formato html. De esta manera, cuando se accede al recurso que contiene al video-presentación, sin todos los elementos "distractores" que aparecen si se accede directamente a la página web de Vimeo.

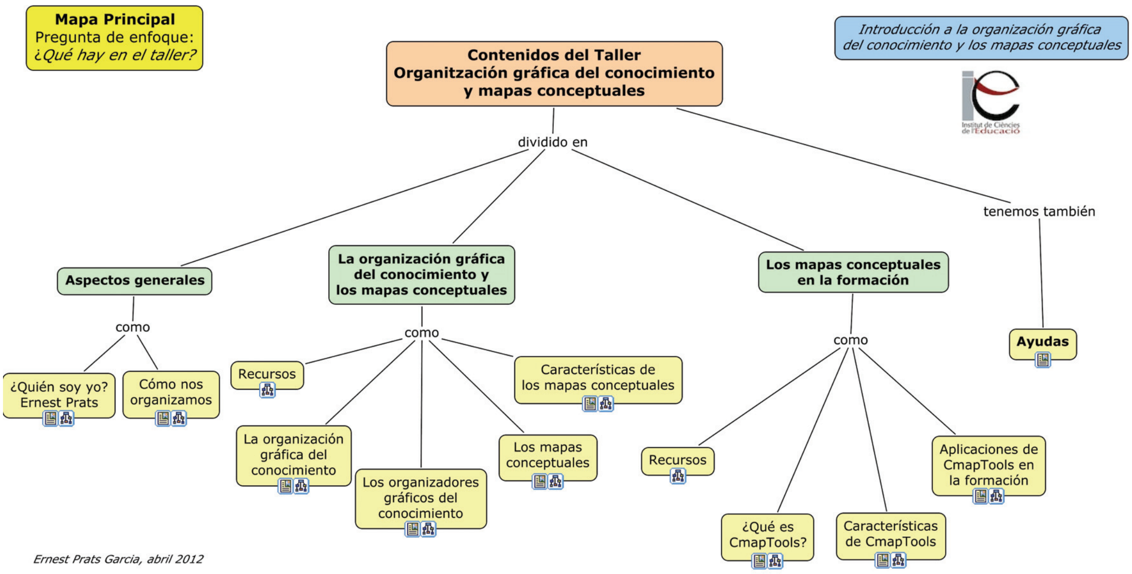

Figura 1. Mapa principal del Taller, con la organización de todos los materiales[1]

5 Aplicación: Taller de Organización gráfica del conocimiento y mapas conceptuales

5.1 Origen de la propuesta

Nuestra experiencia nace de una propuesta del Propuesta del ICE (*Institut de Ciències de l'Educació*) la Universitat Rovira i Virgili (Cataluña, España), para realizar una actuación formativa concreta relacionada con los mapas conceptuales.

Después de diferentes cambios, se establece como formato el de Taller on-line, con duración valorada en 10 horas. Como en todas las actividades de formación en modalidad e-learning, en líneas generales se requieren más horas para completar la actividad que las que se reconocen.

A la propuesta se le dio como título *Taller Els mapes conceptuals: el seu ús en educació* (Taller Los mapas conceptuales y su uso en la educación)[2]. No se trataba de hacer un curso destinado a enseñar el manejo del programa CmapTools. En realidad, lo que se pretendía era que los participantes aprendiesen una serie de conceptos básicos relacionados el tema propuesto, y que reflexionasen sobre ello.

Si bien la propuesta inicial era que se incluyesen dos video-presentaciones (no se marcó formato) de unos 20 minutos de duración cada una, al final optamos por crear los video-tutoriales creados con CmapTools, aumentado su número hasta llegar a nueve, pero siempre con una duración inferior a los diez minutos. Consideramos que si se quiere mantener la atención por parte de los usuarios, se han de evitar las presentaciones largas. Más vale hacer cuatro de cinco minutos que no una de veinte. Además, se decidió que el curso incluiría enlaces a recursos específicos para poder trabajar los alumnos los dos grandes módulos del curso, en forma de mapa conceptual.

5.2 El alumnado del Taller

El número de alumnos que han participado en la actividad, ha sido de 45, todos ellos formadores de formadores (facilitadores) del ICE de la URV. En el caso concreto que nos ocupa, el concepto de *formadores de formadores* hace referencia a docentes de cualquier nivel no universitario, que compaginan su trabajo diario de aula con la formación de otros docentes. También participaban en el curso profesorado adscrito a *Centres de Recursos Pedagògics* o de la misma institución convocante.

5.3 El entorno y la organización de los materiales

El Taller se ha desarrollado en el Entorno Virtual de Enseñanza y Aprendizaje (EVEA), del ICE de la URV de Tarragona, que funciona en Moodle. Como ya teníamos experiencia en el desarrollo de cursos y materiales en este entorno, no hemos tenido ningún problema por lo que se refiere a su organización. En el momento de montar los materiales dentro del EVEA, decidimos clasificarlos en los siguientes apartados:

a) Aspectos generales de la actividad

Se recogían, además de la convocatoria del taller, cuatro fórums que cumplían diferentes funciones, como novedades, presentaciones, consultas…

b) Video-presentaciones y mapas conceptuales

Este apartado pretendía ser una introducción al sistema de organización y funcionamiento de los materiales del curso, que presentaban, generalmente, la misma estructura:

- Video-presentación: Como ya se ha comentado con anterioridad, era la base de todos los materiales del taller.
- Mapas conceptuales: Los mismos mapas conceptuales que se habían utilizado en las video-presentaciones se incluían en formato web, para poder ver el conjunto del mismo y acceder a los recursos asociados.

c) La organización gráfica del conocimiento y los mapas conceptuales

Se trataba de presentar, en forma de mapa conceptual, una relación de recursos que los alumnos podían consultar para entender mejor, a nivel teórico, cómo funciona la organización gráfica del conocimiento y el que son los mapas conceptuales.

d) Video-presentaciones: La organización gráfica del conocimiento y los mapas conceptuales

Recogía cuatro video-presentaciones, acompañadas de sus correspondientes mapas conceptuales.

e) Los mapas conceptuales en la formación de formadores

Nuevamente incluía un mapa conceptual que contenía recursos dedicados a los mapas conceptuales

f) Video-presentaciones: Los mapas conceptuales en la formación de formadores

Si en el apartado (d) las video-presentaciones se referían a aspectos más generales, en éste se intentaba presentar el programa CmapTools y las posibilidades que ofrece. Eran otra vez cuatro video-presentaciones, acompañadas de sus correspondientes mapas conceptuales

g) Actividades de comunicación

A propuesta de los organizadores del curso, se realizaron dos actividades en las cuales los alumnos debían participar y exponer su opinión sobre diferentes temas.

- *Chats*: Con esta herramienta de comunicación síncrona se realizaron dos sesiones, el mismo día pero con diferente horario, para facilitar la participación.
- *Twitter*: Los alumnos debían utilizar esta red de microblogging para responder a diferentes preguntas que se les hacían. También podían interactuar entre ellos.

h) Evaluación

Por parte de la organización del curso se presentó un cuestionario de evaluación estandarizado, mientras que por la nuestra se diseñó otro, destinado a conocer su opinión sobre aspectos concretos del Taller. El contenido del Taller puede verse en las figuras 1 y 2.

6 Herramientas para el análisis de la experiencia

Para poder analizar la experiencia ser dispone de cuatro instrumentos distintos, para intentar conseguir un análisis lo suficiente completo de la experiencia.

a) Cuestionario de evaluación institucional

Se trata de un documento estandarizado, válido para cualquier actividad de formación del profesorado diseñado por el *Departament d'Ensenyament de la Generalitat de Catalunya*. Al tratarse de un documento genérico, la información que nos ofrece puede ser utilizada sólo en parte. Además, se nos entregan los resultados finales del vaciado del cuestionario, sin posibilidad de acceder a los datos originales, por lo que no se pueden establecer relaciones entre las diferentes preguntas planteadas. Los resultados del mencionado cuestionario no han aportado, en un primer análisis, datos significativos.

b) Cuestionario de evaluación propio

Se decidió crear un cuestionario propio que permitiese evaluar los contenidos concretos del taller, en relación directa con los mapas conceptuales y otros aspectos concretos. Después de elaborado el instrumento, este se mostró a un experto, que hizo diferentes sugerencias. Quedó dividido en los siguientes apartados:

- *Perfil personal*: Datos referidos al perfil de los participantes.
- *Formación on-line*: Su finalidad era recoger datos sobre su participación en anteriores actividades de formación on-line y su opinión sobre el taller.
- *Mapas conceptuales y otros organizadores gráficos del conocimiento*: Se recogían pregunta sobre los dos temas mencionados.
- *CmapTools*: Se pretendía determinar si conocían previamente el programa, y si la respuesta era afirmativa, el uso que les daban.
- *Posibles usos de los mapas conceptuales*: Los alumnos debían expresar su opinión de para qué podían utilizar los mapas conceptuales.
- *Twitter*: Como se había utilizado la referida red de micro-blogging en el Taller, se hicieron algunas preguntas relacionadas con el tema.

El cuestionario se diseñó y aplicó empleando la herramienta correspondiente de Google Docs, por las facilidades que ofrece en todos los aspectos: diseño, cumplimentación, exportación de datos.

c) Análisis de las intervenciones en Twitter

Se ha procedido al análisis y categorización de las distintas intervenciones que tuvieron que realizar los alumnos en Twitter. Los resultados de la referida categorización serán analizados en un estudio posterior, el que estamos trabajando.

d) Análisis de los chats

A partir de los chats realizados, y después de eliminar aquellas intervenciones que no se han considerado significativas, se está procediendo a su categorización y posterior análisis, para extraer la correspondientes conclusiones. Queda pendiente de estudio.

7 Un primer análisis de los resultados

El cuestionario ha sido respondido por 29 de los participantes, número que consideramos suficiente para dar fiabilidad a sus resultados. Se ha de tener presente que no todos los 45 inscritos que iniciaron la actividad la finalizaron.

a) Formación on-line

Ha habido un gran equilibrio en las respuestas a la pregunta a cuántas actividades de e-learning habían realizado con anterioridad: El 31% no había realizado ninguna, y el 24% 10 o más.

b) Comparación con actividades formación anteriores

El 58% considera que está al mismo nivel y el 38% a un nivel superior.

c) Formación on-line

Ha habido un gran equilibrio en las respuestas a la pregunta a cuántas actividades de e-learning habían realizado con anterioridad: El 31% no había realizado ninguna, y el 24% 10 o más.

d) Comparación con actividades formación anteriores

El 58% considera que está al mismo nivel y el 38% a un nivel superior.

e) Expectativas frente al resultado final de la actividad

El 48% opina que era lo que esperaba y el 52% mejor de lo que esperaba. Nadie opina que ha sido peor.

f) Aspectos más destacados del Taller, como actividad de e-learning

Dada la importancia de esta pregunta para el análisis de la variable a analizar (validez de las video-presentaciones como elemento en la formación), reproducimos todos sus resultados en la Tabla 1.

g) Conocimiento de los mapas conceptuales

El 93% responde afirmativamente a la pregunta, pero el 31% reconoce que su concepción era incorrecta, normalmente por la confusión con los mapas mentales.

h) CmapTools y otros organizadores gráficos

Mientras que el 45% responde que conocía el programa, sólo el 17% lo había utilizado con anterioridad. Y a la pregunta si utilizan algún otro organizador gráfico, responden de forma positiva el 34%. Se trata habitualmente de programas para crear mapas mentales, u otros de propósito general.

Valor	Frecuencia	Porcentaje
Fórums y chat	4	5,3
Mapas conceptuales	7	9,2
Recursos aportados	17	22,4
Organización del conjunto	10	13,2
Interacción con los compañeros	9	11,8
Video-presentaciones	*27*	*35,5*
Otros	2	2,6

Tabla 1: Aspectos más destacados del Taller

8 Conclusiones: Una primera aproximación

Después del vaciado del cuestionario, y de primer análisis de las participaciones en los chats y Twitter, podemos sacar unas primeras conclusiones provisionales:

1. El aspecto más destacado del Taller han sido las video-presentaciones, según los alumnos (27 de 29 lo consideran uno de ellos). Por tanto, consideramos que su uso es perfectamente válido en entornos de formación e-learning, como elemento conductor o como complementario.
2. A pesar de tratarse de un colectivo de formadores de formadores, con unos conocimientos generales amplios, la mayoría considera que el Taller estaba al mismo nivel o a uno superior de actividades anteriores, y también consideran superadas sus expectativas (y las nuestras propias).
3. Sigue habiendo una cierta confusión entre los mapas conceptuales y otras formas de organización gráfica del conocimiento, especialmente los mapas mentales.

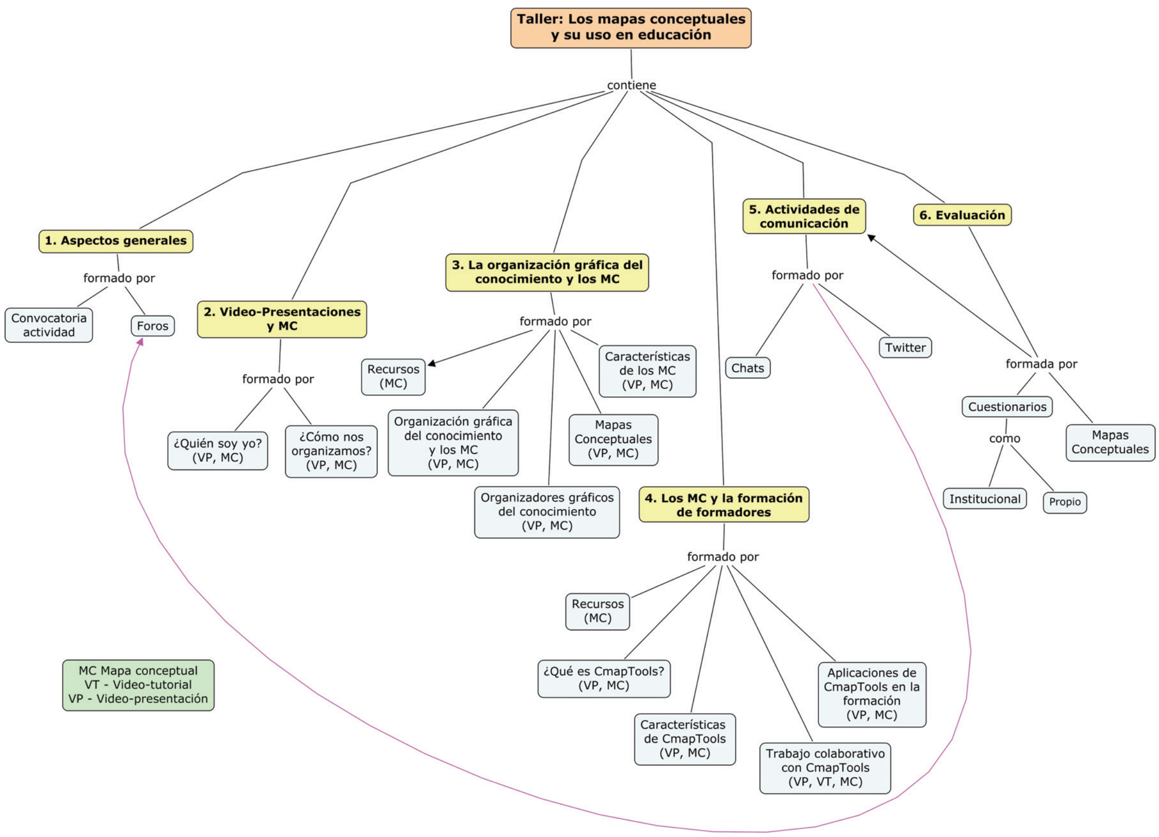

Figura 2. Organización de los contenidos del Taller en el EVEA

Por tanto, consideramos la experiencia como plenamente satisfactoria y los objetivos inicialmente previstos como conseguidos. Como nota curiosa, cabe añadir que, si bien en un principio no estaba prevista la realización de ningún mapa conceptual en el Taller, a petición de los mismos participantes se tuvo que ofrecer esta actividad como opcional. Se prevé analizar los mapas creados como un instrumento de evaluación más.

Para finalizar este apartado de conclusiones, quisiéramos establecer una comparación entre nuestro curso de dedicado a CmapTools y antes mencionado (Prats, 2007).

- Se trata de dos actividades distintas, el curso tiene como finalidad enseñar el manejo de un programa (CmapTools), con una breve introducción previa a los mapas conceptuales. El Taller, en cambio, se centra en apartados teóricos, no entrando para nada en la creación concreta de mapas conceptuales.
- Cuando se concibió el curso, se siguió el formato marcado por la institución: un único documento, en formato PDF, con una determinada secuenciación de actividades. El Taller se fundamenta, exclusivamente, en mapas conceptuales y video-tutoriales.

Como consecuencia de todo ello, estamos empezando a plantear la posibilidad de reelaborar completamente el curso, adaptando sus contenidos (aprendizaje de CmapTools), a otro formato, y con unos recursos distintos.

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ESTUDIO DE LA ESTRUCTURA COGNITIVA: MAPAS CONCEPTUALES VERSUS REDES ASOCIATIVAS PATHFINDER

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Abstract. En este artículo se analizan las principales posibilidades, limitaciones e implicaciones para la investigación, y el estudio del proceso de enseñanza y aprendizaje, de las teorías de Ausubel, Novak y Gowin y de la Teoría de los Conceptos Nucleares de Casas y Luengo, así como las principales técnicas de organización y representación del conocimiento conceptual inherentes a estas teorías.
En este contexto son comparadas las técnicas de construcción de mapas conceptuales y la técnica “Pathfinder Associative Networks" (Redes Asociativas Pathfinder), fundada en el campo de la Inteligencia Artificial, considerada como una de las maneras más fiables e innovadoras de representación de la estructura cognitiva.
Las redes asociativas son un reflejo de la estructura cognitiva de los estudiantes. La técnica de Redes Asociativas Pathfinder permite acercarnos a este constructo proporcionando una representación visual y una detallada información numérica acerca de estas redes. También permiten, y esta es una de sus grandes ventajas, obtener datos sin la interferencia de factores externos, tales como el investigador, la dificultad de la tarea experimental o el contexto en el que se desarrolla el estudio.

