CONCEPT MAPPING AND UNIVERSAL DESIGN FOR LEARNING: MEETING THE NEEDS OF LEARNER VARIABILITY IN EDUCATIONAL ENVIRONMENTS

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Abstract. Fashioned through the work of Joseph Novak's original theory of meaningful learning which states "meaningful learning must underlie the constructive integration of thinking, feeling and acting if learners are to be successful and achieve a sense of empowerment" (Novak, 2010:132), this paper is based on the assumption that learning is very complex involving cognitive processes, conative and affective factors. Furthermore, through research and principles related to the Universal Design for Learning (UDL) framework for meeting the needs of learner variability by designing flexible learning environments (Rose and Meyer, 2000a; Rose and Meyer, 2000b; Rose and Meyer, 2002), this study reinforces Novak's original theory underlying Concept Maps and will discuss that the use of Concept Maps as not limited only to cognition, but involving other important, underlying mental processes such as conation and affectation. Consequently, Concept Mapping is a robust tool, which responds effectively to the learner variability present in classrooms to yield meaningful learning.
Keywords: Concept Map, Universal Design for learning, Meaningful Learning

1 Introduction

The field of education is constantly evolving and we are at a pivotal point of change in the twenty-first century. The learning sciences have demonstrated a need for more flexible learning environments that provide versatility in how learners learn and educators teach to account for variability among learners. As the landscape and goals of education are shifting, so too is the approach to teaching diverse student populations. One way to achieve the flexibility that is needed to provide access for all learners to curriculum is through Universal Design for Learning (UDL). UDL is a pedagogical philosophy that is rooted in modern advances in understanding how the learning brain works. Rather than adapting or changing learners to best fit curriculum (curriculum as defined by: goals, materials, methods, and assessments), UDL focuses on how to build flexible learning environments that prioritize access for all, from the point of design, rather than as an afterthought (Rose & Meyer, 2000a; Rose & Meyer, 2000b; Rose & Meyer 2002; Meyer, Rose & Gordon, 2014). One way to build a flexible learning environment is through the use of Concept Mapping (Novak, 2010) as a tool to respond effectively to learner variability. When Concept Mapping is used to activate prior knowledge and to allow for learners to engage in their learning process by starting from what they know rather than from where the teacher dictates, Concept Mapping provides a more flexible and customizable approach to learning. This notion of fostering engagement in learning is a core component of UDL that functions as a way to address learner variability. From a UDL perspective, thinking and learning are considered to be dynamic interactions of both emotion and cognition (Meyer, Rose, and Gordon, 2014).

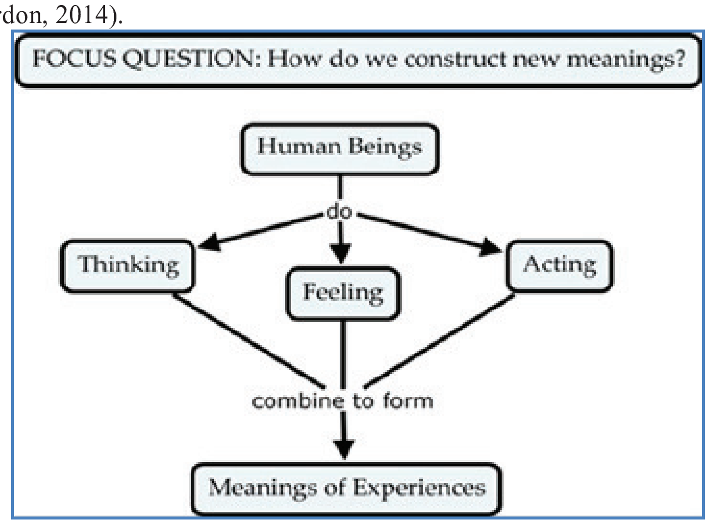

Figure 1: The meanings we construct from our experiences are a composite of our thinking, feeling and acting during the experience. (Novak, 2010:14)

Fashioned through the work of Joseph Novak’s original theory of meaningful learning (Novak, 2010; Figure 1), this paper is based on the assumption that learning is very complex and involves cognitive processes, conative and affective factors. Furthermore, through research and principles of Universal Design for Learning (UDL), this study will reinforce Novak’s original theory underlying Concept Maps and will discuss that the use of Concept Maps as not limited only to cognition but as involving other important underlying mental processes such as conation and affectation. Consequently, Concept Mapping is a tool that responds effectively to the variability of learners present in classrooms, with a view to yielding meaningful learning.

