AN AUTHORING CONCEPT MAPPING KIT FOR THE EARLY CHILDHOOD CLASSROOM

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Abstract. This paper presents an Authoring Concept Mapping Kit that enables preschool children to verbally add meaning to symbolic representations. Building on the prior knowledge and strengths of the users, children and teachers, the Kit is comprised of tangible materials familiar to the early childhood classroom, with the addition of low cost, hand-sized, voice-input devices. Preschool teachers encourage their students to concept map with symbols as a way to overcome illiteracy. However in practice unlabeled symbols allow room for map misinterpretations, concepts cannot be distinguished from propositions, abstract concepts cannot be introduced, and linking phrases cannot be inserted. Testing outcomes from a pilot study performed in an urban Australian preschool with 4-to-5 year olds demonstrates the Kit effectively addresses these problems.

1   Introduction

This paper presents the research for, development of, and the results of a pilot test of an Authoring Concept Mapping Kit (the Kit) for the Early Childhood (EC) classroom. Developed using child-centered design methodologies the Kit is a knowledge representation tool that responds to the needs of teachers and children in the classroom. Nine 4-to-5 year olds from an Australian urban preschool were observed while they used the Kit during free-play time and the performance of one of those children, a 5.6-year old, is discussed. Due to the school's operating philosophy, it was not possible to test children's ability to concept map, as defined in Novak's literature. Therefore their ability to independently make knowledge explicit with the Kit was tested instead. The results of the study showed the children were able to 1) label symbolic representations verbally for disclosing conceptual and propositional meanings, 2) manipulate concepts to show reading direction, and 3) display autonomous behavior. An unexpected outcome of the pilot was the high engagement levels three of the nine children presented while interacting with the Kit. They spent more than an hour in the overall activity, which included picture reading, discussion, and knowledge representation. This result may have implications for the long-term success of the Kit as an educational tool.

2   Background: The Kit as Part of a Doctoral Study

Novak (1998) states that concepts can be labeled with words as well as symbols such as %, +, etc. Also Novak and Wandersee state that young children may quickly learn how to make good concept maps since they haven't yet been exposed to years of rote-learning (1990 in Novak, 1998: 31). These authors theorized, but have neither researched children's use of symbols when labeling concepts, nor their ability at concept map making. However, for more than a decade, growing communities of experts within Early Childhood (EC) have been exploring strategies and adaptations for children to concept map with symbols. Novak and Wandersee's claims and the underlying constructionist theories of this knowledge representation tool are the driving forces behind their interest. In addition the experts also believe concept maps can help the development of young children's learning-how-to-learn skills (Figuereido et al., 2004; Mancinelli et al*.,* 2004; Perez Cabani *et al.,* 1992) and that could be more powerful than clinical interviews and drawings in disclosing children's knowledge (Mancinelli et al., 2004). My doctoral study involves the investigation of the development of an age-appropriate concept mapping tool that may allow for the testing of such claims.

While most researchers within this area have an educational or psychology background, a design perspective underpins the outcomes of this research. I argue that the Design discipline provides an alternate way of approaching the issue as well as constructing possible solutions. My approach has been informed by an analysis of current concept mapping practices in the EC classroom, the learning goals articulated by the teachers, and the tools currently used to achieve those goals. I then compared that analysis with the underlying theory of concept maps. The overlaps and gaps found led to a design method for introducing concept mapping into the classroom. The method is informed by user-centered, and inclusive design philosophies as articulated by Keates and Clarkson (2003) and Norman

(1999). I take up the position that by knowing your users, by understanding their environments and true needs, it is possible to design learning tools that will empower them.

My analysis of the reports of Figuereido et al., (2004), FOD (2004), Merida (2001-2002) and others uncovered the functional curriculums and the children's developing cognitive and literacy skills as major barriers impeding the systematic use of concept maps in the EC classroom. From this I claim that by solving the literacy barrier it will be possible to effectively investigate the developmental ones. Due to illiteracy preschoolers are unable to add meaning to symbolic representations as well as create, and manipulate abstract concept words autonomously. The Kit offers solutions to these problems by enabling concept labeling with voice-input, and too, is pivotal to the investigation and testing of the claim. While I do not argue that it is the answer to how we make concept mapping available to preliterate children, I do argue that it offers a starting point, a way of be able to undertake further research into the kind of concept mapping tools and strategies that are appropriate for use at this level.