1 Introducción

En su libro "Los sietes saberes necesarios para la educación del futuro", Morin (2001) afirma que "hay que civilizar nuestras teorías, o sea, desarrollar una nueva generación de teorías abiertas, racionales, críticas, reflexivas, auto-críticas, capaces de se auto-reformar. "(Morin, 2001, cit. Moreira, 2000, p.67). Cachapuz (2000) comparte este punto de vista y extiende esta idea al considerar que es muy importante seguir profundizando en las bases teóricas del aprendizaje (territorio sobre lo cual todavía sabemos muy poco), ya que puede guiar las nuevas políticas, modelos y prácticas de enseñanza y formación con miras a la excelencia en el aprendizaje." (Cachapuz, 2000, p.67).

Uno de los aspectos más controvertidos de la teoría de Ausubel, en lo que se refiere al aprendizaje de conceptos, es la suposición de que los conceptos se organizan jerárquicamente en la estructura cognitiva del alumno, de los más inclusivos a los menos inclusivos. También es discutible la suposición de que la mayoría de los conceptos es adquirida por diferenciación desde otros más generales, aunque Ausubel considera, pero con menos relieve, otras formas de construcción. "Hay motivos razonables para creer que no sólo la organización psicológica no tiene que seguir este patrón lógico (sobre todo en los alumnos más jóvenes), pero que esta organización jerárquica es, probablemente, enmascarada por limitaciones relativas a las instrucciones dadas a los propios alumnos para construir los designados de mapas conceptuales, así como por los ejemplos generalmente propuestos (dominios altamente estructurados). Esto no significa que no se reconozca el interés didáctico de estos instrumentos, pero tan sólo advertir para la confusión que a menudo se produce entre el constructo y su representación asequible." (Cachapuz, 2000, p. 69)

El aprendizaje natural proviene tanto de la diferenciación de conceptos en otros más específicos, como de la abstracción de conceptos más generales a partir de conceptos subordinados. Wertheimen (1945, cit. Pozo, 1994) muestra todavía que, en la historia de la Ciencia, los nuevos conceptos surgen a menudo por la integración de otros más simples y no por procesos de diferenciación.

2 La Teoría de los Conceptos Nucleares (TCN)

Para entender cómo se adquiere y organiza el conocimiento y cómo se puede caracterizar la estructura cognitiva se vuelve importante conocer una de las teorías emergentes en este campo, la TCN (Casas, 2002 & 2003; Casas & Luengo, 2004, 2005; Arias, 2008; Antunes, 2010; Carvalho, 2011) que ofrece una nueva perspectiva para explicar cómo los procesos de aprendizaje se producen en la mente humana. Esta teoría, que se corresponde al marco teórico general de la Ciencia Cognitiva, se basa en los fundamentos de la teoría del aprendizaje significativo de Ausubel (Ausubel, 1968, Novak & Hanesian, 1983, Novak & Gowin, 1984), entre otros.

La TCN nos ofrece una nueva perspectiva sobre la organización de la estructura cognitiva y asigna una nueva e importante función a los conceptos que figuran de manera más prominente en esta estructura. Ofrece, por lo tanto, una nueva manera de entender cómo funciona el aprendizaje de nuevos conceptos, dando mayor importancia a elementos de la enseñanza y el aprendizaje a que normalmente no es dada la debida consideración, como los conceptos menos universales, menos formales o menos complejos y, por consiguiente, a las representaciones mentales que estos conceptos provocan en los alumnos.

Los principales elementos de la TCN son la "organización geográfica del conocimiento", la noción de "conceptos nucleares" y la noción de "senderos de mínimo coste." (Casas, 2002 & 2003; Casas & Luengo, 2004, 2005; Arias, 2007; Antunes, 2010; Carvalho, 2011). Al igual que otras teorías, hace uso de una técnica propia, la "Pathfinder Associative Networks" (Redes Asociativas Pathfinder), que será descrita más adelante.

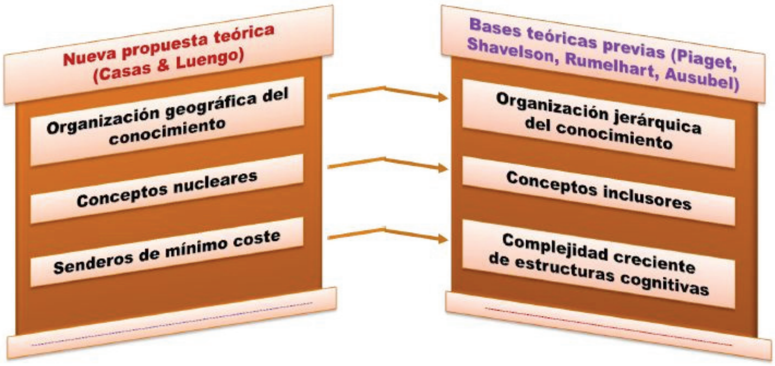

Figura 1. Esquema de los elementos principales de la Teoría de los Conceptos Nucleares

La "organización geográfica del conocimiento" es una metáfora para explicar que la estructura cognitivos de los alumnos no está organizada jerárquicamente en torno a conceptos más generales del que emergen todos los demás, sino de conceptos concretos que no son necesariamente los más generales.

De acuerdo con esta teoría no hay conceptos de nivel superior o nivel inferior, sino que simplemente conceptos (conceptos nucleares) que apoyan el desarrollo de la estructura cognitiva. Es decir, los conceptos nucleares no son necesariamente los más generales, sino simplemente los más significativos para el alumno, los más destacados dentro de su estructura cognitiva. En la práctica, esta teoría tiene por objeto poner de relieve que los alumnos organizan su estructura cognitiva no sólo alrededor de los conceptos más generales o abstractos, sino en torno a conceptos, que en muchos casos, puede ser sólo un ejemplo. Novak & Cañas (2004) describen como, unos años antes, Novak encontró una técnica útil para los estudiantes que fue la de preparar mapas conceptuales mostrando "ideas clave" y sus relaciones, aunque manifiestan que "...éstos no fueron mapas completos, sólo los conceptos clave. Se les pedía a los estudiantes agregar conceptos a los mapas del profesor y reestructurar el mapa de la manera que tuviera más sentido para ellos". Coincidimos en "las ideas clave" pero en el caso descrito por estos autores las "ideas clave" las establece el profesor y las organiza en una estructura jerárquica, mientras que la TCN se refiere a las "ideas clave de los alumnos-conceptos nucleares" que además no necesariamente son jerárquicas.

Los "senderos de mínimo coste" son las relaciones de mayor simplicidad, pero más importantes, que los alumnos utilizan progresivamente a medida que avanzan en la construcción del conocimiento, aunque en su estructura cognitiva afloren cada vez más elementos relacionados entre ellos. Partiendo de esta premisa, la Teoría de los Conceptos Nucleares propone que, según avanza el aprendizaje, la estructura cognitiva de los alumnos se transforma gradualmente, pero paradójicamente, en una estructura más simple.

3 Representación de la estructura cognitiva

Dentro de la Ciencia Cognitiva ha ganado interés e importancia las técnicas de análisis y representación del conocimiento. Existen varias clasificaciones de los procedimientos y técnicas de observación, análisis y representación del conocimiento (Jonassen, Beissner & Yacci, 1993; Gonzalvo, Cañas & Bajo, 1994; Cooke, Salas, Cannon-Bowers & Stout, 2000; Gilar, 2003), que varían principalmente según el tipo de conocimiento en análisis, la fase de análisis y las técnicas cualitativas o cuantitativas utilizadas.

La mayoría de estas técnicas admiten la metáfora espacial para describir la estructura cognitiva y se basan en datos similaridad, es decir, en aproximaciones semánticas entre los conceptos en la memoria humana. Estos métodos requieren, casi todos, la identificación de un conjunto de conceptos relacionados que definen un dominio del conocimiento. El proceso de representación del conocimiento generalmente se produce en dos etapas. La primera busca estimular el conocimiento estructural de un alumno y la segunda trata de representar las estructuras básicas y la interrelaciones dese conocimiento. A continuación, nos centraremos en los procedimientos de representación y análisis de la estructura cognitiva, refiriendo y comparando las técnicas de construcción de mapas conceptuales y la técnica de Redes Asociativas Pathfinder.

3.1 Mapas conceptuales (MC). Potencialidades en la enseñanza

Los mapas de conceptos, o mapas conceptuales (MC), se encuadran en la tipología de las técnicas que consisten esencialmente en solicitar al alumno que coloque de modo organizado un conjunto de conceptos (que le pueden ser presentados o que el propio alumno selecciona de una área específica de conocimiento), que relacione esos conceptos y describa o clasifique la naturaleza conceptual de las relaciones entre los conceptos. Al parecer, es uno de los métodos más simples para evaluar la comprensión de los alumnos acerca de los conceptos más relevantes de un área y las relaciones más importantes entre los mismos, que el alumno ya posee o que se han presentado o se han trabajado durante un proceso de enseñanza y aprendizaje.

Existen varias técnicas de este tipo, entre las que podemos mencionar las "telas semánticas", los "mapas cognitivos", los "mapas de interacción casuales", los "diagramas de Veen", y otros descriptos por Jonassen, Beissner & Yacci (1993).

La técnica de construcción de MC tiene sus orígenes en el movimiento de la teoría cognitiva del aprendizaje significativo de Ausubel y fue utilizada por primera vez por Novak e Gowin en los años 80. (Novak & Gowin, 1984). "Los MC tienen por objetivo representar relaciones significativas entre conceptos en forma de proposiciones." (Novak & Gowin, 1984, p.31). Una proposición (oración gramatical o frase) se compone de dos o más términos conceptuales vinculados por palabras de ligación de modo a formar una unidad semántica. Un mapa es una representación esquemática basada en una estructura bidimensional de proposiciones, que tiene por finalidad poner de relieve un conjunto de significados conceptuales. (Carvalho et al., 2009)

"Dado que el aprendizaje significativo se produce más fácilmente cuando los nuevos conceptos o significados conceptuales se incluyen en otros conceptos más amplios, más inclusivos, los MC deben ser jerárquicos. Es decir, los conceptos más generales e incluyentes deben permanecer en la parte superior o centro del mapa, con los conceptos más específicos, menos incluyentes, sucesivamente colocado debajo de ellos." (Novak & Gowin, 1984, p.32). A veces es útil incluir en el mapa eventos u objetos específicos para ilustrar los orígenes del significado del concepto (la regularidad que se representa).

Los MC tienen el especial propósito de ayudar a los alumnos y educadores a comprender el significado de los materiales de aprendizaje. Para Novak & Gowin, los MC pueden ser al mismo tiempo: un recurso de auto-aprendizaje, un método para encontrar y expresar el significado de los materiales de estudio (por ejemplo, extrayendo las ideas principales de un texto), una estrategia que fomenta la organización de los materiales de estudio. (Carvalho et al., 2009)

Desde la perspectiva de los alumnos, los MC funcionan como una hoja de ruta, que sirve para aclarar las ideas clave en que deben centrarse para realizar una tarea específica de aprendizaje. Al final de esta tarea muestran un resumen esquemático de lo que se aprendió. Los MC, al ayudar a los alumnos a estructurar sus propias representaciones visuales de los conocimientos, los están ayudando a aclarar los conceptos clave o proposiciones a aprender “sugiriendo también conexiones entre el conocimiento nuevo y lo que él o ella ya saben."(Novak & Gowin, 1984, p.38)

Para los profesores, los MC se pueden utilizar para ayudar a planificar el proceso de enseñanza y aprendizaje, es decir, para establecer con los alumnos que caminos hacer para seleccionar y organizar los significados, así como ayudar los alumnos a descubrir nuevas relaciones conceptuales o concepciones alternativas de los alumnos. También pueden servir como herramientas de corrección de errores (Novak, & Cañas, 2004), de evaluación para conocer el estado previo o actual de los conocimientos de los alumnos y evaluar si los alumnos han adquirido la capacidad de analizar, sintetizar y aplicar los nuevos conocimientos.

Un buen resumen sobre la literatura relacionada con el uso de las técnicas de MC para la Educación lo podemos encontrar en Cañas y cols (2003). En concreto, en el capítulo 3 toca temas tan interesantes como la utilidad del uso de MC para la evaluación, los métodos de puntuación de los MC y la fiabilidad y validez para la evaluación. Refleja también evidencias de la efectividad de los MC para la Educación avaladas por estudios en los que se comparó con ellos una intervención educativa alternativa a los MC y otros estudios en los que compararon los MC con otras herramientas y materiales de apoyo al aprendizaje. Pero también es cierto que los MC tienen sus limitaciones, tema que abordaremos en el siguiente apartado.

3.1.1 Limitaciones de los mapas conceptuales

Algunos autores, como Casas (2002), sostienen que, con el propósito de investigación, la técnica de construcción de MC cuenta con algunas limitaciones, especialmente en lo que respecta a la representación de la estructura cognitiva de los alumnos y la posible interferencia de agentes externos, como el profesor o el investigador, la naturaleza de la actividad propuesta al alumno, o los contextos en los que se desarrolla el trabajo. (Casas, 2002)

Consideran que el mayor o menor éxito en la construcción de un mapa no sólo es determinada por el mejor o peor conocimiento de un área, sino también por el dominio de la técnica, por la mayor o menor habilidad de construcción de MC conceptuales. El rendimiento de la tarea de construcción requiere práctica y la utilidad de los MC para la investigación puede verse limitada por la capacidad de los alumnos para reflejar claramente su conocimiento o comprender cómo construir un mapa conceptual. Diversos autores ponen de manifiesto dificultades en el empleo de la herramienta, que parece ser consistente a lo largo de los países y las áreas de uso (Cañas & Novak, 2006). Entre ellas, la dificultad en la construcción y estructura de las proposiciones, la falta de una pregunta de enfoque para guiar la construcción del mapa y la tendencia de construir MC descriptivos en lugar de explicativos. Estas dificultades se manifiestan también en los profesores (Miller, Cañas & Novak, 2006) que manifiestan que a pesar de que un alto porcentaje de los profesores están familiarizados con los MC, y que muchos los usan en sus aulas, la mayoría de ellos tienen graves errores conceptuales con respecto a esta herramienta.

Asimismo, refieren que los MC creados por los alumnos tienden a destacar las ideas fundamentales y la estructura de contenido de un tema (previamente enseñada por el profesor o aprendida, por ejemplo, a través del libro de texto) y no los conceptos clave y los enlaces de su propia estructura cognitiva.

Si bien la capacidad de expresar el conocimiento puede ser un valioso propósito educativo, la incapacidad para evidenciar de manera adecuada lo que se sabe puede interferir con el uso de una técnica de evaluación estructural. "Existe una diferencia entre lo que el alumno sabe hacer y lo que realmente hace, y esto conduce a que el resultado de algunas pruebas esté mediatizado en algunos casos por el dominio de la tarea.

Novak & Gowin (1984) consideran que "desde que el aprendizaje significativo se produce más fácilmente cuando los nuevos conceptos o significados conceptuales se incluyen en otros conceptos más amplios, más inclusivos, los MC deben ser jerárquicos, es decir, los conceptos más amplios y más inclusivos deben estar en la parte superior del MC, con los conceptos más específicos, menos incluyentes, sucesivamente colocado debajo de ellos." (Novak & Gowin, 1984, p.32)

Sin dejar de salvaguardar la idea de que el mismo conjunto de conceptos se puede representar en dos o más jerarquías válidas ("mapas de goma”) formando modelos alternativos de significados y que "está claro que las redes neuronales que se establecen son complejas, con muchos enlaces cruzados entre las células cerebrales en acción" (Novak & Gowin, 1984, p.33), su teoría evidencia la premisa de la organización jerárquica del conocimiento. Sin embargo, consideramos que esta estructuración ni siempre está concebida de forma jerárquica, pues no siempre una persona comienza un aprendizaje significativo en un concepto general o incluyente. Puede, y en muchos casos esto sucede, partir de un objeto o un evento específico que sirven entonces como una referencia clave para la construcción del conocimiento.

Por último, han surgido críticas sobre la dificultad de interpretación de los MC creados por diferentes alumnos o profesores, especialmente cuando los alumnos construyen mapas sobre un mismo tema pero con conceptos distintos o cuando estudiamos grandes cantidades de MC. Actualmente, las últimas versiones de CmapTools, presentan una herramienta que facilita la evaluación de mapas permitiendo “la comparación de un mapa conceptual «experto» de un tema con mapas construidos por estudiantes, y todos los conceptos similares o diferentes se realizan en color." (Novak & Cañas, 2006, p.29). La herramienta a que aludimos, de comparación de MC donde son utilizados los mismos conceptos, devuelve como resultados el porcentaje de coincidencia entre las proposiciones, conexiones entre conceptos, frases de enlace y descripción de conceptos (caso de que exista) entre 2 mapas conceptuales.

Otra limitación fuerte de la teoría de Ausubel se refiere al hecho de no proponer un método convincente para reconocer los conceptos previos que existen en la estructura cognitiva de los alumnos. "Si la gran aportación de Ausubel y Novak a las teorías educativas ha sido la consideración de la importancia de los conocimientos previos, es precisamente en la dificultad de identificar correctamente en la práctica aquellos conceptos que son significativos para los alumnos, que radica una de las debilidades de su propuesta educativa." (Casas & Luengo, 2004b, p.362)

Autores como Sánchez Santamaría (2011) señalan otras limitaciones, como el fomento del pensamiento deductivo frente al inductivo, la limitación del pensamiento circular, el hecho de que el pensamiento se base en relaciones lógicas, más allá del concepto, la complicación de su uso extensivo etc. Otros como Galán, Granell, & Huerta (2002), reconocen que la propia construcción de los mapas tiene un efecto sobre lo que se pretende evaluar y proponen maneras de eliminar ese efecto. Por último, Huerta (1998) señala otros inconvenientes, como que puede existir una dependencia entre la construcción de los MC y la manera en la que se pregunta a los estudiantes para obtenerlos, que los MC podrían no ser reproducibles, que para la construcción de los MC se necesitan habilidades metacognitivas y que no hay criterios objetivos a partir de los cuales analizar los MC de los estudiantes. Propone, para solucionar esta dificultades, una técnica consistente en la aplicación de un test a los estudiantes a partir del cual los investigadores construyeron sus MC cognitivos que sometieron a análisis con posterioridad. Uno de estos análisis se basó en la entrevista clínica.