2 Learner Variability

Learner variability may present itself in the form of various factors such as differing thoughts, feelings, and ways of performing (Matthews et al, 2000). For instance, Brain (2000) suggests that while some incoming information is selected for attention, other information may be neglected. Brain’s work on how information is received is built upon both Broadbent (1958) and Treisman’s (1964) models, which show that information enters the senses through a ‘sensory buffer’ where the information is selectively filtered. This selectivity view is also presented in Sousa’s (2006) model. The way in which an individual perceives a situation can differ based on a number of variables that can shift or change the point of initiation for that experience. Affective responses to experiences can physiologically change a learner’s performance (Immordino-Yang & Damasio, 2007) and these perceptions are considered as initial points of engagement or disengagement for learning (Meyer, Rose & Gordon, 2014) that can skew a learning experience even before it occurs.

Many theories of learning further distill the emotional and cognitive influences on learning. For instance, Dweck & Masters (2008), Brophy (2010) and Forsten et al (2006), reveal how learners can interpret and respond differently to learning experiences in the face of challenge. The appraisal of a situation will determine how learners feel about a situation, that may impact their performance. Marshall Shelton & Stern (2004) also suggest that having teachers who are attuned to understanding feelings, referred to as “emotional information,” would increase the effectiveness of teaching and student learning. Other authors such as Matthews et al (2000:16) state that there are differences in “*stylistic variables such as willingness to respond and preference for speed over accuracy.*” It is worth mentioning here that in most of the literature, factors contributing to learner variability were discussed as disparate units in the brain although they all seem to play a major role, in one way or another, in the learning process.

Historically, different biological functioning could be mapped to different regions of the brain. Though the structures of most human brains are anatomically similar, the patterns of neural connections tend to vary depending on previous learning, experiences, or preferential tendencies for learning across domains. Current studies in neuroscience have shown these dynamic examples of variability among learners by focusing on learning as more than just singular points of neural activity in the brain for any one task, but as connected neural networks (as explained in Meyer, Rose & Gordon, 2014). The white matter, or connective tissue, in the brain forms complex webs or networks. When learning occurs, the brain changes; however, specific points of neural connectivity do not change, the networks that surround them do (Meyer, Rose & Gordon, 2014). Based on the type of task being performed, there are regions of the brain that we can predict will be activated, though educators must consider that variability within networks will be based on a number of variables that are dependent on individual learners within different contexts.

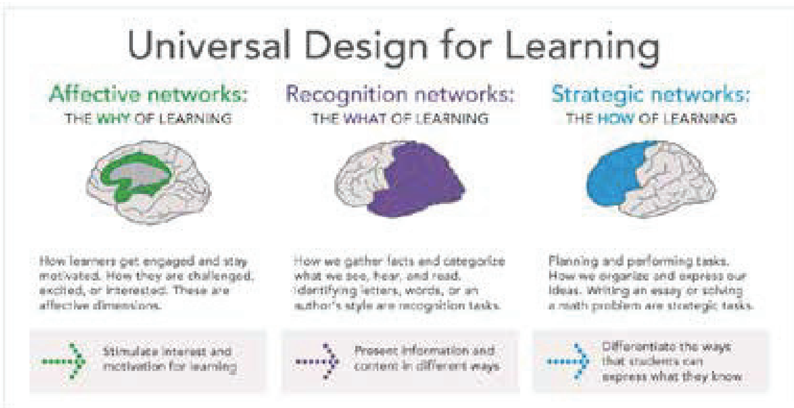

Figure 2: The brain networks (CAST, 2013)

3 Universal Design for Learning (UDL)

Universal Design for Learning distills empirically based, best practices from cognitive neuroscience, the learning sciences, and educational psychology, into guiding principles that support the pursuit of expert teaching and learning (Meyer, Rose, and Gordon, 2014). Seymour Sarason posited that the "*features of classroom contexts of productive learning means that teachers will be using their time in ways that make the concept of respect of individuality other than empty rhetoric and pious sloganeering*" (Sarason, 2004). Inevitably, there is a need for teaching and learning to be redefined in terms that address the entire learning process and promote not only cognitive acquisition and demonstration of knowledge, but also the engagement in meaningful and purposeful learning. Though the perceptual shift is slowly infiltrating educational systems globally, the need for more flexible learning environments has remained constant in both Novak's Concept Mapping and CAST's UDL theories and initiatives. Invariably, learning is a complex system where thinking, feeling, and doing are intertwined both neurologically, and in practice (Meyer, Rose & Gordon, 2014; Novak 2010). Concepts and current findings in neuroscience, along with fundamental principles of learning and development, imply the notion that variability is inherently present in how individuals learn, and educators must adapt practices to best meet all learners' needs.