3   From Symbol-based Maps to Concept Maps: How to Make the Leap

To overcome barriers presented by children's illiteracy and other developmental limitations, teachers have developed playful metaphors and representation tools that allow their young students to represent meanings in the form of simple symbol-based concept maps (see for example Badilla, 2004; Figuereido et al., 2004; Merida 2002; Mancinelli et al., 2004; Perez Cabani et al., 1992). Their objective appears to be the stimulation of children's critical thinking skills as well as the social interactions among peers. Symbols in the form of drawings, toys, and woolen threads are used to represent concepts or conceptual relationships. The connecting lines are maintained but the linking phrases are not introduced, as it is difficult to represent with visuals. The goal is to make the map-making process hands-on and meaningful to them by incorporating familiar languages (Badilla, 2004; Figuereido et al., 2004; Merida 2002; Mancinelli et al., 2004; Perez Cabani et al., 1992). While such approaches have shown to be of educational value, they do not conform to Novak's definition of concept maps and, as such, raise new problems. Unlabeled symbols 1) allow for map misinterpretations, 2) prevent the introduction of abstract concepts, and 3) do not accommodate the insertion of linking phrases.

Novak (1984) claims that the power of concept maps relies on the template elements, which means that the absence of any one of the elements affects the mapping process and the later interpretation of it. He also claims that the linking phrases in the map are what make his technique a meaningful learning activity. This is based on the understanding that people are able to see the linking phrases to interpret how the concepts within the map are related to each other. Meaning negotiation and representation of organized knowledge, which are concept maps key characteristics, depend heavily on these components. Yet if we agree with Novak's logic then the absence of linking phrases and/or concepts means that there is no way of accessing the level of the children's understanding. Finally, if we accept that the gap produced by the use of symbols lies in that impossibility, then a tool that enable children to add concepts and linking phrases with spoken language may provide a way forward. Since preschool children communicate what they know with visual and spoken language.

It can be understood from the preceding argument that the absence of written words limits knowledge externalization and what can be represented or discussed during the mapping process. Merida (2002) and Perez Cabani et al. (1992), who have investigated the problem, argue that is not really the resulting map that is important, but what the mapping process involves: meaning negotiation, collaboration, and training of critical thinking skills such as clustering, hierarchy. While their reasoning is not rejected, this paper does argue that such experiences can be made much richer and more effective if the mapping tools employed provide components that facilitate autonomous behavior and knowledge "explicitation" or in other words make the representation process explicit. I would argue that as children become autonomous map-creators, abstract content can be introduced, and as a consequence of this, a broadening of the content of areas under study becomes possible.

4   Design Characteristics of the Kit

Symbol-based maps support the development of clustering skills and hierarchy (Perez Cabani et al., 1992). But for reaching the three conditions of meaningful autonomous learning - language relatable to the learner, ability to access prior knowledge, and wanting to learn (Ausubel, 1968 in Novak, 1998), the current teacher tools for concept

mapping need re-designing to give full ownership of the authoring to the child. For this reason the Kit was developed to support children at concept labelling by enabling the use of multiliteracy (verbal, symbolic and/or emergent writing skills). It is comprised of concrete materials familiar to the preschool setting, such as magnetic and Velcro strips, markers, pens, colour pencils, construction paper, a write-and-wipe magnetic board, and incorporates voice chip recorders. These are low cost, hand-sized voice-input devices that can be recorded onto and played back many times. Figure 1 shows images of the components.

The Kit:

• *Brings autonomy to the children's mapping process* as it allows room for self-idea exploration, which in turn, may increase intrinsic motivation. It is widely known that good authoring tools require minimum teacher assistance in the making process, but lots of facilitation in the understanding of the topics and overall activity performance.

Figure 1. The Authoring Concept Mapping Kit

• The voice-recorders *make the children's knowledge explicit* by allowing them to verbally add meaning to symbolic representations, include abstract concepts and linking phrase. In current concept mapping practices, for disclosing meaning of images, teachers interview the children (Figuereido et al., 2004; Merida, 2002; Mancinelli et al., 2004) and most times annotate their maps with the answers given (Merida 2002; Mancinelli et al., 2004). With the Kit teachers neither require interviewing the children nor annotating the maps for the purpose of disclosing drawing meaning.