Sin embargo señalamos que los inconvenientes mencionados para la investigación, para nosotros, no ponen en entredicho la importancia y utilidad de los MC como herramientas para apoyar los diferentes procesos de enseñanza, aprendizaje y evaluación.

3.2 Redes Asociativas Pathfinder. Potencialidades para la Investigación

La técnica de Redes Asociativas Pathfinder (Schvaneveldt, 1990), a partir de ahora designada por técnica RAP, permite crear representaciones de las relaciones entre conceptos y fornecer informaciones sobre la estructura cognitiva de los alumnos. Estas son representaciones gráficas de la estructura cognitiva, en que los conceptos se representan como nodos o vértices y las relaciones entre ellos como los segmentos de la línea de longitud variable en función del peso asignado y su proximidad semántica. Esta técnica también permite identificar, de una manera sencilla, rápida y eficaz, los conceptos nucleares en torno a los cuales los alumnos estructuran sus conocimientos. Pueden ayudar a explorar el conocimiento conceptual de los alumnos y conocer, a través de mediciones sucesivas, la evolución de sus redes de conocimiento.

La gran ventaja de la técnica RAP tiene que ver con ser capaz de "crear representaciones en forma de redes de la estructura cognitiva de un sujeto a partir de datos empíricos, que se pueden generar de forma totalmente automática. De este modo se evitan los inconvenientes de la subjetividad y de la influencia externa que otras representaciones, como los MC, tienen." (Casas & Luengo, 1999, p.17)

Las RAP son, por tanto, representaciones gráficas en forma de grafos, en que los conceptos se representan como nodos o vértices y las relaciones entre ellos como segmentos de recta de longitud variable en función del peso dado a su proximidad semántica. (Schvaneveldt, 1990)

Los valores de proximidad o similaridad entre los conceptos, obtenidos por consulta (directa o indirecta) a cada alumno se almacenan y se organizan en una matriz de datos que corresponde a una matriz de coeficientes de correlación. Después de obtener la matriz o matrices, el algoritmo Pathfinder convierte los valores en una red. El algoritmo descubre el camino indirecto más cercano entre los conceptos y selecciona sólo la longitud mínima de las conexiones entre conceptos. Por lo tanto, sólo las relaciones más fuertes son consideradas y representadas gráficamente.

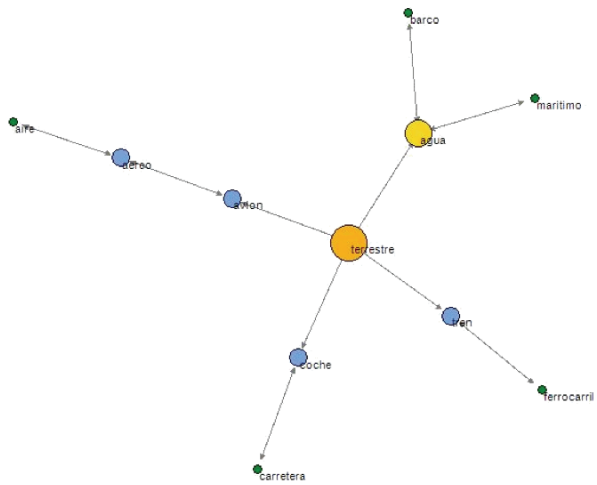

Figura 2. Exemplo de uma rede conceptual sobre los médios de transporte

Los programas de ordenador más utilizados en Educación (KNOT, PATHFINDER, GOLUCA, etc.) que crean estas representaciones (sin la interferencia del alumno) también permiten el cálculo de otras características importantes de las RAP, tales como la coherencia interna, la similitud, la complejidad, las redes medias, los nodos vecinos, etc., que pueden ser analizadas con muchos tipos de pruebas estadísticas, y que apoyan la interpretación objetiva de los resultados. Los programas citados, que representan las RAP, solucionan los problemas de volumen de datos manifestados por Huerta (2006), y además los tratamientos y parámetros cuantitativos aludidos los proporcionan los programas Knot o Goluca, mientras que CMapsTools no lo hace.

3.2.1 Limitaciones de las Redes Pathfinder

En las RAP no se especifican las relaciones entre los nodos, solo su relación de proximidad. Cuando estamos representando redes mentales a través de la técnica de RAP, a partir de las mismas no podemos saber cómo se asocian los conceptos. La RAP solo nos informa acerca de su proximidad conceptual, pero no de cuál es la relación establecida por el sujeto entre dichos conceptos.

La representación depende de los pesos atribuidos a la relación y por ello pueden obtenerse distintas redes según estos valores y esto puede ser de difícil interpretación. Cuando en una representación mental los conceptos base para la obtención de la RAP pertenecen a un mismo contexto, cada nodo está relacionado con todos los demás en mayor o menor medida. La representación es útil cuando refleja de una manera gráfica las relaciones más fuertes. Si representamos todas las relaciones resulta una red enmarañada que no nos proporciona más información que la que ya sabemos: que todos los conceptos están relacionados. Es cuando destacamos los más fuertes cuando obtenemos información acerca de las diferencias entre unas RAP y otras. Por tanto hay que tener especial cuidado en las comparaciones de RAP, determinando que los parámetros de las fuerzas de la RAP sean los mismos en unas y otras.

4 Conclusiones

A lo largo de este artículo hemos tratado de mostrar que las dos técnicas tienen muchas posibilidades de aplicación y también sus limitaciones y características propias. Los MC parecen tener su máxima utilidad cuando se usan para reflejar la estructura de la Ciencia. En investigación debe tenerse especial cuidado al sacar consecuencias sobre los MC que hacen los alumnos, porque a veces no hacen el MC que responde a su estructura conceptual (lo que piensan de la materia), sino que tratan de reproducir el contenido de estudio inducidos por el profesor o por los propios libros de texto u otros recursos educativos.

Por eso, las herramientas utilizadas para ayudar la representación de la estructura cognitiva, basadas en la técnica de RAP, pueden ser una plusvalía en la investigación que se desarrolla en las Ciencias de la Educación, donde sea relevante determinar el conocimiento conceptual de los sujetos. La técnica de RAP, que se viene explorando en nuestras líneas de investigación, principalmente estudios de doctorado y master (ver abajo las paginas web donde se hace su recensión), tiene un gran potencial para el estudio del conocimiento conceptual de los alumnos. Utilizada adecuadamente, es un método simple, rápido y eficaz que los investigadores y los profesores tienen a su disposición para identificar los conceptos nucleares en torno a los cuales los alumnos estructuran sus conocimientos y para explorar y conocer la evolución de las redes de conocimiento de los alumnos cuando se encuentran en situaciones de enseñanza y aprendizaje.

Una forma posible de lograrlo es mediante la comparación de las redes de los alumnos con las redes de otros compañeros, con la red media de un grupo de alumnos, con las redes de los profesores o especialistas e incluso con la estructura de los conceptos que aparecen en un libro de texto o en un recurso educativo en formato digital.

Además, pueden constituir un complemento a los métodos tradicionales de evaluación de conocimientos. Este trabajo se puede realizar en triangulación con otras formas de diagnóstico y evaluación de las actividades realizadas por los alumnos. En base a la información que se recopila a través de este proceso, el profesor dispone de alternativas para comprobar los conocimientos previos, los intermedios y los finales que los alumnos desarrollan a lo largo del proceso educativo y, de acuerdo con los resultados, decidir planificar situaciones de aprendizaje o el uso de recursos de apoyo que ayudan a fortalecer y consolidar los aprendizajes.

Los resultados que estamos obtenido en nuestros estudios, en particular los relativos a la evolución de la estructura cognitiva de los alumnos, refuerzan la importancia y la necesidad de que los profesores dispongan de medios y condiciones para evaluar los conocimientos de los alumnos antes, durante y después de un proceso educativo. Los datos y las lecciones aprendidas de esta evaluación son esenciales para ayudar el profesor a conducir y a mejorar su práctica pedagógica.

La reciente Teoría de los Conceptos Nucleares también nos está abriendo nuevas perspectivas de enfoque de los conocimientos aplicables a las diferentes áreas de investigación y educación.

- Líneas de investigación:
  http://www.unex.es/investigacion/grupos/ciberdidact/estructura/lineas
- Tesis doctorales y tesis de master:
  http://www.unex.es/investigacion/grupos/ciberdidact/estructura/tesis
- Publicaciones (libros, artículos en revistas y en conferencias)
  http://www.unex.es/investigacion/grupos/ciberdidact/estructura/publicaciones
  http://www.unex.es/investigacion/grupos/ciberdidact/estructura/ponencias

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EVALUACIÓN ESTRUCTURAL DE MAPAS CONCEPTUALES EN EL TEC DIGITAL

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Abstract. Los Mapas Conceptuales (MC) han sido utilizados como herramienta de evaluación en investigaciones y educación superior, ya que permiten analizar el conocimiento que tiene una persona acerca de un tema en particular o simplemente ayudarles en su proceso de aprendizaje; por esto, se hace imprescindible saber elaborar un buen MC según criterios elementales que lo caracterizan. La implementación de una herramienta de evaluación y ponderación de mapas conceptuales (MC) en un Sistema de Gestión de Aprendizaje (LMS, por sus siglas en Inglés) como .LRN, tiene como objetivo fundamental facilitar a los docentes el proceso de asignar una calificación a los mapas conceptuales en un entorno de aprendizaje dentro del módulo de evaluaciones. Es importante señalar que para esto se debe de contar con un LMS de código abierto, que permita extender su funcionalidad. Otro de los objetivos es promover en los estudiantes de la plataforma un aprendizaje significativo, a través de una herramienta que sirva como guía de criterios sobre la construcción de los MC que están elaborando. Este trabajo identifica y plantea una solución en .LRN[1] (o dotLRN) de una herramienta de evaluación estructural o de taxonomía topológica de MC, como parte adherida al paquete de evaluaciones de dicha plataforma. Cabe añadir que este trabajo está en un proceso inicial en el que se integra con los servicios del CmapServer y CmapAnalysis del Institute for Human and Machine Cognition (IHMC).

1 Introducción

Los mapas conceptuales han adquirido importancia en el proceso enseñanza-aprendizaje, puesto que esta estrategia permite al estudiante tener un aprendizaje significativo, en que puede construir nuevos conocimientos, trabajar de forma colaborativa mediante el servidor de mapas conceptuales y aprender a aprender.

La razón de poner a disposición una herramienta que ayude en la evaluación y pondere de forma automatizada los MC, surge de la necesidad de brindar apoyo al docente; que usa los MC en sus cursos y no tiene a su disposición un mecanismo evaluativo. Además, se busca inducir a otros profesores a que incluyan MC en su proceso de enseñanza.

Actualmente se dispone de un servidor de MC CmapServer[2] del IHMC[3] (Institute for Human and Machine Cognition) integrado al módulo de asignación y evaluación de la plataforma del TEC Digital. Esto permite que el docente pueda asignar tareas tipo MC, pero no se encuentra implementado ningún tipo de rúbrica o un criterio de análisis de la estructura de este tipo de asignaciones en .LRN.

Además, en esta implementación se busca brindar una guía al estudiante donde pueda verificar la estructura y proposiciones de su o sus MC, basada en criterios de puntuación sobre algoritmos y técnicas en cuanto al tamaño, calidad y estructura, que han sido elaborados por el IHMC (Cañas, Bunch & Reiska, 2010). La importancia de poner a disposición una herramienta para evaluación estructural de MC es una extensión que viene a dar una mayor consistencia y complemento a la integración del CmapServer en .LRN, propiciando mejoras al proceso de enseñanza-aprendizaje del quehacer en la institución.

Actualmente son muchas las universidades que hacen uso de esta herramienta como complemento para su proceso de enseñanza-aprendizaje, lo que hace más evidente la necesidad de ponerla a disposición en una plataforma de aprendizaje como .LRN.

Diversas publicaciones describen la importancia de los MC como herramienta para el aprendizaje significativo de cualquier disciplina como matemática, física, química o economía entre otras (Garcia & Diez, 2010), razón por lo que muchas instituciones de educación superior han optado por esta técnica. No obstante, para que los MC tengan un efecto positivo en el aprendizaje significativo, es necesario que exista un entrenamiento apropiado para su elaboración y su interpretación, así como la posibilidad de un ambiente colaborativo para poder comparar con otros mapas de referencia. Además, es necesaria una herramienta de guía -que es uno de los objetivos de este proyecto- como el integrar el CmapAnalysis[4] en la plataforma TEC Digital.

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1 Ambiente educativo virtual que facilita la colaboración y gestión de clases a través de internet.
2 http://cmap.ihmc.us/
3 http://www.ihmc.us/
4 http://code.google.com/p/cmapanalysis/

Este artículo tiene el objetivo de presentar al lector una solución de implementación en .LRN -plataforma en el que está basado el TEC Digital-, sobre la evaluación estructural de mapas conceptuales mediante la integración de la herramienta CmapAnalysis del IHMC.

1.1 Trabajo relacionado

Existen trabajos de investigación que presentan la forma de evaluar MC, como el esfuerzo parte del proyecto "Conéctate al Conocimiento" del Ministerio de Educación de Panamá en conjunto con el IHMC (Miller, Cañas & Novak, 2006), en donde se desarrolla un esquema de calificación de la taxonomía topológica y semántica (para más detalle ver el apartado sobre taxonomía topológica) de MC adaptada a sus necesidades.

También existen rúbricas (Domínguez, Sánchez & Aguilar, 2010) para guiar la interpretación del docente en la evaluación de los MC realizados por los estudiantes. Un esquema que ha sido muy utilizado es el de Novak y Gowin (1988). Estos dos autores plantean unos criterios de puntuación basados en proposiciones, jerarquía, conexiones cruzadas y ejemplos, dando cierta cantidad de puntos al cumplimiento de cada uno de estos criterios, para obtener un total basado en la sumatoria de los mismos.

En Chacón (2010), la autora enumera tres de los métodos de evaluación de MC más conocidos, a saber: la estructura topológica que busca identificar la forma de organizar el pensamiento; el contenido, donde se valora la coherencia y veracidad de las proposiciones y, por últimos, se valora mediante una herramienta -desarrollada por autora- el proceso de construcción y re-elaboraciones de un MC bajo el argumento de que un mapa conceptual es un proceso que requiere mejoras en su elaboración (se valora mediante una herramienta desarrollada por la autora).

En la propuesta de implementar la evaluación de MC en .LRN es de interés automatizar en una primera etapa, la taxonomía topológica, bajo la integración de una herramienta que se describe a continuación. Uno de los proyectos de software sobre ponderación de la estructura y proposiciones de MC es el del IHMC, el cual se encuentra en etapa de desarrollo. Este ha sido llamado CmapAnalysis (Cañas, Bunch & Reiska 2010) y basa sus criterios en:

Taxonomía topológica: Incluye una puntuación de 0 a 5, donde el 5 indica la mayor calidad del MC [5]. Para este cálculo existen criterios individuales tales como:

- Media de palabras por concepto: es el número total de palabras, (separadas por espacio en blanco), dividido entre el número de conceptos en el mapa. Los conceptos concisos son importantes para la ponderación de la taxonomía.
- Contador de enlaces: número total de los conceptos y frases de enlace que tienen al menos una conexión de entrada y más de una conexión de salida.
- Contador de conceptos: cantidad de conceptos en el MC.
- Contador de frases que unen otros conceptos: cantidad de frases de enlace en el MC.
- Conceptos huérfanos: cantidad de conceptos que no tiene conexiones en el MC.
- Contador de proposiciones: cantidad de proposiciones en MC. Una proposición es la unión concepto-frase de enlace- concepto.
- Contador de raíces hijas: número de conceptos en el mapa que tienen una conexión de entrada de un concepto de raíz. Un concepto raíz se define como uno que tiene las conexiones salientes, pero no las conexiones entrantes.
- Contador de submapas: cantidad de conceptos raíz de otros mapas que se encuentran en el MC.
- Puntuación de taxonomía: ponderación de taxonomía topológica del MC.

Criterios de centralidad: Se refiere a la conexión de los conceptos en el MC e incluye los siguientes aspectos:

- Media de frases de enlace por concepto: relación de frase de enlaces y los conceptos.
- Media de proposiciones por concepto: relación de proposiciones y los conceptos.
- Centralidad del concepto: número de conexiones de entrada y salida de un concepto dado.

[5] En el siguiente apartado se amplía el concepto de taxonomía topológica

- Tres conceptos más centrales: lista separada por comas de las etiquetas de texto de los tres conceptos con la medida de mayor centralidad en el MC.

2 Fundamento de la Evaluación Estructural de Mapas Conceptuales

Actualmente, se está desarrollando un proyecto -dentro del módulo de evaluaciones del .LRN- que busca evaluar y valorar los MC, por lo que es importante mencionar las formas que existen sobre dicho tema. Hay al menos tres niveles de evaluación de MC, a saber: el estructural (taxonomía topológica), el de proceso y el de contenido (semántico). Como parte inicial del proyecto "Mapas Conceptuales" del TEC Digital se pretende abarcar la taxonomía topológica, por lo que este artículo se enfocará en torno a este nivel.

2.1 Taxonomía Topológica

En la taxonomía topológica, que es análoga a la taxonomía de Bloom (Cañas, Novak, Miller et al, 2006; Novak & Gowin, 1988), se analizan los componentes estructurales de un MC, tomando en cuenta ciertos criterios como los siguientes: el nivel de jerarquía, ramificaciones, enlaces cruzados, frases de enlaces y reconocimiento de concepto. Esto resta importancia al significado de conceptos y al contenido de las proposiciones. A continuación, se definen cada uno de estos criterios básicos para clasificar la estructura de un MC.

Reconocimiento de conceptos: criterio determinado por la forma en que están representados los conceptos en el mapa, si los conceptos están bien identificados o si aparecen como oraciones, proposiciones u otras estructuras gramaticales. Frases de enlace: se llama "frase de enlace" a la palabra que une dos concepto con el fin de formar una proposición, esta conexión de dos concepto se hace mediante palabra(s), letra(s) o número(s). Grado de ramificación: esta medida se entiende como los puntos donde el mapa se divide en más de una rama, sean conceptos o frases de enlace. Profundidad jerárquica: se refiere al nivel de profundidad determinado por la cantidad de enlaces que hay desde el concepto raíz al concepto de mayor profundidad jerárquica del concepto raíz. Enlaces cruzados: son todos aquellas proposiciones que unen conceptos que están ubicados en diferentes sectores del MC, excepto el concepto raíz, formando de esta manera un circuito cerrado entre ciertos conceptos. (Cañas, Novak, Miller et al, 2006)

La taxonomía topológica es complementada por la taxonomía semántica ya que este se basa en el significado y coherencia del contenido del MC. Es importante mencionar que la taxonomía topológica no hace una evaluación de un MC, sino que es un apoyo que da criterios sobre la parte estructural del MC.