Keeping in mind the goal of developing opportunities for all learners to experience purposeful, meaningful learning, the creators of UDL recognize that equity and opportunity for learning may not always result in equal pathways for learners to accomplish any one goal (Meyer, Rose & Gordon, 2014). When flexibility and options to reduce barriers in order to access curriculum are established from the beginning of curriculum development and implementation, the purpose of learning experiences shifts from focusing only on content attainment and expression, to having learners engaging in meaningful (Novak & Gowin, 1984; Novak, 2010), expert learning (Meyer, Rose & Gordon, 2014). Similar to the work of learning theorists like Lev Vygotsky (1978) and Benjamin Bloom (1984), guiding principles for UDL are established through a three-part framework. UDL is focused on creating access through three primary learning networks in the brain: affective, recognition, and strategic networks (Figure 2). The provision of options to recruit learner engagement (motivation and connection expressed toward the process of learning), representation (how students receive information or content), and expression (how students demonstrate what they know) (Rose & Meyer, 2000a; Rose & Meyer, 2000b; Rose & Meyer 2002; Meyer, Rose & Gordon, 2014) strive to activate and initiate all three networks in concert with one another to lead toward expert learning. By building flexible learning environments that consider differences in experiences across contexts, with a predictable range of learner variability, customization of resources can be possible at the point of design, rather than retrofitting, or creating scaffolds in the moment to only support individual learners during implementation (Meyer, Rose & Gordon, 2014).

As a way to support educators to consider variability in learning environments, CAST developed a set of guidelines (Figure 3) based on the distillation of a vast body of work that focused on empirically validated research, approaches, or interventions to foster meaningful learning to highlight areas that may present barriers to learners accessing curricula. The UDL guidelines were created as a blueprint for educators and curriculum designers to consider options for the optimization of learning environments. The UDL guidelines provide concrete examples, through checkpoints for each principle, along with options for best practices to consider flexibility for all learners. Similar to the process of using concept maps as a formative process to monitor learner progress, using the guidelines as a lens for educational practice, allows educators to constantly monitor their own progress by systematically choosing options embedded in "UDL-ized", flexible curricula, for in the moment customization of learning experiences.

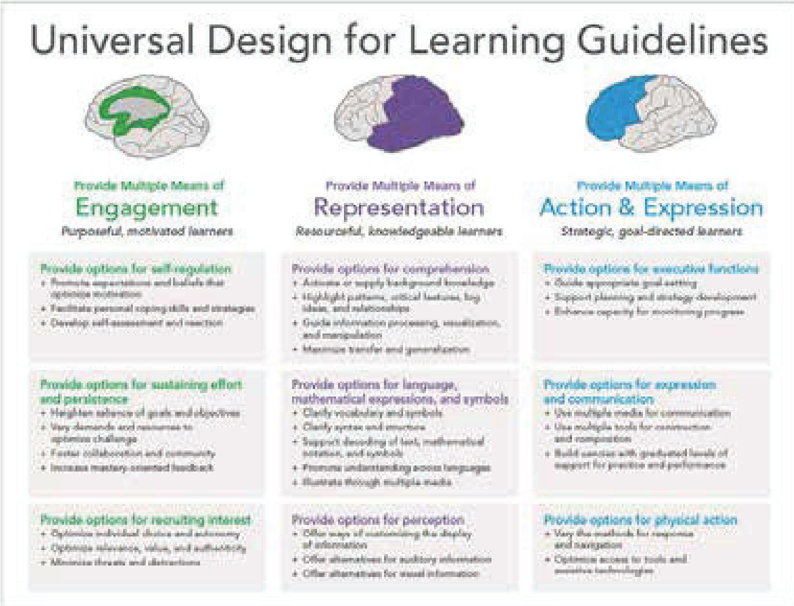

Figure 3: The Universal Design for Learning (UDL) Guidelines (CAST, 2013)

For the purposes of this paper, the goal that seeks to be achieved in considering UDL as a framework for curriculum design is to achieve meaningful, expert learning. In order to be an expert learner, individuals need not only to have expertise in any singular domain, but should possess the skills to be resourceful, strategic, and purposeful when learning across contexts and domains (Meyer, Rose, and Gordon, 2014). Similar to Novak's original theory of meaningful learning; as interactions between thinking, feeling, and doing, expert learning is presented as the goal for activating the three learning networks in the brain through opportunities to refine the best practices of teaching and approaches to learning (Meyer, Rose, and Gordon, 2014).

