Concept Mapping as a Reading Comprehension Tool

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ARTICLE INFO	ABSTRACT

The main intent of this study was to find-out the effectiveness of the use of concept mapping in improving the reading comprehension skills of students, at Asian College of Technology. Based on the findings, a reading enhancement plan was proposed. The study utilized the Quasi-Experimental Method, with reading comprehension questions and concept maps. The research subjects were the forty education students. They were divided into two groups. One group served as the experimental group while the other group served as the control group. The researchers made reading comprehension questions on the three reading texts and concept maps to the two groups of respondents. Appropriate statistical tool was used to analyze the data collected and gathered. Concept mapping is proven to be helpful in improving the reading comprehension skills of the students. Through concept mapping, the students' analytical, structural, and creative skills would be gradually enhanced making them better readers. A syllabus enrichment was proposed to utilize concept mapping as one of the essential teaching and reading strategies in developing the students' reading comprehension skills.

1. Introduction

One of the most indispensable skills that college students have to equip themselves is reading. Most academic endeavors in the college level have to deal with reading. It is expected that college students read and comprehend what they read. However, most college students nowadays are visual readers and learners. They would be more interested and engrossed to read if they would combine graphics or graphical representations on the texts. This implies that through graphical representations, they may manifest personalized and authentic thoughts, ideas, and understanding of the texts read concretely.

Further, encouraging and exposing these college students to the different reading texts in reading areas or corners and reading laboratories may have helped them develop their own way or culture of reading. The acceptance of the said culture of reading is a step forward towards internalizing and practicing critical, structural, and creative thinking skills.

On the contrary, there are some college students who would just read because they are forced to do so. The result seems to be unfavorable as those students may have low scores in reading comprehension and vocabulary exercises. With that, they may become reluctant towards reading, ignore reading or hate reading at all. Nonetheless, it is a prime concern among college English teachers to consider many reading factors such as some college students' style of reading, their perceptions on readings, and their comprehension of varied reading texts or selections. Developing critical and creative thinking skills in reading goes beyond the understanding of printed letters, symbols, words, phrases, sentences, and paragraphs. It is properly or correctly assimilating ideas from different texts and applying them in a more personal, professional and academic ways.

An authority in reading says that the more one reads, the more he will know about things. The more a person learns, the more places he will go. This only proves that reading or having the culture and firm belief towards reading surely gives an edge or advantage to those who continuously read. Moreover, college English teachers continually look for strategies and methodologies to enhance the reading skills and interests of the students.

As observed, some second year education students in Asian College of Technology took reading as a passive routine or worst, their burden. They were into superficial reading as they could not focus well and lack the necessary skills for efficient reading comprehension. That could be shown through their low scores in some reading exercises.

If this unfavorable trend continues, then it will hamper the second year education students' academic performance. Nevertheless, those education students have to cultivate their structural and creative thinking skills in reading and harmonize their prior knowledge and experience on the texts being read for a more meaningful and life-long learning. It is of this reason why the researcher intend to study concept mapping and its effect in improving the reading comprehension skills among the students.

2. Theoretical Background

This study is anchored on Joseph Novak's Learning How to Learn Theory. In the early 1970s Novak and his research group from Cornell University developed the idea of concept maps (Novak, 1998). Concept maps are designed to represent meaningful relationships among concepts in the form of propositions (Novak & Gowin, 1984). For Novak and Canas (2006) propositions are statements about something in the universe that may be natural phenomena or constructed phenomena, and these propositions contain two or more interconnected ideas that form a meaningful statement with the use of linking words or phrases.

Moreover, if meaning making and knowledge organization are the conceptual underpinnings of Novak's Theory, the key tool for bringing those about on the one hand and evaluating learning on the other is the concept map. Thus, active and collaborative learning happens when learners, faced with challenging-but-within-reach-material choose to cognitively reorganize that material by making modifications of their prior knowledge to accommodate the new knowledge (Novak, 2010). Concept maps are simple tools that help make learning meaningful and the creation of effective knowledge frameworks that not only allow utilization of the knowledge in new contexts, but also the retention of knowledge for longer periods of time (Novak, 1990).

Further, the use of concept mapping is often linked to the constructivist view of learning as concept mapping makes a good starting point for constructivist teaching. There are a number of ideas which are grouped together under the constructivist heading. This has been usefully summarized by Novak (1993) as being based in the view that from birth to senescence or death, individuals create and recreate the meaning of events and objects they observe.

Concept maps are also effective in helping teachers identify students' prior knowledge and understanding and organize teaching and learning in a way that is meaningful to them. Studies have shown that subjects that use concept maps perform better than those non-concept mappers in longer term retention tests.