1 Descripción de la herramienta propuesta

Actualmente, el Instituto Tecnológico de Costa Rica tiene integrada una herramienta de MC en la plataforma de e-learning del TEC Digital (Arias & Chacón, 2010). Se cuenta con un servidor de mapas conceptuales CmapServer vinculado a esta plataforma. Además, se adaptó el módulo de evaluaciones incluido en la plataforma .LRN para poder agregar asignaciones tipo MC. Esto creó otra necesidad dentro del proceso de evaluación de la plataforma, ya que el único que posee es el predeterminado por .LRN, que se reduce al hecho de asignar una nota por la tarea en evaluación. Para extender lo descrito anteriormente y dar un mejor servicio sobre MC, se busca poner a disposición de los usuarios del TEC Digital una herramienta que permita valorar y evaluar la estructura o taxonomía topológica de los MC. Con esta herramienta el docente tendrá un apoyo sobre diferentes criterios seleccionados por él para analizar el MC. Por otro lado, el estudiante tendrá una guía para verificar el conocimiento adquirido sobre un tema se refleje bien en el MC.

Se pretende generar un producto que se base en la herramienta multi-plataforma CmapAnalysis, por lo que cuenta con las misma características de dicha herramienta, en cuanto a análisis se refiere (Cañas, Bunch & Reiska, 2010).

- Entre las características que debe poseer este producto se encuentran:
- La aplicación debe permitir analizar la calidad, tamaño y la estructura, estos términos han sido abarcados en artículos sobre CmapAnalysis (Cañas, Bunch & Reiska, 2010).
- La aplicación debe de ser capaz de leer archivos CXL o cmap, que son los archivos generados por el editor de MC CmapTools (Cañas et al, 2004). Estos archivos pueden estar de forma local en el cliente o en el servidor CmapServer del TEC Digital.

- La aplicación debe poseer un alto grado de usabilidad, permitiendo al usuario que pueda personalizar el análisis del MC.
- La aplicación debe publicar los resultados en pantalla y permitir exportar dichos resultados en una hoja de cálculo (xls) o CSV.
- La aplicación debe permitir la comparación de MC de la solución propuesta por el docente con la elaborada por los estudiantes.

2.2 Requerimientos de la Implementación

Los requerimientos establecidos en esta aplicación para evaluar MC son los siguientes:

1. La aplicación deberá facilitar al docente un apoyo, que mediante diversos criterios basados en la taxonomía topológica y centralidad, pueda evaluar de forma personalizada las asignaciones tipo MC en sus cursos.
2. La aplicación proveerá al estudiante una herramienta que lo guíe en las construcciones de sus MC. Esto se puede lograr mediante la comprensión de los criterios de la herramienta y una debida preparación de los estudiantes para poder interpretar los valores retornados por la aplicación.
3. La aplicación debe ser integrada a .LRN y debe poseer características para ser integrada a otras plataformas LMS.
4. La aplicación deberá presentar un alto grado de usabilidad y extensibilidad para futuras mejoras, especialmente para la adaptación de nuevos criterios.

3 Integración de CmapAnalysis en .LRN

Es importante mencionar que esta integración se hará sobre una distribución del sistema operativo GNU/Linux y en la plataforma de e-learning .LRN y con Postgresql como motor de base de datos.

El módulo de .LRN en el que se integra con el CmapAnalysis corresponde al paquete “evaluation” que incluye la asignación y evaluación de las tareas, exámenes y proyectos de los estudiantes de un curso determinado. El paquete permite a estudiantes cargar uno o varios ficheros con trabajos que han sido asignados por el professor. El profesor podrá comentar y realizar la evaluación correspondiente a los trabajos asignados y puede mostrar el resultado a los estudiantes de forma individualizada.

Este proyecto depende de algunas aplicaciones que fueron creadas por el IHMC, las cuales se detallan a continuación:

- CmapServer es un servidor de MC que le permite a sus usuarios conectados a internet, colaborar en la realización de sus mapas, compartir el conocimiento que ellos mismos construyen, buscar, criticar y comentar sobre otros Cmaps, todo esto mediante la página web del mismo servidor (Arias & Chacón, 2010).
- CmapTools es una aplicación para crear y editar MC que se conecta con un determinado servidor de CmapServer o también se puede trabajar de forma local, en cualquiera de estas dos ubicaciones se pueden almacenar estos mapas.
- CmapAnalysis que es una herramienta de software que permite a los usuarios definir y ejecutar análisis de una serie de MC utilizando varios criterios, técnicas y algoritmos (Cañas, Bunch & Reiska, 2010). El resultado del análisis es un archivo xls, que es una hoja de cálculo de Microsoft Excel (XML6) en donde se analizan los criterios seleccionados por el usuario.

La etapa de integración de la herramienta CmapAnalysis en el paquete “evaluation” del .LRN, se puede llevar a cabo gracias a que el CmapAnalysis es una herramienta de código abierto desarrollado en Java. Por su extensibilidad se puede adaptar a cualquier LMS. En la figura 1 se puede visualizar la arquitectura propuesta para la integración de esta herramienta.

[6] De sus siglas en inglés Extensible Markup Language

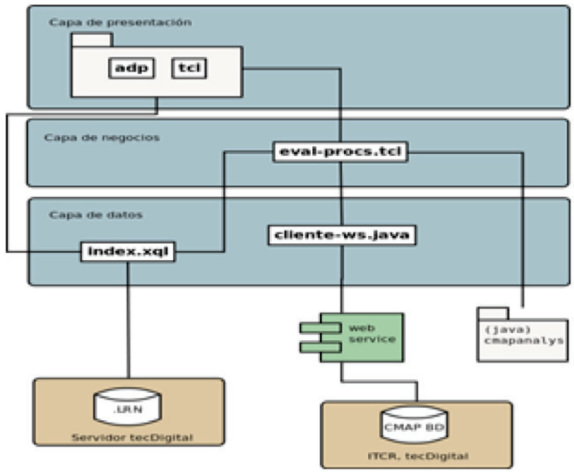

Figura 1. Arquitectura utilizada para integrar CmapAnalysis en .LRN.

En la Figura 1 se describe la arquitectura de la integración entre el CmapAnalysis, el módulo de evaluaciones del .LRN y el CmapAnalysis. Para poder lograr esto, se cuenta con un cliente de servicio web desarrollado en Java (ver Capa de Datos), que permite la comunicación entre el servidor CmapServer y el módulo de evaluación. De esta manera los MC obtenidos serán analizados mediante la aplicación CmapAnalysis (java). Todos los procesos realizados son provocados por una petición del servidor de .LRN, que inmediatamente invoca un proceso que manda a ejecutar los servicios web, para accesar a algún MC que va a ser evaluado y que se encuentra ubicado en el servidor de MC del TEC Digital. De esta manera se puede realizar el análisis de los mapas y así esperar una respuesta de esta aplicación y guardar los datos pertinentes en la base de datos de .LRN.

2 Experiencia y resultados obtenidos

Como producto de la investigación realizada acerca del análisis estructural de MC, se plantea una solución en .LRN mediante un prototipo de aplicación para el módulo de evaluaciones de la plataforma del TEC Digital. El papel del docente es muy importante en esta aplicación, ya que un porcentaje de la nota es resultado del análisis realizado por el docente en los diferentes MC elaborados por los estudiantes, este porcentaje es “Nota profesor. A continuación se muestran cada uno de los pasos que tiene que realizar el docente en el proceso de evaluación de asignaciones tipo MC.

En el primer paso, tal y como se muestra en la Figura 2, el docente tiene que indicar el valor porcentual que quiere asignar a los diferentes rubros de calificación de la evaluación de los MC. Entre los porcentajes de evaluación se encuentran. “Evaluación de metadatos del MC”, “Evaluación de centralidad”, Evaluación estructural” y “Nota profesor”.

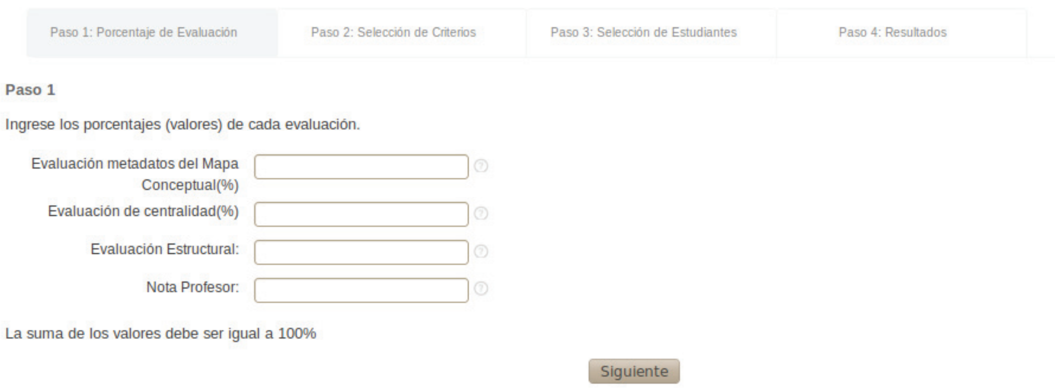

Figura 2. Formulario para indicar el porcentaje de cada evaluación.

En el segundo paso, tal y como se muestra en la Figura 3, el docente debe seleccionar los criterios de centralidad y de taxonomía topológica con los que va se van a analizar los MC. En los criterios de centralidad se relaciona con el nivel de conexión entre los conceptos de los MC. En los criterios de Taxonomía Topológica se ponderan elementos de características topológica y puntaje de taxonomía topológica. Estos criterios ya fueron aclarados en apartados anteriores.

Figura 3. Selección de criterios para el análisis estructural de MC.

En el tercer paso, tal y como se muestra en la Figura 4, el docente debe de seleccionar a los o/y las estudiantes cuya asignación tipo MC está en proceso de evaluación.

Figura 4. Selección Estudiantes.

En el cuarto paso la aplicación muestra en pantalla los resultados del análisis estructural de los MC analizados. También, el docente tiene que registrar la nota de calificación del MC elaborado por cada estudiante. Para ello, el docente puede ver cada MC mediante la herramienta existente del “visualizador de mapas conceptuales” (Arias & Chacón, 2010) del TEC Digital. Otras de las características que presenta esta herramienta es que se pueden exportar de manera individual o grupal los resultados del análisis en un archivo compatible con aplicaciones de hojas de cálculo compatible con el formato “.xls” y además el docente puede visualizar de forma extendida el resultado del análisis estructural de los MC.

Este cuarto paso presenta tres tablas sobre resultados y calificación de los MC. Los resultados del análisis hecho por la herramienta como la nota del profesor de los estudiantes que ya han sido calificados previamente, tal y como se muestra en la figura 5, en donde se puede desglosar de forma particular cada una de las calificaciones dada a los porcentajes dado a los diferentes rubros de calificación.

Paso 1: Porcentaje de Evaluación | Paso 2: Selección de Criterios | Paso 3: Selección de Estudiantes | Paso 4: Resultados

Paso 4

Resultado del análisis estructural y evaluacián semántica hecha por el profesor

Estudiantes que ya han sido evaluados

Estudiantes	Nota Metadatos	Nota Centralidad	Nota Estructural	Nota Profesor	Nueva Revisión
ARAUZ BADILLA , DIEGO ARMANDO	100	100	95	90	
ATENCIO BADILLA , JOSE ROGER	100	100	90	90	
BADILLA SALAZAR , KAREN VICTORIA	90	90	80	80	
CALDERON VARGAS , ERICKA VANESSA	100	100	100	100	

Figura 5. Resultados de la ponderación de MC de los estudiantes ya evaluados.

En la figura 6 se puede apreciar los resultados, desplegados por la aplicación, de los estudiantes que ya han enviado su tarea y que no han sido evaluados por parte del profesor, al igual que en la tabla anterior se pueden desglosar por estudiante y por rubro de calificación los criterios seleccionados en el paso 2. Además, el profesor puede visualizar el MC que cada estudiante subió como la solución dada a la tarea.

Estudiantes que ya enviaron su tarea y no han sido evaluados

Estudiantes	Nota Metadatos	Nota Centralidad	Nota Estructural	Nota Profesor
CHAVES GRANADOS , DIANA CAROLINA	70	70	100	
CORDERO MORA , LORENA MERCEDES	70	100	100	
CORDERO RETANA , MARILYN PAMELA	70	80	100	

Enviar Notas

Figura 6. Resultados de la ponderación de MC de los estudiantes a calificar.

Esta última tabla de calificación, como se puede ver en la figura 7, corresponde a los estudiantes que no han subido la solución de su tarea en la plataforma al momento de la revisión por parte del profesor, lo que implica que la herramienta califica en los diferentes rubros bajo la nota mínima que es cero. También añade de forma automática la nota correspondiente a la calificación profesor.

Estudiantes que no entregaron su tarea y no han sido evaluados

Estudiantes	Nota Metadatos	Nota Centralidad	Nota Estructural	Nota Profesor
CORRALES RETANA , RICARDO JOSE	0	0	0	0
ESQUIVEL FONSECA , DAVID ESTEBAN	0	0	0	0
FALLAS YAMASHITA , VLADIMIR KAZUOMI	0	0	0	0
FLORES HIDALGO , DIANA ELENA	0	0	0	0
GOMEZ VALVERDE , ANA LORENA	0	0	0	0

Figura 7. Resultados de la ponderación de MC de los estudiantes que no subieron la solución a calificar.

En cuanto a los datos retornados por la herramienta CmapAnalysis, son productos de teorías del IHMC y han sido probados con mapas expertos, por esta razón el producto generado será objeto de estudio por un grupo de especialistas en el área, para sugerir mejoras y adaptarlo cada vez más a las necesidades de la academia en la Institución.

4 Conclusiones y trabajos futuros

La integración del CmapAnalysis con la plataforma del TEC Digital es una excelente herramienta de apoyo a los procesos de enseñanza-aprendizaje y de complemento al proceso de evaluación de MC en una plataforma de e-learning.

El análisis de la estructura topológica (taxonomía topológica) se complementa con la taxonomía semántica, que es producto del análisis del docente sobre los MC elaborados por sus estudiantes, bajo el esquema de Evaluaciones del .LRN. El impacto que ha generado la utilización de los mapas conceptuales en el campo educativo es muy positivo, sin embargo, para hacer uso adecuado de los MC se necesita adquirir criterios acerca de cómo elaborar correctamente un MC.

Es sumamente importante destacar que para que un docente logre un verdadero beneficio de esta herramienta, debe contar con la capacitación adecuada en cuanto a la interpretación de los resultados obtenidos del análisis estructural de los MC y tener conocimientos acerca del análisis semántico. También es importante resaltar que las plataformas e-learning son una herramienta con mucho potencial en los procesos de enseñanza virtual, es por eso que se busca extender las formas de evaluación que puedan ofrecer una plataforma como esta.

Entre los trabajos a futuro que derivan de este proyecto, está el de extender los criterios de taxonomía topológica y de proposiciones de los MC de acuerdo a las necesidades de la Institución. También se pretende realizar una investigación sobre las otras formas de evaluar MC y su factibilidad para ser implementados en .LRN, por ejemplo, la herramienta de evaluación de proceso MC descrita en el artículo de Chacón (2010), ampliar con la evaluación semántica a través de procesamiento de lenguaje natural (PLN).

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Valletta, Malta 2012

EVERYBODY TOGETHER WITH " ENERGY" WE ARE PART OF THE EARTH

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Abstract. Being a Montessorian teacher is a challenge in a society characterized by a strong crisis that involves different levels, such as school, family, and society. The answer to the crisis is contained in our method, which aims at promoting humanity. Therefore, school humanization is necessary, connecting the anthropological dimension to the social one. Humanizing school means to create significant learning environments where children can build their knowledge, and learn how to be and how to do, according to their personal needs and times. Children who grow up in settings that do not respect them will turn into weak, irresponsible, unreliable, spiritually impoverished adults. The function of Montessorian education is to let children - as well as future men - discover their place in order to aim at common goals. Educating children to the environment is the correct way to make them aware of the fact that they are an integral part of nature and they have to manage it responsibly for the "Common Good". This requires the use of a flexible, participative, constructionist teaching method. The new vision of science calls for a deep review of purposes and teaching methods of the scientific disciplines. Concept maps accompany all the construction steps of knowledge and are a specific instrument to reinforce cognitive and metacognitive strategies, helping students to build a structured, significant network of knowledge.

1 Introduction

Although Maria Montessori did not speak about investigation-action, her methodology perfectly agrees with such a practice. According to her, children must be allowed to use a scientific method that responds to their personality and needs. Children are spontaneously curious, and are therefore natural scientists. Giving children a global vision of the universe allows them to find an answer to all questions. Moreover, it gives them a kind of organized, systematic knowledge, in addition to favoring meta-cognition processes. This can be achieved by:

- Brainstorming and clinical conversation in order to detect the children's spontaneous knowledge.
- Learning routes that originate from the children's motivations and interests.
- Cooperative learning activities that, through the promotion of positive interdependences and social skills, allow children not only to acquire knowledge, but also to get to know themselves and give value to their person for what they can do.
- Lived body activities, where hands and mind are indissoluble. Children build meanings according to their experiences and mental order.
- Promotion of itineraries that, in addition to stimulate curiosity, allow children to give answers and reflect on their metal routes (meta-cognition). This determines the creation of open, flexible minds.
- Construction of concept maps at general and individual level, in order to give a meaning to the experiences they live, and also develop negotiations with peers and teachers in the so-called "cosmic" laboratory. The cosmic laboratory is the place where knowledge is organized, creates a global vision and allows for the development of intelligence through a significant learning.