This paper sets out to strengthen the argument that variability is inherent in learning environments (Meyer, Rose, and Gordon, 2014). To account for such variability, educators can explore what it means to be engaged in meaningful and expert learning to provide options for learners to work toward their goals. We believe that one of the tools to facilitate meaningful and expert learning is through the use of Concept Mapping. Concept Mapping can provide a flexible demonstration of learning through the identification of options needed for curriculum enhancement, while responding to learner variability. Not only do concept maps allow for options in representing the knowledge which is meant to be learned, they also provide the monitoring of progress through further expansion of propositions and concepts developed, or established during the actual learning process. Furthermore, this process can also activate a sense of engagement and autonomy as the independent "maps" of an individual's learning process are visualized through this interactive tool. Intersections between UDL and Concept Mapping become illuminated through the philosophical underpinnings of providing flexible learning opportunities to think, feel, and act to elicit meaningful, expert learning opportunities.

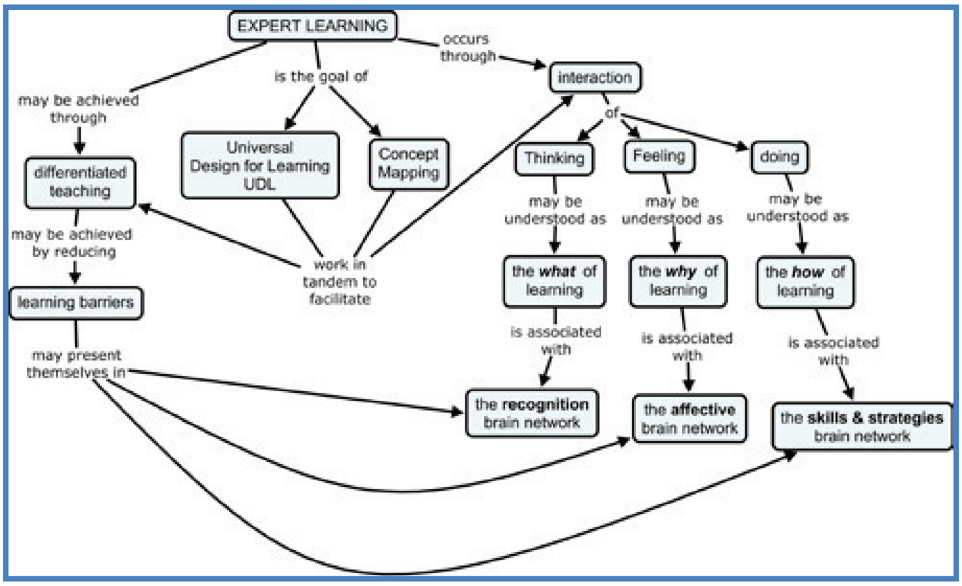

Figure 4: Intersections of Concept Mapping and Universal Design for Learning (UDL)

4 Concept Mapping

Concept Mapping may respond effectively to the development of a learner-centred approach and to teaching and learning which addresses learner variability and individual differences. Across a variety of settings, grade levels and content areas, the use of CMaps in the classroom has shown positive effects on learning (refer to Fig.5-8). This has been revealed in the wide-variety of research studies presented at International Concept Mapping conferences.

A concept map is a type of a node-link diagram that has labeled nodes to represent the concepts or ideas relevant to the topic under study. Links that represent the relationships between the concepts or ideas are included to indicate the nature of the relationship. This node-link-node representation promotes deep learning and challenges surface or superficial learning. Consequently, Concept Maps challenge rote learning, since to create the link between two concepts the learner must have understood the concepts really well. Many learners tend to study by heart chunks of information, without deeply understanding the meaning. Through Concept Mapping learners are encouraged to think reflectively and creatively and to construct their own knowledge in a way that would make sense to them and learning in this way becomes less superficial and more meaningful. Furthermore, knowledge which is learned by rote tends to be forgotten quickly unless it is repeated several times. However, that knowledge which is learned meaningfully, knowledge which is learned in a way which makes sense to the learner, tends to last longer. Learning by heart does not modify or delete faulty ideas but Concept Mapping allows the learner to reflect, evaluate, add, delete or modify the development of new knowledge.