• *May facilitate teacher instruction* by providing them with resources adaptable to different mapping situations. It aims at enabling the teacher to diversify the range of strategies and the themes to explain concept maps or other mapping techniques to the children. The proposed design is open-ended and flexible. It is expected that the children and teachers add their own signature and ideas to improve the making process.

• *Facilitates sharing, manipulation, and preservation* because the pieces are easy shareable, removable and replaceable. The children can draw on the board; use post-it or construction paper of any kind. Connections can be either represented with a marker or the arrows provided. The magnetic board size delimitates space for mapping and the elements placed on it can be modified and revisited as desired. Whatever is produced during the session can be kept until next session or for as long as teachers and children want to keep it. The Kit materials make an abstract process less abstract. By making it look like a manipulative, we attempted giving the illusion that the concepts can be grasped and touched.

• Equips children with materials that not only speed up the mapping process but also *supports their developing cognitive and motor skills*. Some of the developing skills identified are limited memory retention (short attention span), conceptual development and self-regulation. Knowing-how to use the Kit responds to such limitations and

is facilitated by the familiarity of the components; therefore the tool learning curve is low as the children can explore the different parts.

5   Pilot Field Study

Nine children, from an Australian urban preschool, aged 4 to 5 were observed in their natural setting. While I worked with the whole class, 25 children in total, I am only permitted to report on 9 of these. The children interacted with the Kit during free-choice playtime for 6 sessions of 1½ hour each. The research was seeking to identify if (and to what extent) children could independently make knowledge explicit. The knowledge was to be made explicit using the Kit by labeling symbolic representations with the voice-recorders and showing reading direction with the arrows. Labeled symbols helped to distinguish concepts from propositions, identify abstract concepts, and what relationships were formed between concepts using linking phrases. All of these elements in sequence will allow the teacher or researcher to interpret the concept map.

Figure 2. (a) Working on the conceptual relationship "the egg is in the stomach. (b) Working on the concept "egg".

The teacher/director of the school facilitated the interactions, gave me suggestions on how to work with the children and information about their background, but did not intervene in the process. Experiential learning is her teaching approach: based on the children's needs and interests, identified through observation, she presents the children with tools that will stimulate and promote their learning. Concept maps had not been of interest to her, as she saw them as being contrary to her teaching philosophy: she did not believe in telling children how-to-do things, rather she preferred them to explore their world. However she was interested in observing how the children would interpret the Kit. Because of this situation, the inexperience of the facilitator (paper author) in Early Childhood methodologies and lack of familiarity with the students' background, the children were neither instructed on Novak concept maps nor assessed on concept acquisition. The methods approved for data collection were participant observation, audio recording of the sessions, photography of the working process and the children's work, plus anecdotal notes.

In each of the 6 sessions different strategies were trialed for engaging children in concept mapping. Four out of the six sessions they were invited to perform a concept mapping foundational activities such as proposition and two-level map making. Their performance was poor, possibly due to the inexperience of the facilitator and the heavily directed character of the interactions with which they were unfamiliar. However by contrast, in session 2 and 5, the children responded positively to the material presented, maybe because it encouraged independent behavior, and built on their prior knowledge and interests. A brief summary of session 2 is presented together with transcripts of the knowledge representation activity - KRA of a 5.6-year old. This is the only child I can report on here, as the other two children were not approved to participate in the study.

In session 2, three children agreed to play. The facilitator invited them to read and discuss the pictures of the illustrated book *The Egg* (Mettler et al., 1990), and to use the Kit (or The Thing as the children named it) to make a

story of what they remembered from the reading. The book was chosen based on the children's interest and prior knowledge. The session was structured in three stages: reading and discussion (group activities) and KRA (individual activity). The facilitator paced the interactions, stimulated discussion, prompted questions, demonstrated how to make a story with paper cards, the voice-recorders, the arrows, and provided direct support in the making at children's request only. Each child was to place on the magnetic board self-created, voice-labeled symbols representing ideas from the book and use the magnetized arrows to show reading orientation.

The 5.6-year old engaged in the activity for 77.3 minutes (reading: 21.9, discussion: 10.3, KRA: 45.4 minutes). During KRA, the child worked independently during the session; asked questions; created symbols and voice-recorded meanings in the form of concepts (egg, the egg) and conceptual relationships (the egg is wet, the egg is dry, etc); and connected the concepts and/or propositions (formed by symbols attached to recorded voice-recorders) with arrows to show reading orientation. See figure 3 for completed story in map form. The following transcript excerpts give example of just described. Al and Glo are the aliases for the child and the facilitator respectively, [undisclosed] appears when the dialogue involves children out of the study and [inaudible] when the audio is unclear. Vrec is the abbreviation for voice-recorder.