2 Cosmic learning laboratory

The scientific laboratory is the cognitive place where to find an answer to the multiple questions and problems that may originate from the observation of a scientific phenomenon. The teacher prepares and organizes materials, procedures and significant situations that urge and guide the learning processes.

The topic is energy, more specifically some of its properties (transfer and transformation) in order to understand interactions between man, plants and the environment. The work involved children from the last year of kindergarten (5/6 years old) and children from the first and second year of primary school (7/8 years old). Given the importance of this topic, it was decided to extend the work to all school levels, including middle school, from a systemic point of view and in order to elaborate a vertical syllabus. The development of the energy transfer and transformation concepts was characterized by investigation, experimentation and construction of meanings by using the body. Concept maps were used in each activity in order to give a systematic organization to knowledge and obtain useful information on conceptual errors (misknowledge). The basic idea of the project comes from the need to develop, starting from early childhood, wide processes in terms of attention and responsibility towards the environment. Talking about the environment is a long, articulated work that must be carried out during several years. This work offers the opportunity to put together ideas, memories and concepts in order to understand how nature works and how things are mutually interconnected.

METHODOLOGIES

- Brainstorming/clinical conversation
- Cooperative learning
- Lived body
- Tutoring
- Narration
- Problem solving
- Task in situation

STEPS

- Sowing experience with and without light
- Reflections on the concept of energy
- Energy through the body
- The needs of plants
- Concept maps

3 Designing the learning environment

"The Words of Science" project aims at teaching the main concepts of science through experimental activities in order to build the meaning of keywords, such as *object*, *properties*, *material, interaction, system, transformation, measurement, energy, and model.* The teacher prepares and organizes materials, procedures and significant situations that urge and guide the learning process from a constructivist viewpoint, interpreting knowledge as the student's active process. The study area is "energy in our lives": what happens in the world around us is the result of energy transfer from the sun to the earth.

Teacher's design map:

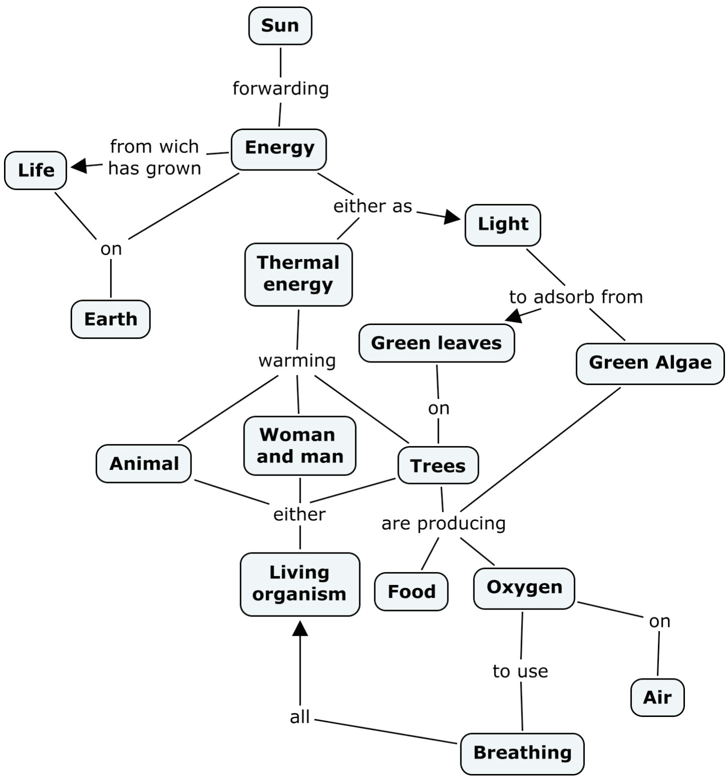

Figure 1. Teacher's design map.

Specific goals:

- Getting to know the functions of energy (transfers and transformations) in order to understand interactions between man, plants and the environment.

Help children to learn concepts while having fun and make them feel the protagonists, developing creativity and interest.

WORK UNIT

TOPIC	Energy and matter in living beings
CONCEPT	"To be alive": which conditions?

WORK STEPS

Step 1: Detect the children's spontaneous knowledge on the concept of heat.

1. Conversation

TEACHER

Have you ever heard the word "energy"? What do you think about when you hear this word?

- *panels*
- *electricity*

TEACHER

Do you know any other forms of energy that are closer to you?

- Children do not answer.

Step 2: Stimulate experiences to enrich their knowledge

2.1. The teacher stimulates a body activity that allows children to experiment a transfer of energy.

At the end of the activity, the teacher invites students to write what they have felt on a piece of paper, following the rules of cooperative activity and using the structure of the SIMULTANEOUS DESK GAME.

2.2. The teacher reads the answers: a variety of heat types is identified

- Heat from our body
- Heat from the wind
- Heat from the sun and from solar panels
- Heat from fire

Step 3: Investigate the concept of heat through experiments.

3.1. After dividing the class into cooperative groups, the teacher works like this:

- The teacher gives a bowl and one ice cube to each table of four students.
- Children pass the ice cube around with their hands.

The teacher asks:

- What happens? What do your hands do? What does ice do?

Children talk together and write answers down.

- What does ice take? *Heat*
- And what do your hands do?
- *They give heat to the ice*
- What happens to the ice?
- *It melts.*

Figure 2. Teacher's design map.

The teacher says that A TRANSFORMATION has occurred, because by using their hands children have transferred energy as heat and the ice has melted. Heat goes from the hands to the ice, which melts.

3.2. Then the teacher uses GENERALIZATION, stimulating reflection with a crucial question**:**

Which other heat exchanges do you know?

- *Heat is exchanged when I touch the radiator.*
- *Heat is exchanged when I take my friend's hand.*
- *Heat warms me up when I lay in the sun*
- *When I feel hot, this is heat.*
- *Heat is my friends' energy.*
- *I feel heat on my hands.*
- *Heat comes from fire*
- *The sun is hot; the fan takes away the heat and creates coolness.*
- *The sun transfers heat to solar panels*

Children have widened their knowledge on the concept of heat through the stimulation of a process based on game and experimental activities, in such a way to perceive the concept at multiple levels: body, motion, sensation, cognition.

Step 4: Favor the awareness of the sun as an essential energy source for the life of plants.

4.1. The teacher brings to the classroom two pots with earth and a bag of seeds and puts one pot into the class locker and one pot on the window sill. Then the teacher invites the students to sow the earth in both pots.

4.2. After some time, the teacher proposes the following PROBLEM SOLVING:

Do plants grow with or without light?

- Plants don't grow without light.

The teacher asks the crucial question “DO YOU THINK IT IS TRUE? HOW CAN WE FIND OUT?

Then, the teacher invites the students to travel on the DISSONANCE and DISCOVERY boat.

Figure 3. Sowing experience with and without light

4.3 Observation of sowing experience with and without light

The teacher guides the observation of the two pots and makes students discover the differences in the color of the leaves and the stem of the two plants. The students observe that the plants that were born and grew without light have white stems and pale, yellow, small leaves. Instead, the plants that were born and grew with light have thicker stems and green leaves.

Then, the teacher asks the question: “What does a seed need to grow?”

In order to answer the question, the teacher starts a step about the knowledge of an artificial and a real leaf.

Step 5: Understand the function of chlorophyll

5.1 The teacher brings to the classroom real and artificial leaves. Then, he/she invites students to observe their shape, color, and size. Then, he/she gives out some posts-it and asks the students to identify whether leaves are real or artificial, explaining the reason why through a series of stimulation questions, such as:

- What is an artificial leaf made of? What happens if you smell it? And if you touch it?
- Do you think that real leaves are heavier than artificial ones?
- What does a real leaf do?
- And the artificial one?
- Where does the leaf live?

5.2 After discussing about the tactile, visual, and olfactory sensations of the leaves, the children are divided in cooperative groups and are invited to represent the properties and differences of real/artificial leaves with words or drawings through the maps

Figure 4. Maps of 5/6 year old children

The real leaf
- is green
- smells good
- is sour
- is noisy
- is rough

The real leaf
- smells good
- is darker

The artificial leaf
- does not smell
- is lighter

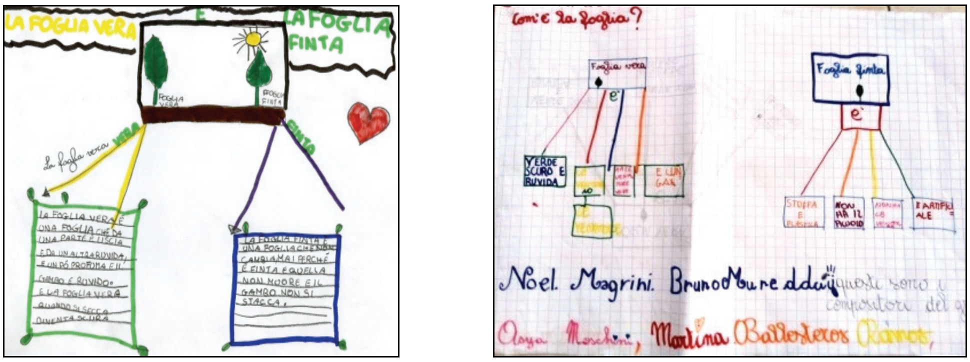

Figure 5. Maps of 5/6 year old children

The real leaf
- is smooth on one side and rough on the other side. When it dries, the real leaf becomes darker.

The artificial leaf
- never changes, it is faked, it doesn't die and the stem doesn't come out.

The real leaf is dark green and rough
- has real veins, and is long

The artificial leaf is made of fabric and plastics.
- has no stem and no veins.
- Is artificial

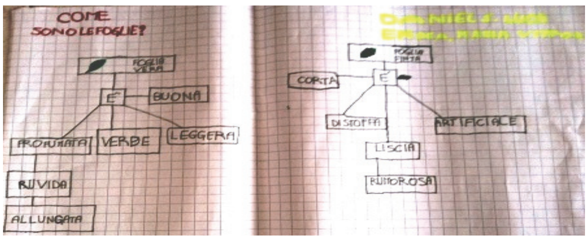

Figure 6. Maps of 5/6 year old children

The real leaf:
smells good, is good, green, light, rough, elongated

The artificial leaf:
is short, made of fabric, artificial, noisy, smooth

5.3. In order to reinforce the understanding on the function of chlorophyll, the teacher uses the narration of a cosmic story, named “Aslan's dream”, which tells the story of a child, called Aslan, who imagines being something else: an animal, a flower, a father.
“I was a basil plant and I lived quietly in my garden: my leaves were straight and green and scented the air, until, all of a sudden, I realized that one of them was different. It was a small, yellow leaf, it bends downwards, as if it was tired and had no longer the necessary strength to stay straight.
While he is telling the story, Aslan gets agitated and yells: “What's happening to my leaf? Why isn't it as green as the other leaves?”
What would you tell Aslan? Write it on your post-it
5.4. Then the teacher divides the class into groups and proposes an experiment named “Searching for the green” in order to discover that leaves contain chlorophyll, giving the following instructions.

1. Take some basil or spinach leaves
2. Put them in a bowl and break them into small pieces.
3. Add alcohol (the one used to make liquors) to the leaves in the bowl.
4. Take a spoon and smash the pieces of the leaves in alcohol. After smashing them for a while, stop and look: is alcohol still colorless?
5. Pour the contents of the bowl in a small vase and close it with the lid.
6. Wrap the vase with tin foil to protect it from the light.
7. Leave the vase like this for two days, then open the vase and see what happened.

At the end of the experiment the teacher asks: “What is chlorophyll for?”
5.5. In order to let students answer the question, the teacher uses the second part of “Aslan's dream"
“Still in the dream, Aslan meets a scientist name Albert and asks him: - What is chlorophyll for? –
Albert replies - You must know that leaves are just like the pots you use to make soup: air gives the carbon dioxide and water, then everything cooks in the pots-leaves and at the end you get a soup made of starch, oxygen and sugars that nourish the plant.
Absorbed in his thoughts, Aslan listens to the scientist and replies:
- How can leaves cook the soup made of carbon dioxide and air, if the fire is not on under the pot?-
(Of course, Albert knows everything, but says nothing: he wants to see if Aslan can understand by himself. Do you want to help him? Suggest your idea).
After a while, Aslan bursts out: - I got it .... it's the sun that cooks the stuff in the pot-leaf, although I don't know how!”
Albert is happy. – That’s a good idea: the sunlight on the leaf is just like the fire under the pot; the sun cooks the water and carbon dioxide in the leaf to create a soup made of starch, oxygen and sugars! But how could you demonstrate this?
Aslan is excited and has no hesitations: - You simply need to cover the leaves so that the sunlight cannot reach them and see what happens, comparing them with the other uncovered leaves.”
At the end of the narration, the students have discovered that plants need a soup where a vital combination between carbon dioxide, light and water takes place. **The energy of the sun creates starch and sugars (which nourish the plant) and liberates oxygen.**

Step 6. Evaluating the cognitive increment
The teacher proposes questions about the concept of heat and energy to evaluate their cognitive increment, according to the requirements of the Montessorian school that measures learning with the "*mneme*" parameter. The students build the new concept maps according to the knowledge retained from the teaching unit.

The existing knowledge is mediated with the group through the dialog and effective strategies can be activated to acquire the new knowledge, operating in what Vygotskij (1980) defines as *proximal development area* through the communicative and social relation with peers and teacher.

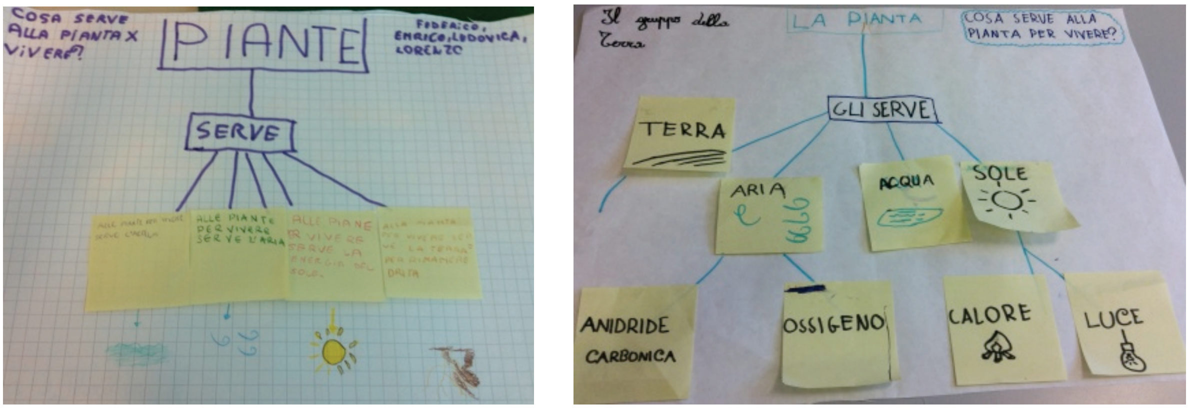

Figure 7. Maps of 7/8 year old children

In order to live, plants need:
- water
- air
- sun energy
- earth (to grow straight)

In order to live, plants need
- earth
- water
- sunlight
- carbon dioxide
- oxygen
- heat
- light

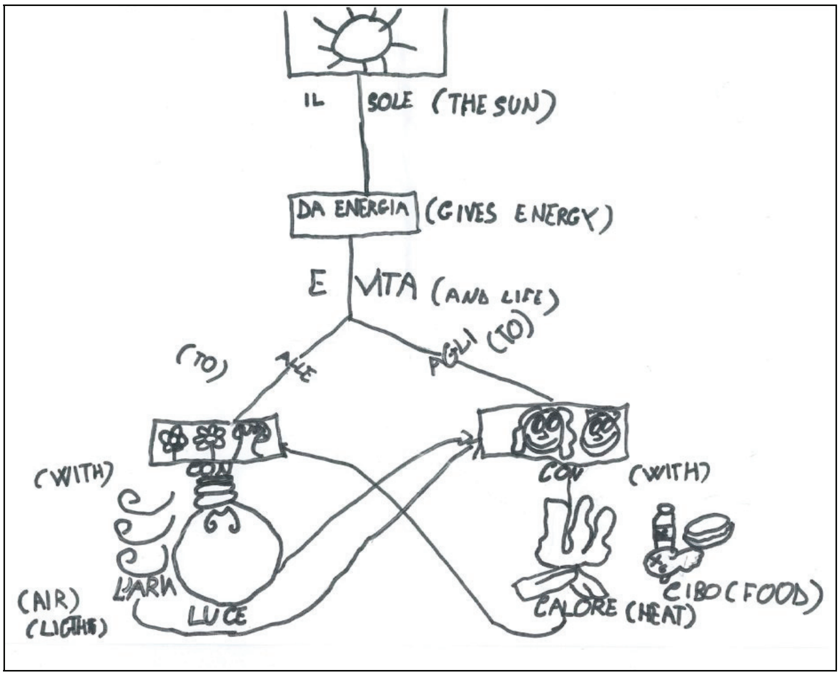

Figure 8. Map of 7/8 year old children

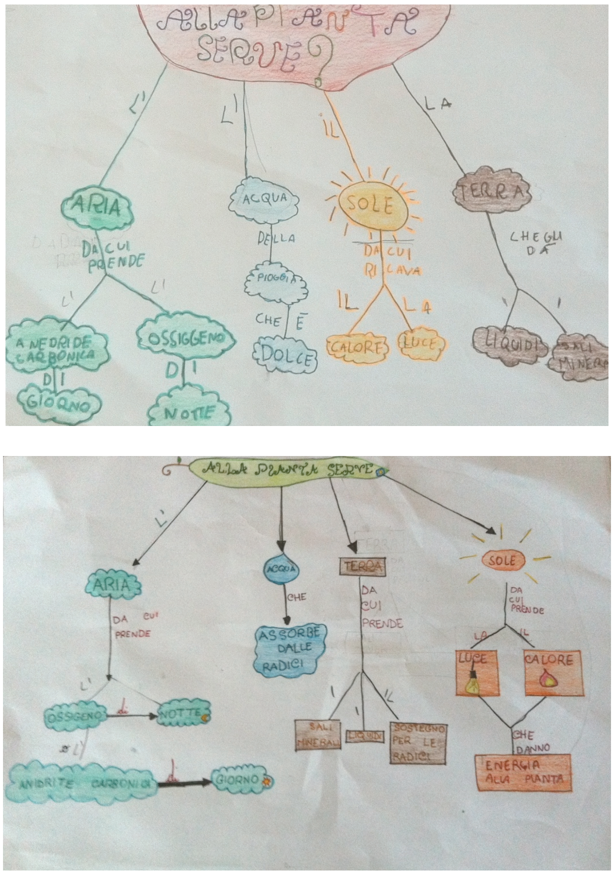

Figure 9. Maps of 8/9 year old children

4 Summary

Children discovered concept maps to be a very good system to organize and represent the knowledge they are building in a significant, solid network. The knowledge referred to transfer and transformation of heat in their reality, i.e. their body and the world closer to their perception, that is the sun and plants. Maps proved to be a crucial instrument to make meanings contained in learning materials emerge. They favored motivation to learn and structured the organized, effective thought in every single learning step. As we demonstrated in this unit, building concept maps is a valid tool for students during understanding. At the same time, it gives teachers suitable information to follow their intellectual development. The maps built by the students clearly show if the desired changes have taken place, or if misconceptions remain. In the latter case review activities and additional conceptual constructions can be started. Therefore **maps acquire a deep meaning in terms of educational evaluation.** The richer the maps, the deeper and the more significant learning will be.