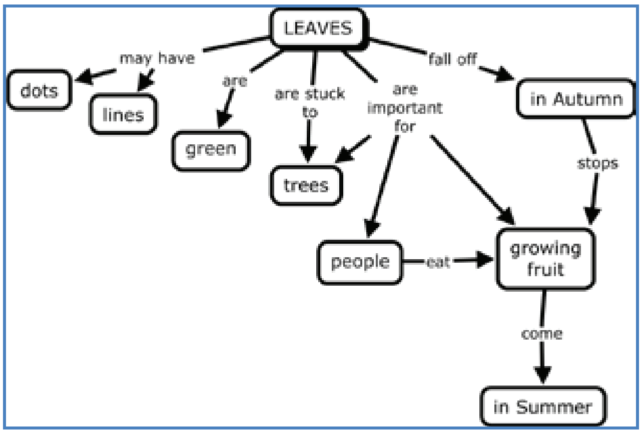

Figure 5: A seven year old First Concept Map before the learning programme.

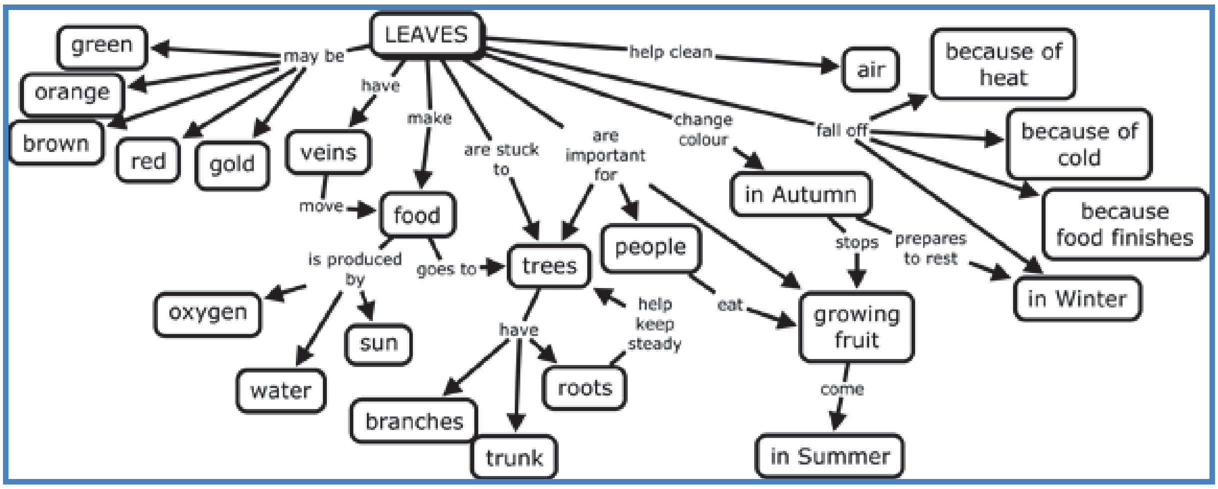

Figure 6: A seven year old Second Concept Map after the learning programme.

Research shows that new meaningful knowledge does not occur in a vacuum and therefore prior knowledge has to be taken into consideration if we expect meaningful learning to take place. One of the values of CMaps is that when learners construct their own Concept Maps for a question or problem in any domain, they visually and clearly convey at a glance what the learner already knows since CMaps give a specific picture of what knowledge the learner has and how this is being developed. As a result the teacher and learner can negotiate and plan together to build upon this. This is referred to in educational psychology as metacognition and scaffolding (better known as Vygotsky's Zone of Proximal Development).

When teachers understand what students think about concepts or events under study, they can be in a much better position to pin-point any invalid ideas or any missing information and they will be able to better formulate lessons and differentiate instruction based on the learners' needs. Vanhear (2008, 2012) reveals that meaningful learning is achieved when learners are given the opportunity to construct a first Concept Map at the beginning of a learning programme to capture prior knowledge and then this is developed into a second Concept Map at the end of the learning programme (refer to Fig 5-8). Similar results were reflected and substantiated by Balgopal and Wallace (2009).