Al is voice-recording by herself, first try

48.7min	Al:	*the egg is in the chicken's tummy!* [Voice-recording]
	Al:	*the egg is in the chicken's tummy!* [Voice-recording]
	Glo:	*[undisclosed]*
	Al:	*It's just saying the egg, the egg, it's just saying the egg*
	Glo:	*You said the egg*
	Al:	*No, I said the egg in the tummy [inaudible] says the egg*
	Glo:	*Say it again until you have it right* [meaning to try voice-recording again]
	Al:	*[inaudible]*
	Al:	*I said it [inaudible] times*
	Glo:	*Do it again until you have what you want* [motivating the child to continue trying]

From 49.4min to 52.7min the facilitator is working with two other children while Al is labeling (voice-recording) her drawings independently. She does not ask questions or request for help. In the background, the facilitator can also hear Al pushing, playing back the voice-recorder to disclose the sequence arrangement.

49.4min	Al:	*the egg is in the stomach* [voice-recording]
	Al:	*the egg is in the stomach* [voice-recording]
	Vrec:	*the egg is in the stomach* [playing back what's been voice-recorded]
	Glo:	*[undisclosed]*
	Glo:	*[undisclosed]*
	Al:	*eggs are cracking* [voice-recording a new idea]
	Vrec:	*eggs are cracking* [playing back what's been voice-recorded*]*

52.7min	Vrec:	*Egg*
	Vrec:	*The egg is in the stomach*
52.9min	vrec:	*The eggs are cracking*

The facilitator checked on Al: together revisited what has been recorded so far.

53.3min	Glo:	*How are you doing? Al, how is it going?*
	Al:	*I already did [inaudible]*
	Glo:	*You already did and how is the story going there?*
	Al:	*[inaudible]*
	Vrec:	*egg*
	Glo:	*how the story goes?*
	Al:	*"egg", "the egg is in the stomach", "the eggs are cracking"*
	Glo:	*So, the egg is in the stomach and the eggs are cracking? [Inaudible] that's a very good one!*

From 56.2min to 66.9min Al continues working independently. Again in the background from 63.3 min to 66.9 the facilitator can hear her voice recordings playing back as she pushes them.

63.3min Al: *the chicken is dry* [voice-recording*]*
64.7min Al: *the chicken is wet* [voice-recording]
64.8min Al: *the chicken is wet* [trying to voice-record again]
65.0min Al: *the chicken is wet* [trying to voice-record again]
66.2min Al: *egg* [voice-recording]
66.9min Al: *a [inaudible] with watery stuff that used to be inside the egg*

Al requests for arrows

69.5min Al: *I need those pointy things*
    Glo: *You need a pointy… what do you need? A pen? Tell me sweetie… Ah! Pointy things. How many?*
        [She was meaning arrows]
    Glo: *[undisclosed]*
    Glo: *You need how many?*
    Al: *Three*
    Glo: *Three*
    Al: *Actually, umm*
70.7   *Glo:*   *Remember, Al, that you are making a sort of a story that other people can understand what are you saying*
    Glo: *Is that enough?* [Referring to the arrows]
    Al: *I made three stories* [meaning three propositions]
    Glo: *That's very good*

[Facilitator continue working with other children]
*71.4min Al:*   *I made all these ones*

[Facilitator continue working with other children]
71.8min Al: *I'll do the whole. I'll do my my little story. I want to read my little story*
    Glo: *I am gonna do this* [meaning finish something] *and then you can tell me your story*

6   Conclusions

This mapping experience indicated that the child was able to undertake concept representation, organization and manipulation. After been demonstrated how to use the Kit, the 5.6-year old could autonomously made conceptual knowledge explicit: added meaning to symbols and linking phrases as part of the conceptual relationship formed; could represent abstract concepts; and changed symbol labels during the process (e.g. replaced *the egg is in the chicken's tummy*, with *the egg is in the stomach*). In figure 2(a) the child has a sequence arrangement *egg-→ the eggs are cracking -→ the eggs is in the stomach*. In figure 2(b) she has changed the order to *egg -→ the egg is in the stomach -→ the eggs are cracking*. This is an example of autonomous knowledge organization.