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EXÁMENES DE CALIDAD DE LA EDUCACIÓN SUPERIOR (ECAES) DE MEDICINA, ESTILOS DE APRENDIZAJE Y REPRESENTACIÓN DEL CONOCIMIENTO

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Abstract This report presents the results of research conducted by medical interns of medicine at the Fundación Universitaria de Ciencias de la Salud, whose objective was to determine the impact of the implementation of knowledge representation systems in a virtual learning environment, according to the styles cognitive students obtained in a preparation course for ECAES. In the development of research used a 2 x 4 factorial design of two variables: learning styles versus knowledge representation systems. The subject groups were obtained by applying the test of classifying them according to Kolb learning styles: assimilating, accommodating, diverging and converging. Through the development of tests determined the incidence ECAES with the knowledge representation systems (concept maps, graphs, frames networks and mentefactos). The working hypothesis was to determine whether significant differences in conceptual transfer between subjects according to their learning styles due to knowledge representation systems used in the study of basic skills of medicine. It showed that 53% of students are divergent group (reflective - observation). The knowledge representation systems with which the participating students were more successful mentefactos frameworks and, although results were not significant. The subjects had the highest scores converged in this type of evidence, which is consistent with the Kolb's theory. Assimilators subjects obtained better results with concept mapping. Components in Public Health and Administrative Actions, students obtained the highest averages with concept maps, further stressed the health of the Elderly, secondly, after the frames.

1 Introducción

¿Cómo mejorar las estrategias de enseñanza (Martínez, Estilos de Enseñanza; conceptualización e investigación, 2009) y aprendizaje (Amsel, 1989) (Alonso, 1992) en medicina (Contessa, Ciardelo, & Perlman, 2005) (De Simone, 2008)?, ¿cómo enseñar conceptos con aplicaciones informáticas?, ¿cómo concebir un material pedagógico eficaz para el aprendizaje autónomo?, son algunas preguntas casi obligadas en el ejercicio de la enseñanza de la medicina que tienen que ver con la transferencia de los desarrollos científicos y tecnológicos en los espacios académicos.

Estudiar la influencia de diferentes sistemas de representación de conocimiento de los materiales pedagógicos en una interfaz gráfica da cuenta de la memorización, la comprensión y la transferencia de los aprendices, en procesos del aprendizaje autónomo de la medicina. Este trabajo es una aproximación al conocimiento de cómo el ser humano aprende de acuerdo con su estilo de aprendizaje (Alonso, Gallego, & Honey, 2000) a partir de informaciones estructuradas gráficamente.

2 Diseño de la investigación

Puede definirse un Ambiente Virtual de Aprendizaje (AVA) como "el conjunto de entornos de interacción, sincrónica y asincrónica, donde, con base en un programa curricular, se lleva a cabo el proceso enseñanza aprendizaje, a través de un sistema de administración de aprendizaje" (López, Escalera, & Ledesma, 2002).

Para la investigación, el AVA fue desarrollado en la plataforma Virtual de la Fundación Universitaria de Ciencias de la Salud, como una aplicación de Excel (test de Kolb (Kolb, 1984), (Kolb, 1985) cuestionario tipo ECAES) y otras de CmapTools y DIA para las imágenes de los sistemas de representación de conocimiento. Para el desarrollo de la investigación se realizaron las siguientes fases en el ambiente virtual de aprendizaje:

I fase: Usando el test de KOLB (Kolb, 1984) (Kolb, 1985) se clasificaron los estudiantes de último año de la carrera de medicina de la Fundación Universitaria de Ciencias de la Salud según los cuatro estilos de aprendizaje, generando cuatro grupos: Convergentes, Divergentes, Asimiladores y Acomodadores.
II fase: Los cuatro grupos de sujetos repasaron los contenidos de Salud del niño y salud de la mujer.
III fase: Los cuatro grupos repasaron los contenidos de salud del adulto, salud del adulto mayor, salud de la familia.
IV fase: Los cuatro grupos repasaron los contenidos de salud pública y medio ambiente, ética y bioética.
V fase: Los cuatro grupos repasaron los contenidos de acciones médico–legales, acciones administrativas.

Al final de las fases segunda, tercera, cuarta y quinta los estudiantes presentaron una prueba semejante a la de las pruebas ECAES (Ministerio de Educación Nacional de Colombia, 2003) (ICFES, 2008) en un cuestionario de evaluación, dispuesto en el Aula Virtual.

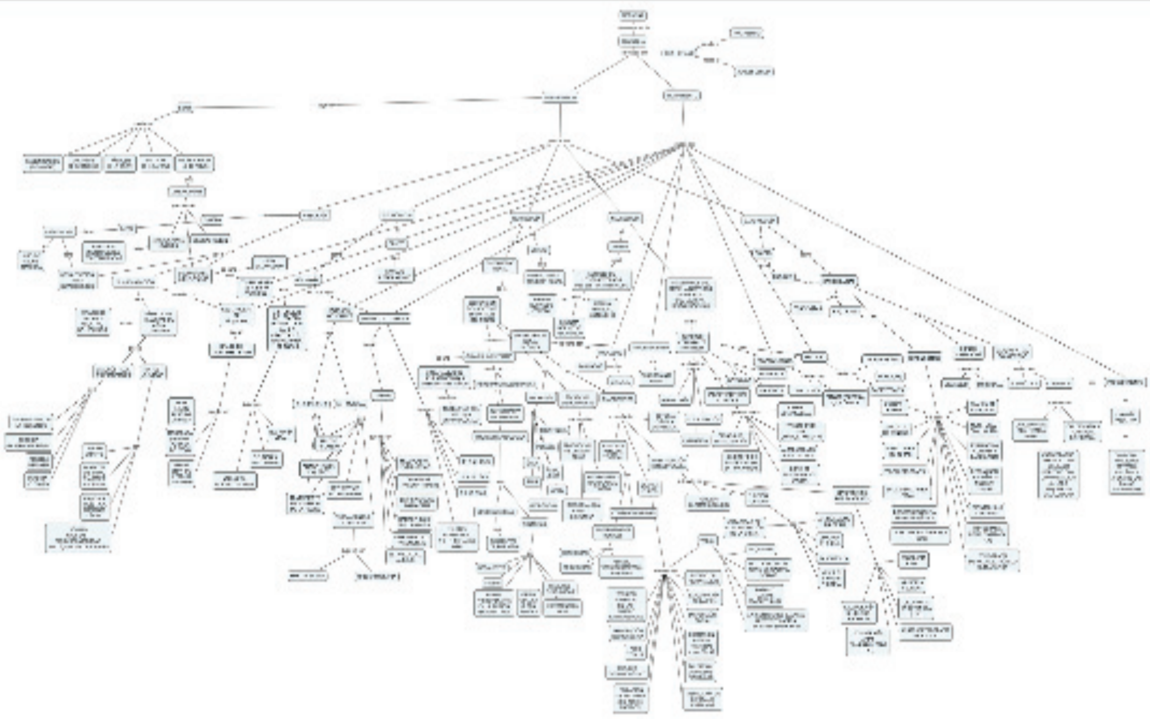

Figura 1. Mapa conceptual de pedagogía.

En el aula virtual los sujetos ingresaban al curso correspondiente de acuerdo con el estilo de aprendizaje. En el ambiente encontraba la imagen del sistema de representación de conocimiento (mapas, grafos dirigidos, redes de marcos, mentefactos), en formato GIFT de una dimensión aproximada de 35 cm * 50 cm. Se elaboraron los sistemas de representación de conocimiento tomando como base diez (10) preguntas de la prueba ECAES relacionadas con el componente a estudiar, esta delimitación se realizó porque el dominio de conocimiento es demasiado grande para poderlo representar de forma tal que los dicentes lo estudiaran en un espacio inferior a una hora.

En cada una de las sesiones que se realizaron se propuso a los sujetos estudiar los contenidos presentados a través de los diferentes sistemas de representación de conocimiento por un espacio de cincuenta (50) minutos y luego debían contestar la evaluación que se realizaba a través de un cuestionario en la plataforma que presentaba cinco (5) preguntas tomadas al azar de las diez (10) que se utilizaron como base para elaborar el sistema de representación de conocimiento, cada sujeto disponía de hasta diez (10) minutos para responder las preguntas.Se desarrolló una investigación en la que los estudiantes respondían un test para determinar su estilo cognitivo (Activo, Reflexivo, Teórico o Pragmático) de acuerdo con los planteamientos de Kolb (1984) y se utilizó como instrumento para determinarlos el "Kolb Learning Style Inventory" (1985). Una vez clasificados los sujetos de la investigación participaron de una capacitación en un ambiente virtual de aprendizaje, *esta capacitación estaba conformada por cuatro etapas diseñadas para proporcionar un repaso de los temas base de la evaluación en medicina en las pruebas ECAES*. El trabajo desarrollado en las fases 2, 3, 4 y 5 corresponde a un diseño cuasi -experimental del tipo factorial (Hernández, Fernández, & Baptista, 2010) 2 x 4 de la siguiente forma:

Tabla 1. Diseño experimental.

		Sistema de representación del conocimiento			
		FASE II	FASE III	FASE IV	FASE V
Estilo cognitivo	Acomodador	Mapas conceptuales	Grafos dirigidos	Mentefactos	Marcos conceptuales
	Asimilador	Grafos dirigidos	Mapas conceptuales	Marcos conceptuales	Mentefactos
	Divergente	Mentefactos	Marcos conceptuales	Mapas conceptuales	Grafos dirigidos
	Convergente	Marcos conceptuales	Mentefactos	Grafos dirigidos	Mapas conceptuales

Son dos variables independientes, estilos cognitivos y sistemas de representación del conocimiento, cada uno de ellos con cuatro indicadores.

La estructuración de conocimiento de estos ambientes se presentó mediante sistemas de representación de conocimiento (mapas conceptuales, grafos dirigidos, marcos conceptuales y mentefactos). Al finalizar cada etapa de capacitación se realizó una evaluación basada en las pruebas ECAES, con el fin de responder a la siguiente pregunta de investigación:
¿En qué medida afectará el aprendizaje de las competencias básicas de medicina la forma de representación de conocimiento del ambiente virtual de aprendizaje y el estilo de aprendizaje (Keefe , 1988) de los estudiantes de último semestre de medicina de la FUCS medida a través de las pruebas ECAES?
De la pregunta de investigación surge la siguiente hipótesis:

H1. Existen diferencias significativas en la transferencia conceptual entre sujetos según sus estilos de aprendizaje debidas a los sistemas de representación de conocimiento (Sowa, 1984) empleados en el estudio de las competencias básicas de medicina.

H2. Existen diferencias significativas en la transferencia conceptual entre sujetos debidas a los estilos de aprendizaje empleados en el estudio de las competencias básicas de medicina.

3 Población y muestra

La población corresponde a los estudiantes de último año de la Fundación Universitaria de Ciencias de la Salud, de Bogotá D.C. Colombia. Para participar en la investigación el único requisito fue el de estar cursando último año de medicina en la Fundación Universitaria de Ciencias de la Salud, no existió para esta investigación criterios de exclusión.

- Muestreo

Los sujetos se dividieron en cuatro grupos, de acuerdo a la clasificación dada por el instrumento Learning Style Inventory (Kolb, 1984), (Kolb, 1985). Participaron ciento cuatro estudiantes de último año de la carrera de medicina y se distribuyeron así: Convergentes 13%, Acomodadores 13%, Asimiladores 21% y Divergentes 53%. Así, más de la mitad de la población participante corresponde al Estilo de Aprendizaje Divergente (Kolb, 1985), esto permite inferir que más de la mitad de los Internistas del año 2009 se caracterizan porque se desempeñan mejor en la experiencia concreta (EC) y la observación reflexiva (OR). Su punto más fuerte es la capacidad imaginativa. Se destacan porque tienden a considerar situaciones concretas desde muchas perspectivas. Son personas que funcionan bien en situaciones que exigen producción de ideas. El siguiente grupo lo conforman los sujetos Asimiladores (Kolb, 1985) quienes se caracterizan por ser sujetos en los cuales predomina la conceptualización abstracta (CA) y la observación reflexiva (OR). Su punto más fuerte lo tienen en la capacidad de crear modelos teóricos. Se caracterizan por un razonamiento inductivo y poder juntar observaciones dispares en una explicación integral. Se interesa menos por las personas que por los conceptos abstractos, y dentro de éstos prefiere lo teórico a la aplicación práctica.

De acuerdo con el modelo de Kolb (1985) se puede también plantear que los estudiantes de medicina de esta cohorte se caracterizan por la observación reflexiva en general, aprenden probando en forma reflexiva o imparcial. Se basan en juicios sobre observaciones precisas. Prefieren las clases expositivas. Son introvertidos.

4 Resultados

A continuación se presenta el resumen de estos datos agrupados por cada uno de los componentes que plantea la prueba ECAES (Ministerio de Educación Nacional de Colombia, 2003) (ICFES, 2008), obtenidos en el ambiente virtual de aprendizaje (Burgos, 2006).

Tabla 2. Resumen estadístico agrupación de datos por componente ECAES vs. Sistema de Representación de Conocimiento

	Sistema de representación			
Componente	**mapa**	**grafo**	**mentefacto**	**Marco**
Salud de la mujer	3,083333333	3,111111111	3,108695652	2,857142857
Salud del niño	2,230769231	2,6	2,653846154	2,727272727
Salud del adulto	3,210526316	3,75	3,833333333	3,255319149
Salud del Adulto mayor	3,818181818	2,8	3,833333333	3,481481481
Salud Pública	3,4375	3,333333333	2,8	3,230769231
Bioética	1,875	2	2,2	2,384615385
Acciones médico legales	3	2,769230769	3,5	3
Acciones administrativas	3	2,692307692	1,75	2,75
PROMEDIO	*2,956913837*	*2,881997863*	*2,959901059*	*2,960825104*

De acuerdo con los datos de la tabla 2 respecto a los sistemas de representación de conocimiento (Sowa, 1984) (Winograd, 1987) los mentefactos (2,959) y redes de marcos (2,96) permiten mayores niveles de comprensión, aunque los resultados de los sujetos que estudiaron con mapas conceptuales(2,957) (Fonseca, 2000) (Añez, Ferrer, & Velazco, 2007) (Ausubel, Novak, & Hanneesian, 1997), son muy próximos, siendo los de menor resultados en la transferencia conceptual los grafos dirigidos (2,882) (Calderero, 2004). Los mentefactos (De Zubiria, 1999) y los marcos (Collins & Quillian, 1969) agrupan y estructuran la información (Sowa, 1984) facilitando el estudio de los mismos a diferencia de los mapas conceptuales (Ausubel, Novak, & Hanneesian, 1997) los grafos (Calderero, 2004).

En cuanto a la prueba ANOVA se observa en la tabla que todos los valores de F son menores que el valor de F crítico lo que permite afirmar que no existen diferencias significativas entre los diferentes grupos al emplear los sistemas de representación de conocimiento, es decir no existe incidencia significativa entre el estilo de aprendizaje y el sistema de representación (Lynch, Woefl, Steele, & Hanssen, 1998) empleado para estudiar los diferentes componentes de la prueba ECAES.

A continuación se presenta el resumen de los datos de la investigación agrupados por los sistemas de representación de conocimiento al interior de cada uno de los cuatro grupos experimentales (asimiladores, acomodadores, divergentes y convergentes).

De los datos de la tabla 3, en los cuales se realizó el análisis estadístico al interior de los grupos, se encuentra que los sujetos que obtuvieron los mejores puntajes fueron los convergentes. De acuerdo con las características sugeridas por Kolb (1985) las personas de este estilo se desempeña mejor en las pruebas que requieren una sola respuesta o solución concreta para una pregunta o problema. Organiza sus conocimientos de manera que se pueda concretar en resolver problemas usando razonamiento hipotético deductivo.

El grupo que obtuvo el promedio más bajo corresponde a los sujetos acomodadores que se caracterizan porque se desempeña mejor en la experiencia concreta (EC) y la experimentación activa (EA). Su punto más fuerte reside en hacer cosas e involucrarse en experiencias nuevas. Suelen arriesgarse más que las personas de los otros tres estilos de aprendizaje. Se lo llama "acomodador" porque se destaca en situaciones donde hay que adaptarse a circunstancias inmediatas específicas. Es pragmático, en el sentido de descartar una teoría sobre lo que hay que hacer, si ésta no es coherente con los "hechos".

Tabla 3. Resumen estadístico intragrupal.

	ESTILO APRENDIZAJE			
SISTEMA REPRESENTACION	ACOMODADOR	ASIMILADOR	DIVERGENTE	CONVERGENTE
MENTEFACTOS	2,5	2,625	2,881270903	3,833333333
REDES DE MARCOS	2,875	2,807692308	3,368400315	2,792207792
MAPAS CONCEPTUALES	2,657051282	3,514354067	2,65625	3
GRAFOS DIRIGIDOS	3,275	2,855555556	2,730769231	2,666666667
PROMEDIOS GRUPOS	2,826762821	2,950650483	2,909172612	3,073051948

En cuanto a la prueba ANOVA comparando los sistemas de representación de conocimiento entre los cuatro grupos se encuentra que para los sujetos asimiladores ($f_{obtenido}$ 2,915 $f_{crítico}$ = 2,114) divergentes ($f_{obtenido}$ 8,224 $f_{crítico}$ = 2,046) y convergentes ($f_{obtenido}$ 2,383 $f_{crítico}$ = 2,195) si existen diferencias significativas debidas a los sistemas de representación de conocimiento empleados.