Concept Maps are grounded in theories of how people learn and they have originated from a constructivist perspective theory of learning which holds that learners construct their own knowledge as opposed to the preceding dominant belief of knowledge as something that is acquired through direct transfer and rote learning (Gage & Berliner, 1998; Twomey Fosnot, 2005; von Glasersfeld, 2005). Constructivists suggest that prior knowledge is used as a framework to learn new knowledge. Furthermore, they suggest that how we think influences how and what we learn. Concept Maps identify prior knowledge, the way we think and the way we see relationships in between knowledge.

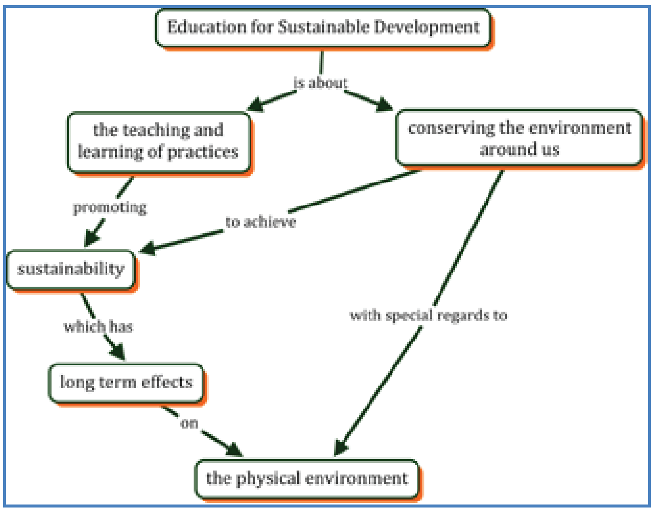

Figure 7: A Higher Education student First Concept Map before the learning programme.

Nonetheless, although CMaps may be seen as an effective cognitive tool, the actual process of constructing a Concept Map involves another mental process which in UDL terminology is referred to as the strategic network. Learners are actively engaged while constructing a Concept Map and they will be creating it at their own pace. The CMapTools software features enhance this brain network by allowing different means of action and expression. This whole process will lend itself to the active participation of the students and will create an environment of learning where understandings are negotiated and knowledge is constructed as opposed to environments where learners are "passive recipients of the wisdom of a single speaker" (Ramsden 2003:108). Engaging the students in active participation increases their motivation to learn and so makes them more likely to learn, retain and process the information presented (Novak & Gowin 1984; Novak, 1998; Booth, 2011). Price & Nelson (2011:70) suggest that "when students are involved in lessons or activities made interactive through the use of active participation strategies, they are also more likely to be attentive, less likely to be off-task, and more likely to feel good about their competence." This will lead learners to have a sense of positive feeling while constructing their own Concept Map. This will consequently lead to learning enthusiasm, commitment and co-operation. Hays (2006:346) shows that positive emotions enhance motivation and help the learners to focus their attention on learning. Furthermore, "practices that enhance positive emotions, and help the learner perceive the task as interesting and personally relevant help enhance motivation and result in increased effort." A positive motivation practice improves performance and achievement. This cognitive and affective domain connection was explored through the use of Concept Maps and substantiated by Balgopal and Wallace (2009) in the Environmental Education field to promote ecological literacy.