Overall, the results are positive in regard to preschool children's ability to undertake autonomous knowledge representation processes and the facilitative possibilities that this assistive tool offers to that process. As a broad conclusion, the Kit itself has been designed and tested and it is ready to be applied in any EC classroom. Now preliterate children can have easy access to a tool that makes them the owners of their knowledge "explicitation" productions. Its usefulness in terms of teaching is that teachers, by evaluating these productions, may be able to make a judgment in regard to conceptions and misconceptions of the children. An unexpected outcome was the children's level of engagement. Al worked on the activity for 77.3 minutes and spent more than 45 minutes working individually during KRA. The two children from session 5 also spent 66.5 minutes in the whole activity and 44 minutes on their individual KRAs. These values are even more impressive if we consider that all was performed during free-play time.
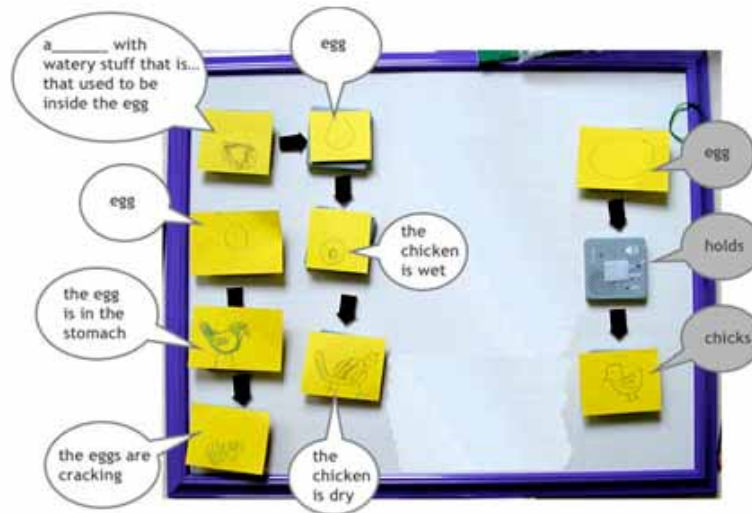
Figure 3.   (Left board side) the 5.6-year old story in map form, (Right board side) the sample proposition done by the facilitator

Open-ended tools that enhance hands-on experiences are understood in this context, and relate to the theory of child development and strategies for stimulating thinking. The Kit is sufficiently intriguing and attractive that teachers who have been exposed to it want to try it, even though concept mapping as a learning strategy is still not employed in Australian preschools. Work needs to be done to convince Australian teachers of the benefit of such an approach. Conversations with the teacher involved in this research suggest that the use of voice-input devices might be of benefit in classroom learning/activities currently being used. As well teachers present at the author's talk at the Children of the New Millennium Conference (Gomez, 2005) showed a great deal of interest. For those countries and teachers in the rest of the world who are using concept mapping, this research has produced a tool that might help overcoming one of the most significant barriers preventing the use of concept mapping in EC settings, that of children being able to make symbols explicit, include linking phrases, and abstract concepts autonomously.

We do not know yet if the Kit facilitates concept mapping instruction as concept mapping was not introduced in this test. Moreover it was not a goal of this study to show that the ability to verbally add meanings to symbols will solve all the problems surrounding this strategy in the EC classroom. By adding verbalization via voice-input to the knowledge representation process, we are turning the discussion to more fundamental questions such as: what strategies are appropriate to introduce children to proposition making or the understanding of connections? The problems for concept mapping in preschool are beyond the representational disadvantages presented. However thinking, developing and testing prototypes similarly to the Kit described in this paper is a useful way to stimulate productive discussions that lead to the implementation of educationally sound and effective concept mapping tools for this age group.

7   Future Work

The results indicate that the Kit could be adapted to any EC classroom. Recently I have undertaken a follow-up study at a US university-based kindergarten classroom with teachers familiar with the children's needs. Discussion of this study is beyond the scope of this paper, however to view two resulting maps visit http://www.gloriagomez.com/BigCats-Tigers.swf and http://www.gloriagomez.com/BigCats-Leopards.swf. Future work will involve a two-month pilot study in the same US-university setting, working in a multi-disciplinary team, where we will teach children to concept map.

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