A partir de los datos de la tabla 3 y de la información de la ilustración 3 se puede afirmar que los sujetos asimiladores obtuvieron puntajes significativamente superiores cuando usaron mapas conceptuales ($\bar{x}$ = 3,5143) que cuando emplearon mentefactos ($\bar{x}$ = 2,625) con un valor de $F_{obtenida}$ 2,915 mayor que el valor de $f_{crítica}$ de 2,11. En cambio los sujetos divergentes obtuvieron puntaje significativamente superiores con $F_{obtenida}$ de 8,224 mayor que $F_{crítica}$ 2,046 cuando emplearon redes de marcos ($\bar{x}$ = 3,368) que cuando usaron mapas conceptuales ($\bar{x}$ = 2,656) y los sujetos convergentes obtuvieron puntajes significativamente superiores con $F_{obtenida}$ (2,383) mayor que $F_{crítica}$ (2,195) cuando emplearon mentefactos ($\bar{x}$ = 3,833) que al usar grafos dirigidos ($\bar{x}$ = 2,667).

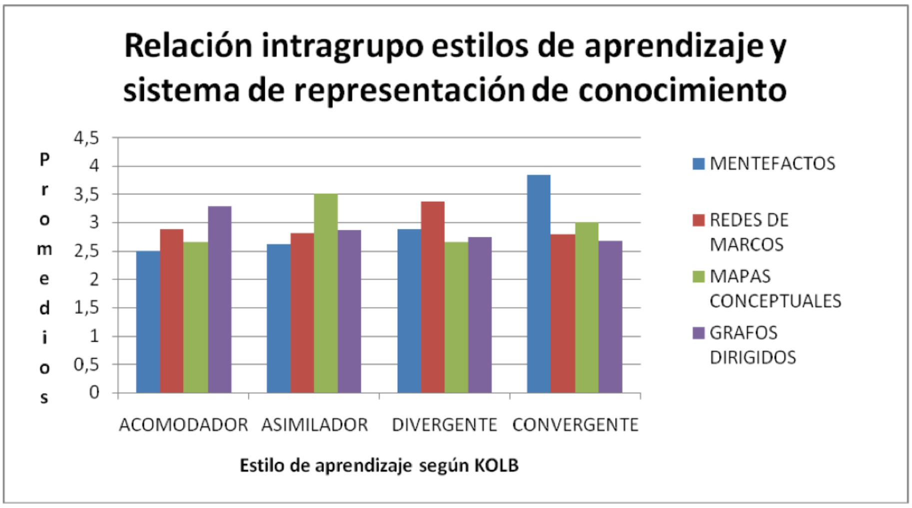

Figura 2. Relación estilos de aprendizaje y sistemas de representación de conocimiento.

5 Conclusiones

Para dar respuesta al problema de investigación respecto a la afectación del aprendizaje de las competencias básicas de medicina, teniendo en cuenta las formas de representación del conocimiento y los estilos de aprendizaje de los estudiantes, basados en la evidencia experimental arrojada por este trabajo de investigación, los hallazgos fundamentales consisten en la evidenciación de relaciones entre los estilos de aprendizaje y los sistemas de representación de conocimiento así:

Para los estudiantes con estilo de aprendizaje Asimilador, el sistema de representación de conocimiento con el cual obtuvieron puntajes significativamente superiores fue el de mapas conceptuales como se puede observar en la Figura 2. Los resultados más bajos los obtuvieron al emplear mentefactos, como han reportado otras investigaciones (Shastri, 1988) (Winograd, 1987). Para los estudiantes con estilo de aprendizaje Divergente, obtuvieron puntajes significativamente superiores al emplear redes de marcos y los más bajos con mapas conceptuales.

Los estudiantes con estilo de aprendizaje Convergente obtuvieron puntajes significativamente superiores cuando emplearon mentefactos y muy bajos cuando emplearon los grafos dirigidos. Para los estudiantes con estilo de aprendizaje Acomodador se obtuvieron resultados superiores al emplear grafos dirigidos, aunque este valor no fue significativo.

El sistema de representación de conocimiento que más favoreció los resultados en las pruebas tipo ECAES fue el de redes de marcos, seguido por los mentefactos, los mapas conceptuales y finalmente los grafos dirigidos. La diferencia fue significativa, ya que la f_{obt} fue mayor que la f_{crit}. Estos resultados son acordes con la investigación de Burgos (2006) en la que se plantea que la estructura de nodos de los marcos es mucho más rica que en las redes tradicionales, habilitando procedimientos y métodos para recuperar, completar y enlazar información. Se puede asumir, siguiendo a Sowa (1984) que los bajos resultados que obtuvieron los estudiantes al emplear los grafos dirigidos, radica en que son sistemas de lógica orientados a la representación de la semántica del lenguaje natural, lo cual los hace estructuras altamente formalizadas que implican altos niveles de conocimiento conceptual para su comprensión.

Los estudiantes cuyos puntajes fueron superiores son los de estilo de aprendizaje Convergente, lo cual es acorde con el planteamiento de Kolb (1985), que los caracteriza porque se desempeñan mejor en las pruebas que requieren una sola respuesta o solución concreta para una pregunta o problema. Los estudiantes que obtuvieron los puntajes más bajos corresponden al estilo de aprendizaje acomodador, caracterizados por la experimentación, que se adaptan mejor a circunstancias inmediatas específicas y prácticas.

De los ocho componentes de las pruebas ECAES los de "Salud del niño", "Acciones administrativas" y "Bioética" los sujetos presentaron los puntajes más bajos, estando por debajo del valor de aprobación. Esto implica que se deben tomar acciones correctivas para mejorar los puntajes de los estudiantes al presentar las pruebas oficiales ECAES.Este tipo de investigaciones se constituyen en aportes valiosos para que los profesores puedan generar unas relaciones más asertivas entre los dominios de conocimiento y los estudiantes, al tomar en cuenta sus características particulares y así fortalecer sus aptitudes y asumir con pertinencia las dificultades propias de los estilos de aprendizaje de cada uno de ellos.

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FOLLOW THE ARROWS: TRACING THE UNDERLYING STRUCTURE OF A DOCTORATE

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Abstract: This paper reports on the results of a four year longitudinal study of PhD students and their supervisors. The students were all registered in lab-based PhDs within a research-intensive university within the UK. Sequential concept map-mediated interviews were used to gain insight to the students' and supervisors' perspectives on the content and the process of gaining a doctorate. The evidence gained suggested that the students tend to focus on the PhD in terms of a product to be completed (in terms of writing a thesis and writing for peer-reviewed journals), whilst the supervisors tended to concentrate more on the process of learning and scientific development, placing the student's contribution into the wider disciplinary discourse. The structural observations from the concept maps generated within this study are that the students perceive the PhD as a linear structure, whereas the supervisors are more likely to generate a cyclic structure to illustrate the dynamic, iterative processes of research more generally. Further structural elements emerge from the analysis of the maps, indicating the need for holistic understanding of the content, structure and meanings in concept maps.

1 Literature Review

Concept maps have been widely used to interrogate the quality of understanding held by students at all levels of education (Novak, 2010; Turner, 2011). The qualitative analysis of concept maps has revealed relationships between the structures produced and the nature of the understanding displayed (Kinchin, Hay & Adams, 2000). The spokes, chains and networks described by Kinchin et al. (2000) have been augmented with cyclic maps that have been identified by Safayeni, Derbentseva and Cañas (2005), in which concepts are viewed as continuously changing and influencing each other in a loop. Such cyclic representations are seen to be more dynamic than other structures which seem to represent more static relationships (see Figure 1).

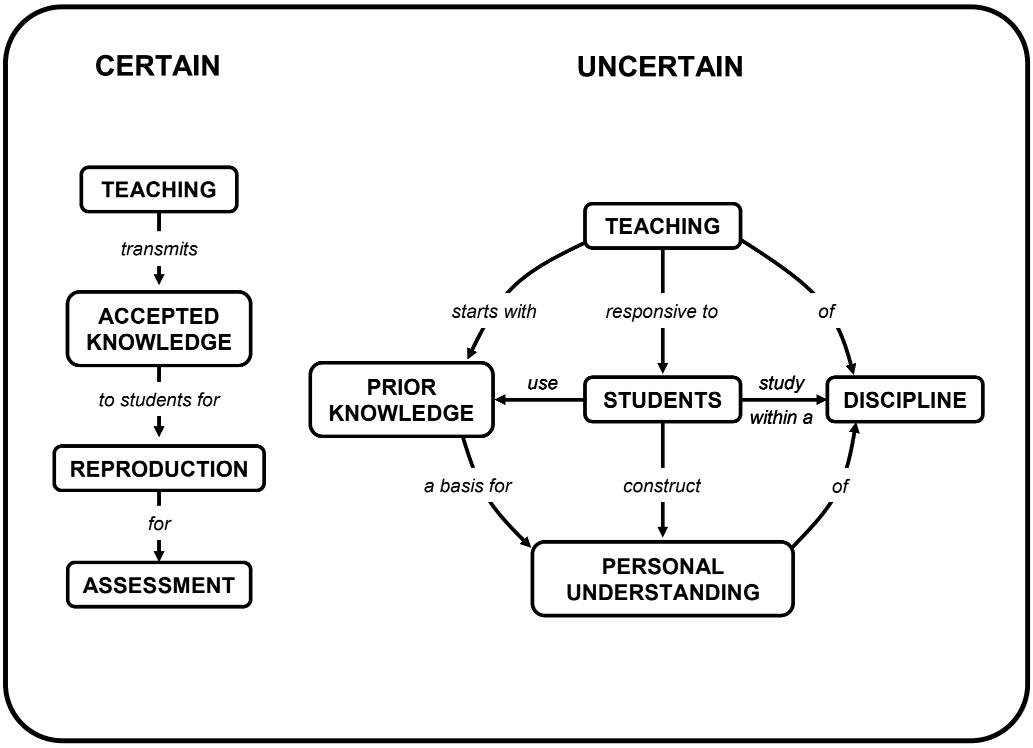

Figure 1. Linear and cyclic concept maps of teaching (after Kinchin 2011).

Doctoral education pedagogy has been a traditionally understudied area (Pearson, 1999; Pearson & Brew, 2002; Walker et al., 2008). Building on research on the visualisation of learning (Kinchin et al., 2000), the graphical depiction of the components of the underlying conceptual structure can be seen as a natural feature of the thesis. However, most theses tend to be less visual and more textual in their representations, and so the uncovering of the underlying framework may be more problematic.

This study used concept mapping to explore how students and supervisors represented their underlying conceptual frameworks in a visual manner, and how this developed and changed over time. The subsequent question that emerged was whether common features developed and if there were sufficient common attributes to describe ‘conceptual structures’ within doctoral studies. This allows for the development of a generic visualisation of conceptual structures that can be used as a tool in the supervisory relationship of doctoral studies.

2 Methodology

In this longitudinal study (Kandiko & Kinchin, 2009; 2010; 2012), the authors interviewed PhD students and their supervisors in order to gain a picture of how each viewed the content of the PhD and the nature of doctoral study more generally. The interviews were mediated by the production of a concept map (Kinchin et al., 2010) that was then the main artefact for analysis, augmented by transcripts from the interviews. The interviews were repeated with students and with supervisors throughout the life of the PhD, during which the participants were invited to develop the ideas presented in their maps (Figure 2). This process has generated a large volume of data, although space permits the representation of only three concept maps from the total of 123 unique maps, collected over 88 interviews during the four years of the study.

The goal of this approach is to provide rich descriptions of the beliefs and understanding of the participants in a particular context. This is to be expressed in participants’ own language, representing their world view rather than a researcher’s conceptualisation of participants’ personal constructs. This is not intended to contribute to the bureaucratisation of the supervisor-student relationship (Cribb & Gewirtz, 2006), but as a tool to help supervisors to engage with the conceptual framework for the thesis.

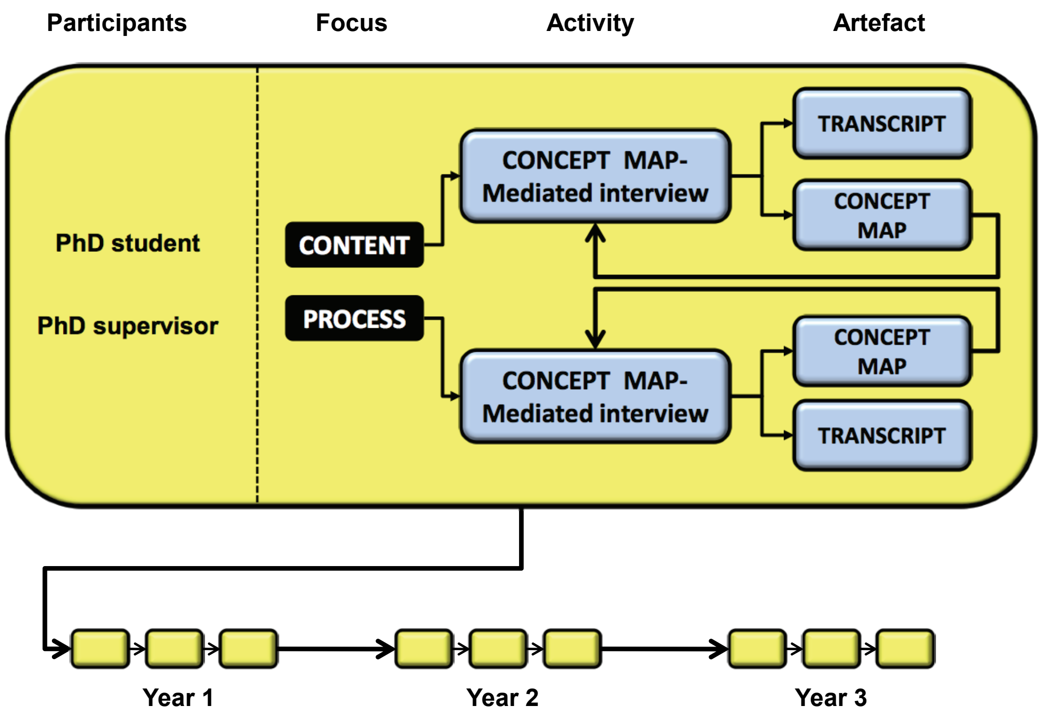

Figure 2. Graphical summary of the research process

3 Results

The concept maps revealed that the supervisors and students held different perceptions of both the content of the PhD and the process of doctoral study (Kandiko & Kinchin, 2012). The supervisors saw each student’s PhD as part of a bigger picture, both in relation to their own work and to specific area of study. The supervisors tended to view doctoral study as a process rather than as a product. The students were more focused on their own studies than on the discipline as a whole, and were very product (thesis) oriented – represented as a linear pathway that has an observable end point. An example is seen in a student's map of the process of a PhD (see Figure 3). Although the approach is linear and leads to publishing and a degree, the content, seen in the third row in the map, all relates to learning.

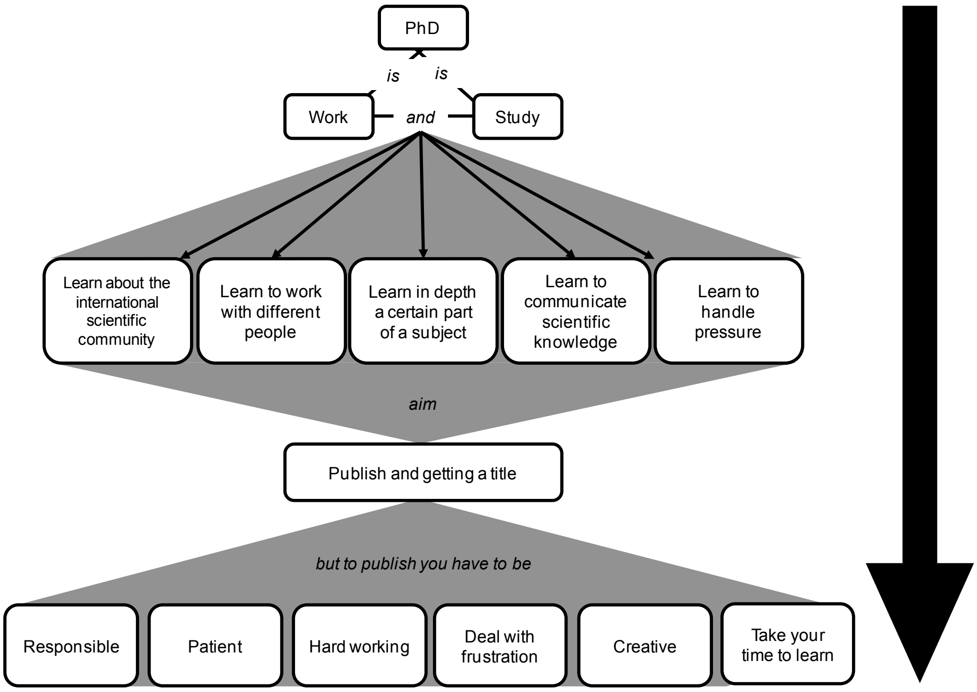

Figure 3. Student map of the process of a PhD

A contrast is seen in a different supervisor's map about the process of a PhD (see Figure 4). This map takes on a 'matrix' structure, which differs from the linear, spoke or cyclic models. The four sets of concepts that run horizontally are structured roughly as a chain, but interrelate with the other concepts. There is also a nascent cycle connecting the fourth concept back to the first one. The four concepts that run vertically are concepts that represent actions and learning the student 'should' do. The matrix design in the middle of the map is specific, meaning that not all concepts link to one another, although there is generic use of linking words ('in order to' and 'feed into'). The matrix map does not represent hierarchy. There is no sense of differing importance amongst the concepts, particularly the four that run vertically along the left of the map. Overall the matrix functions as more than a combined linear set of chains, but does not describe cycles of learning and development.