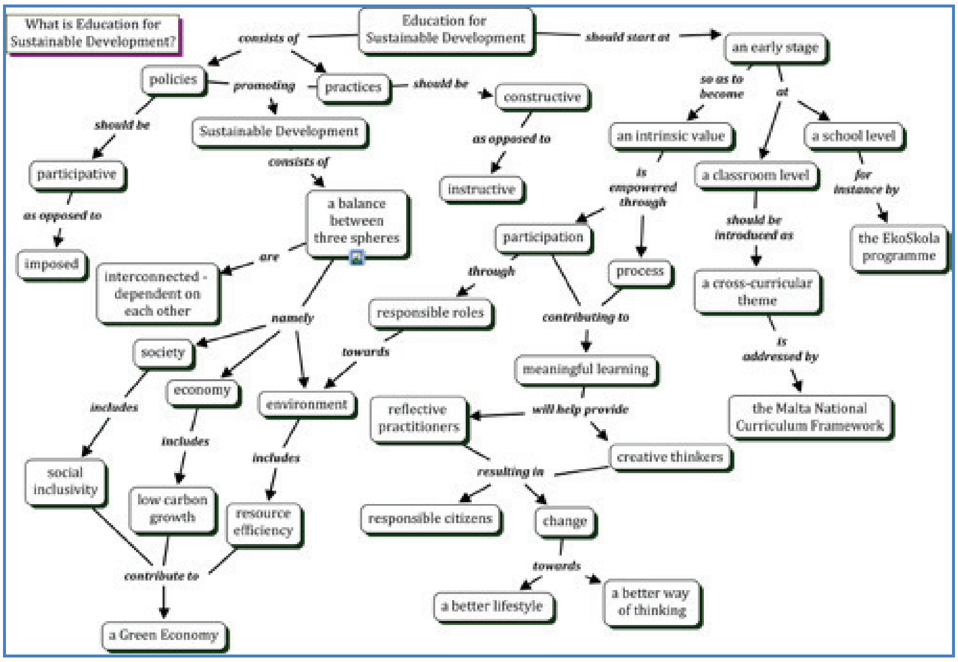

Figure 8: A Higher Education student Second Concept Map after the Learning Programme.

Novak's creation of Concept Maps emerged as a new paradigm in cognitive learning, highlighting the learners' internal mental processes as the major factor in learning. Novak's work has always, since its inception, referred to these mental processes as a complex interplay between **thinking** (cognition), **acting** (conation) and **feeling** (affectation) (Novak & Gowin, 1984; Figure 1). Nonetheless, some authors tend to highlight cognition and to a lesser extent conation at the expense of the importance of the role of affectation in using Concept Maps. The general discussions of results generated by some authors and researchers in the field of the use of Concept Mapping in education focused on concepts and propositions and their development and showed that the uses of Concept Maps reveal personal complex structures of knowledge and how this is integrated and expanded within a learner's cognitive structure. This kind of research presents only results related to cognition and miss out on showing how or what kind of other mental processes were involved in learning thus limiting the potential of the use of Concept Maps.

This may be due to the fact that "*most research in education is **method driven** rather than **theory driven***" (Novak, 2010:20 original emphasis) and as such, researchers using Concept Maps limited their use to what could be measured and as a result overshadowed or devalued the aspects of doing and feelings or emotions. Similarly, various authors in the field argue that attention to cognition and overt behaviours has overshadowed the significance of feelings (James, 2009; Forgas, 2000; Fineman, 1993, Jarvis, 2006).

5 Conclusion

Although "*the person is a complex phenomenon*" (Jarvis, 2006:195) and we do not know enough information to determine causal attributions to learning since "*humanity and the human society are continually developing*" (Jarvis, 2006:200), research in neuroscience is revealing that cognition, affectation and conation cannot be studied as disparate elements, but must analyze systems and networks of connections if one wants to understand how learning occurs and empower meaningful and expert learning experiences. This discussion aims to promote Concept Maps not only as cognitive tools, but tools which also take into consideration other mental processes namely, affective and conative. Similar to UDL's mission and research base to educate the whole learner, Novak's theories for learning focus on the process of learning, rather than content acquisition alone. Such theories of learning emerged as paradigm shifts to consider learning as a complex, dynamic system of networks that impact the process of thinking (cognition), acting (conation), and feeling (affectation) (Novak & Gowin, 1984) through the three main neural networks that impact learning in the brain: recognition, strategic and affective (Rose and Meyer, 2002). This perceptual shift in education emphasizes ultimate goals of learning to be directed toward purposeful, meaningful experiences that are guided through expert teaching and learning practice. With process- and theory-focused initiatives, rather than only method driven, the implications of flexible learning opportunities to reduce barriers and account for variability present in learning environments are innumerable. We propose that studies of Concept Mapping as a tool to initiate learning through affective neural networks, as a point of engagement and access to curriculum, be further pursued and better integrated into educational preparation and practice.

> *"Successful education must focus upon more than the learner's thinking. Feelings and actions are also important. We must deal with all three forms of learning. These are acquisition of knowledge (cognitive learning), change in emotions or feelings (affective learning) and gain in physical or motor actions or performance (psychomotor learning) that enhance a person's capacity to make sense out of their experiences. A positive educational experience will enhance a person's capacity for thinking, feeling and/or acting in subsequent experiences. A maleducative or miseducative experience will diminish this capacity. Humans engage in thinking, feeling and acting, and these combine to form the meaning of experience."*
>
> (Novak, 2010:13)

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