Another supervisor map on the process of a PhD (see Figure 5) is further indication that in the complex environment of doctoral education; there can be many 'sets' of conceptual frameworks or understandings. Moving from the upper left-hand side diagonally into the centre of the map is a rough chain of concepts. This leads to the 'cyclic' structure in the bottom right, which the supervisor saw the student being 'stuck in' for some time. This then led into another cycle, seen in the bottom left. This indicates a 'bottleneck' where the student feels like the experiments have reached a dead-end and that their thesis is ruined. Similar patterns of behaviour often emerged for students a few months after the mid-point of the PhD, when suddenly the final thesis deadline seems to be looming. This cycle (in grey) leads to the third cycle, seen in the upper right. These cycles represent combinations of trial and error, the development and refinement of the scientific process and progression within a complex learning environment.

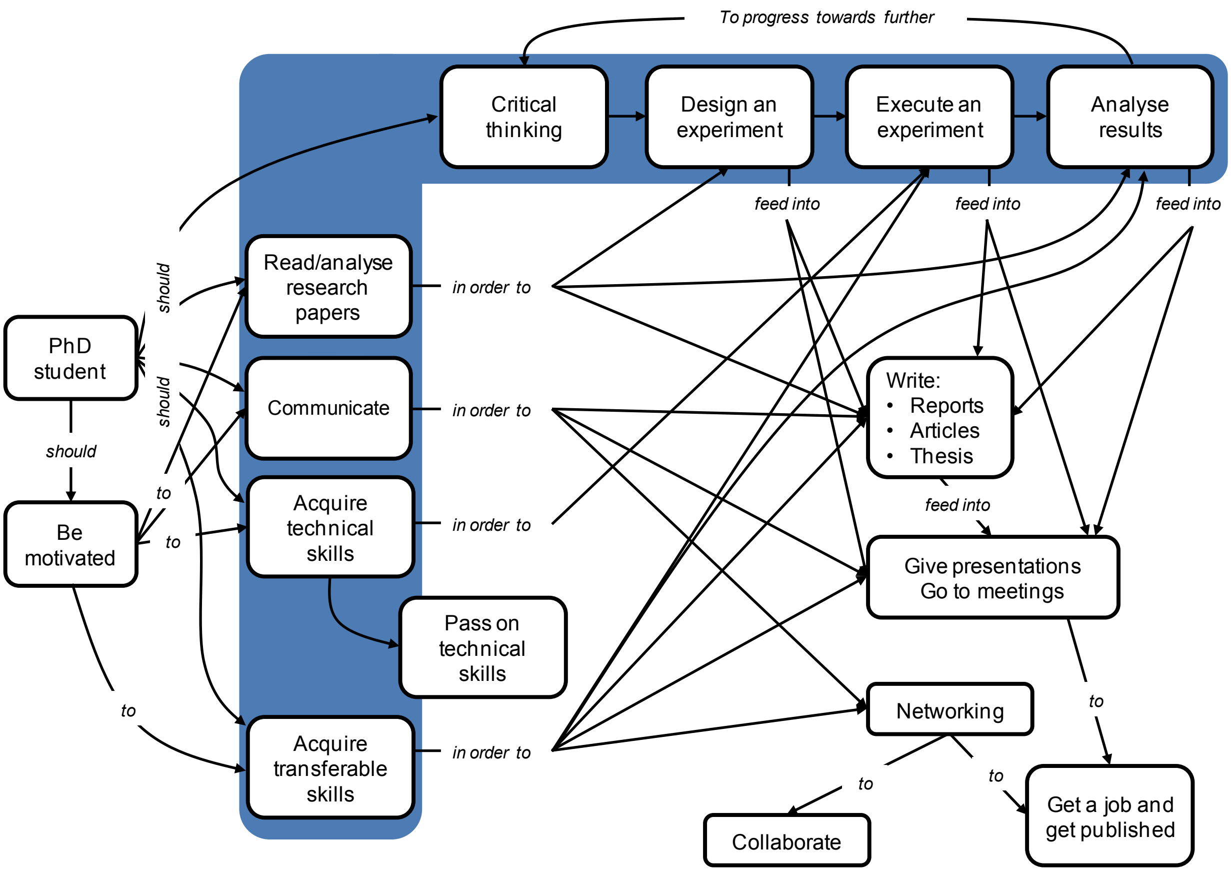

Figure 4. Supervisor map of the process of a PhD

The messiness of the map in Figure 5 may be taken as an indication that the map is acting as a 'trading ground for ideas' or an 'arena for rehearsal of understanding' rather than a record of learning that has been completed. This further reinforces the notion that supervisors focus more on the PhD as a process of learning, compared with the student concentration on the product (Kandiko & Kinchin, 2012). In the maps presented, it may be the case that students are trying to 'make sense' and use the maps as an organising tool, whereas the supervisors have the big picture of the research in their minds and can use the maps to 'trace the journey' on how to get there. The arrows for the students point to the 'end goal' of the completed thesis, whereas the supervisors' arrows show the cyclical and multiple pathways that are an inherent part of the research process.

4 Discussion

The multiple conceptual structures that exist within the maps can make them difficult to understand, particularly without the wider context of the PhD. However, following the arrows within the structures presented can be seen as indications of learning pathways. The importance of the arrows can be seen within the linear and hierarchical structures; linear chains may be seen as irreversible (one-way) systems, unlike network and cyclical structures. So for example, in dentistry, the clinical procedure (linear chain) may be seen as irreversible; e.g. once a hole has been drilled in a tooth, it cannot be "undrilled". Similarly in teaching, once a classroom activity has occurred, it cannot "un-occur". Whereas the network of understanding has multiple routes through the concepts which can be revisited and revised in such a way that it does not have such an evident pre-conceived end point.

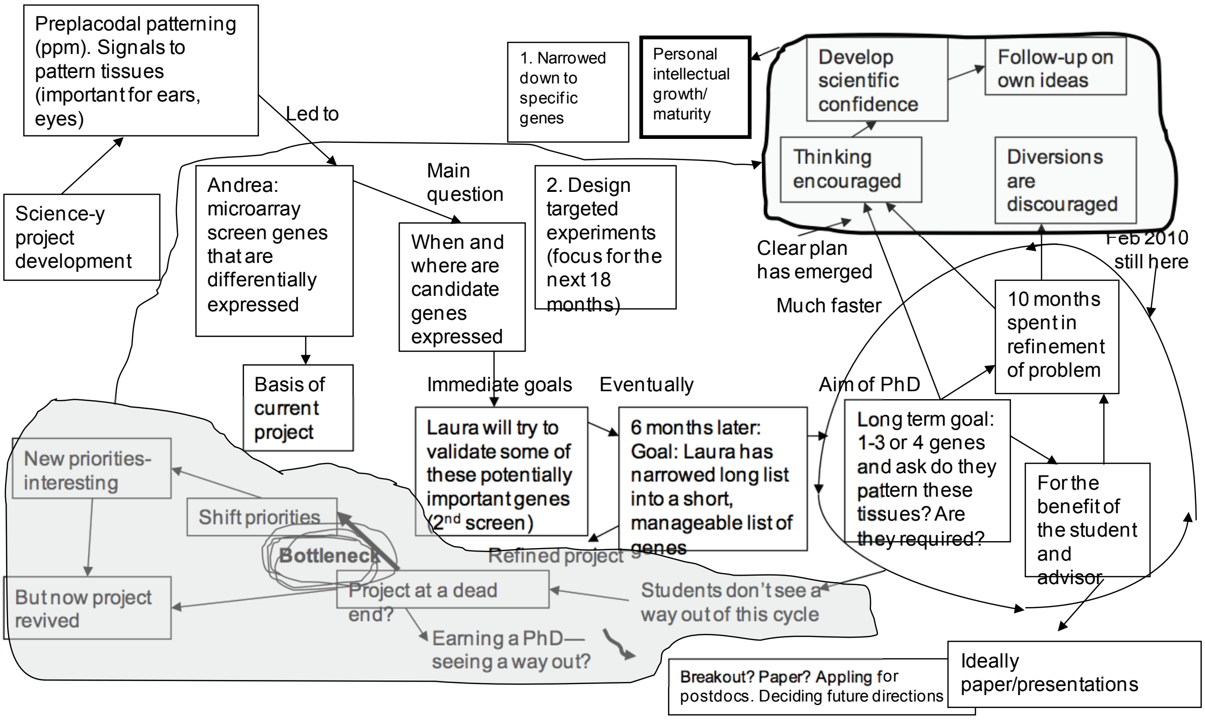

Figure 5. Supervisor map of the process of a PhD

What we can see emerging are 'knowledge structures', or learning activities, which make up the conception of the process of the PhD. Three of these have been developed in the work of Kinchin et al (2000), depicted in Figure 6, as spokes (A), chains (B) and networks (C). Building on the work of Safayeni et al (2005) and Kinchin (2011), we have also added the cyclic model, describing the notion that the concepts develop and influence one another. We are further adding the matrix structure (E), which is characterised by the supervisor map in Figure 4. This structure contains elements from the other four structures described, but appears to function in a different way.

A key difference between spokes and chains on one side and networks, cycles and matrices on the other is the notion of reversibility. In the former, once a step has been taken, there is no 'revisiting' the learning process. The student must carry on to the next step, or the supervisor must move on to the next point. In the case of the latter, cycles and repetitions develop dynamically, allowing for concepts and processes to be revisited. This is where the direction of the arrows is important, which allows one to follow a chain, enter into a network or cycle, or become enmeshed in a matrix. These can be revisited a number of times, in similar or changing pathways.

We argue that the major matrix intersections and cyclical formations are indications of thresholds, either of concepts or processes. These cycles, or interstices, represent continuous, but developing, learning processes. This follows in the tradition of the Hegelian dialectic, often depicted as an upward spiral of cycles of thesis, antithesis, synthesis and thesis again. This notion is depicted in Figure 7, which shows a conceptual structure, which through repeated cycles of rehearsal leads to greater conceptual development and sublation of previous understanding.

These developments extend the traditional notions of traditional concept mapping when using it in higher-level learning. This reiterates the need for the holistic assessment of concept maps in higher education settings (Kandiko, Hay and Weller, 2012). For advanced higher education, postgraduate education and research-based work, it is not only the development of concepts or the links between them, but also the broader knowledge structures that are formed. Although the participants in the study were briefed on concept mapping, many of the maps that developed strayed from traditional Novakian concept maps. This can be seen particularly in Figure 5. The structure and style of the maps may in fact more closely relate to the 'messy' and developing nature of the thesis and the process which eventually leads to the final product. Although a final map of the thesis, reflecting back from the position of the final product, may resemble traditional concepts maps, the maps represented here reflect the dynamic process of learning and development within the setting of advanced doctoral education.

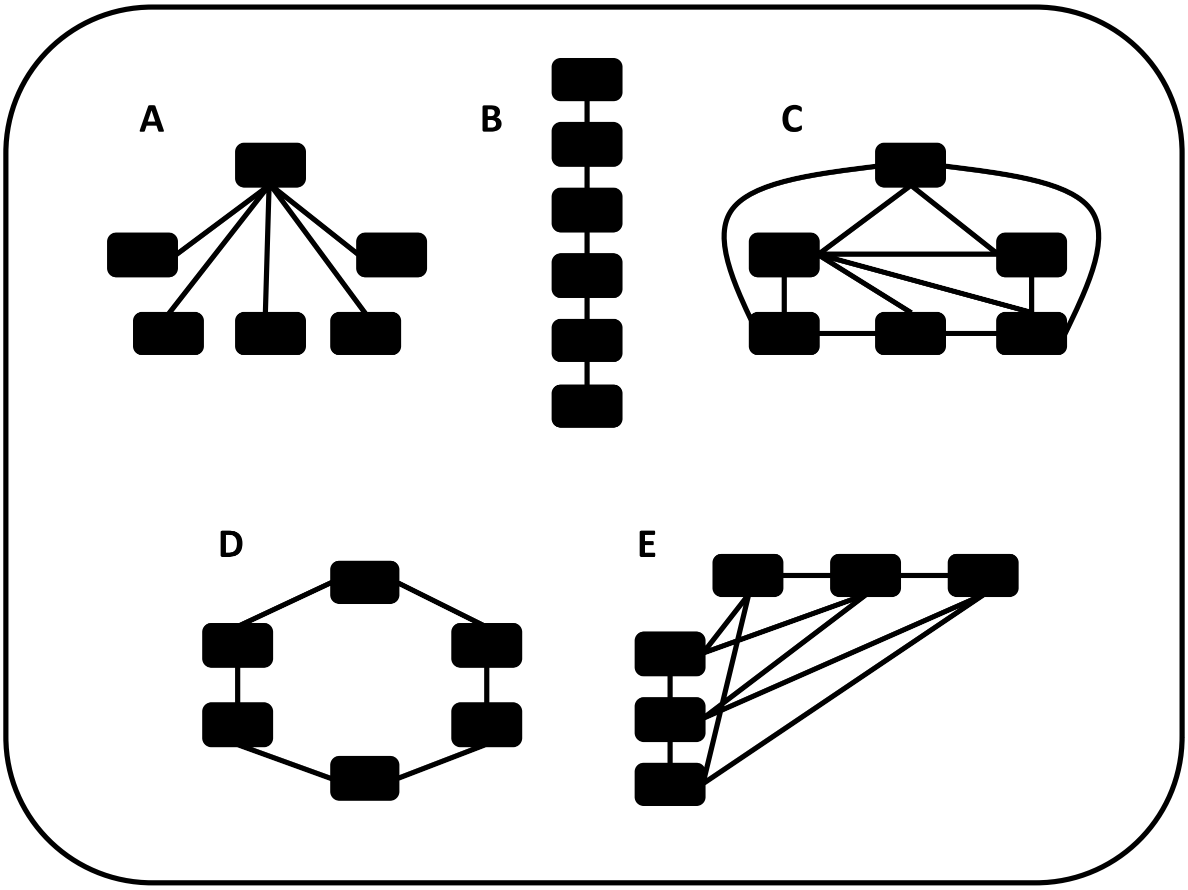

Figure 6. An expanded typology of conceptual structures, A: Spoke; B: Chain, C: Network; D: Cyclical; E: Matrix

5 Summary

In this study, concept mapping revealed more than interviews and transcripts alone. The content and the structure of the maps produced were indicative of the divide in understanding between students and supervisors, even when they appear to be talking about the same topic and using the same terms. The process of map production is seen as a useful addition to the doctoral supervision process. The cyclic processes that are illustrated by the supervisors indicate their appreciation of the changing nature of understanding and the necessity for repeated interaction with the material being studied. The cycles of learning that are described can be used as a tool within the supervisory process, which often represent the dominant method of learning, development and discovery in the discipline. In concept maps from the humanities, the cycles described are referenced to drafts, feedback, edits, and redrafts of essays and chapters.

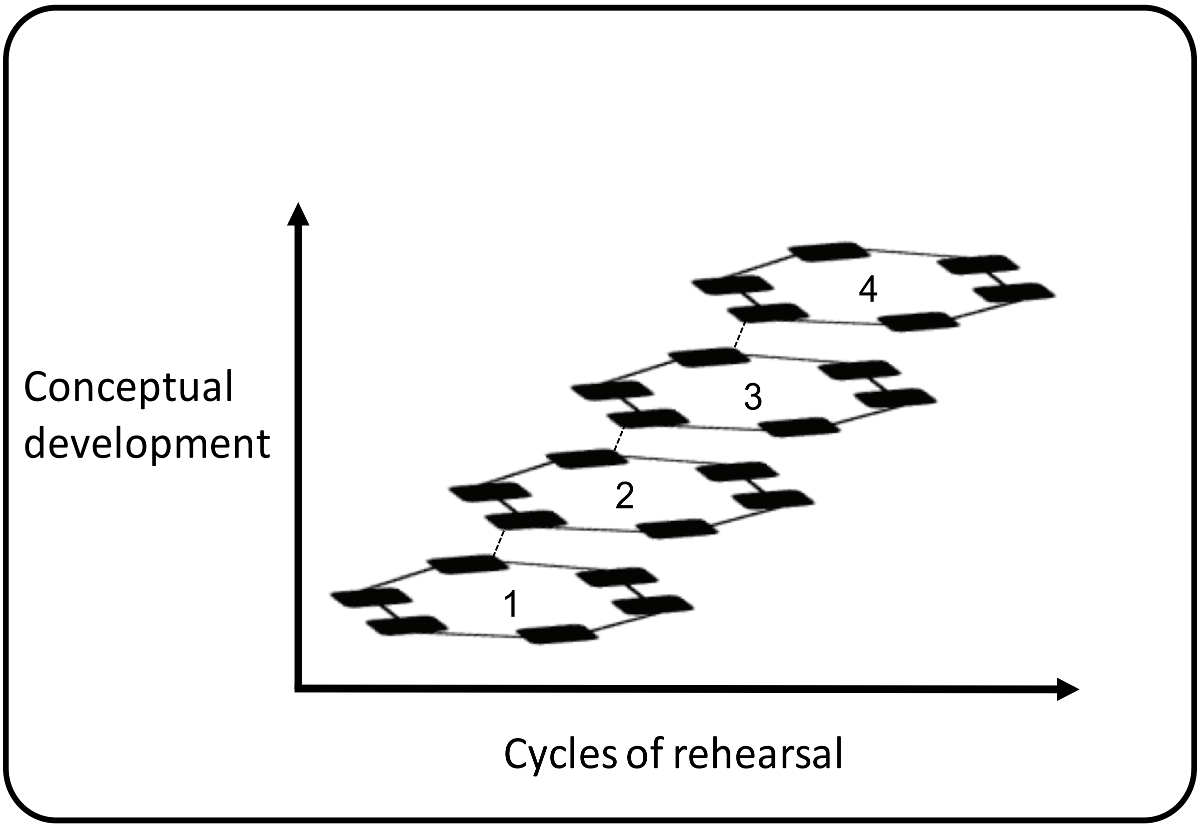

Figure 7. Repeated cycles of conceptual development

Concept maps can be used by students and supervisors as pedagogical tools, as points of departure for conversation and dialogue, and as physical representations of conceptual understandings. Such maps can also function as synopses of a student's developing thesis, which can be useful when sharing the work outside of the supervisory relationship, at a conference or with a lab-group, for example. Supervisors can investigate common 'threshold areas' and develop strategies to help students progress, particularly for when students are stuck in the 'bottlenecks' and may not see the process as one of repeated cycles of rehearsal and advancing conceptual development.

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Index