Joseph Novak's Learning How to Learn Theory is supported by Ausubel's Subsumption Theory. This theory looks into how we process large amounts of meaningful information from verbal/textual presentations in a school setting in contrast to theories that are developed as results of laboratory experiments (Ausubel, 1963). Subsumption is an important process involve in learning wherein new material is related to relevant ideas in the existing cognitive structure on a substantive, non-verbatim basis. These cognitive structures represent the residue of all learning experiences; forgetting happens because certain details become integrated and as a result would lose their individual identity.

Ausubel (1963) has pointed out that overviews and summaries which simply stress important ideas and are presented at the same level of abstraction and generality as the rest of the material are different from advance organizers. These advance organizers act as a subsuming bridge between new learning material and existing related ideas.

Another theory that also supports Joseph Novak's Learning How to Learn Theory is Kolb's Experiential Learning Theory. Experiential Learning Theory (ELT) provides a holistic and multilinear model of the learning process which is consistent with our understanding about how people learn, grow, and develop (Kolb, 1984).

The theory is called Experiential Learning to give emphasis to the significant role that experience plays in the learning process, an emphasis that separates ELT from other learning theories. The term experiential is used to compare ELT both from other cognitive learning theories, which highlight cognition over affect, and behavioral learning theories that do not recognize any role for subjective experience in the process of learning. (Kolb, 1984). From the perspective of Experiential Learning Theory, learning is the process of creating knowledge is through the transformation of experience. Knowledge is the product of the combination of grasping and transforming experience.

The ELT learning model implies that learning would require abilities that are polar opposites, and that the learner must continually choose which set of learning abilities he or she will use in a specific learning situation. In order to understand experience some of us would have to perceive new information through experiencing the concrete, tangible, felt qualities of the world, counting on our senses and engaging ourselves in concrete reality.

3. Related Literature

Concept maps are the visual representations of ideas or concepts and their interconnectedness that are intended to represent the knowledge structures that human beings store in their minds (Jonassen et al, 1997). Concept maps can help facilitate in the teaching and learning process in many ways. It can also help teachers and students in identifying the key concepts and principles for any specific learning task that the need to focus (Novak & Gowin, 1984).

McAleese (2008) said that another important function of concept maps is that they allow off-loading of thinking and show the result of engaging in knowledge construction. Using this framework, concepts maps provide learners with opportunities to engage in the process of their learning.

Simply being able to read does not guarantee comprehension. Readers must use the printed words to build on prior knowledge and relate concepts to each other (Antonacci, 2001). Concept maps have been shown to support readers who are struggling (Lovitt & Horton, 2004) by building off of these students' background knowledge and asking them to reflect on their understanding while reading. Concept maps can be used across all subject areas and they are easy to construct.

One strategy that can stimulate lazy readers to think more deeply about the ideas in the text is the use of mapping. This strategy is considered as an active reading process because readers must figure out relationships between ideas and the hierarchy of their organization (Sinatra & Pizzo, 1992). The need for rote memory can be reduced by the process of concept mapping, thus and make learning more meaningful (Novak, 1998).

The thought process involved in organizing the map, in conjunction with the actual physical production, drawing, connecting, writing, and the visual aspects reinforce and deepen comprehension (Wilkes, Cooper & Lewin 2009). Concept maps can be utilized as a learning tool and at the same time as a tool to evaluate students understanding, thus encouraging them to use meaningful-mode learning patterns (Mintzes, 2000).

There is still relatively little known idea about memory processes and how knowledge finally gets incorporated into our brain, but it seems evident from diverse sources of research that our brain works to arrange knowledge in ordered frameworks and that learning that enable this process significantly improve the learning capability of all learners (Tsien, 2007).

Graphic organizers such as concept maps improve reading comprehension by emphasizing text structures, and they improve different aspects of comprehension, such as literal and relational comprehension, recall, and vocabulary learning (DiCecco & Gleason, 2002). Graphic organizers can also enhance how adolescents' see themselves as empowered writers (Hallenbeck, 2002) and coupled with strategy instruction, can improve writing fluency (Montague & Leavell 1994).

Concept mapping can effectively help learners see and understand the relationships among different concepts. Teachers who are modeling the process of concept map creation, should give particular attention to the linking or joining words and should help leaners understand that they are what makes the whole thing have meaning (Sparks, 2003).

For learners who can communicate their ideas better through symbols, concept maps, pictures (or photos or drawing images) can be used to replace text labels (words). Drawings or pictures can also be used by and for learners who speak a different language or have reading or writing difficulties (Pearson & Somekh, 2003).

Concept mapping can be used for several purposes. It generates ideas (brainstorming). It designs complex structures (long texts, hypermedia, and large web sites). It communicates complex ideas. It aids learning by explicitly integrating new and old knowledge, and it assesses understanding or diagnose misunderstanding.

Further, visual representation has several advantages. Visual symbols are quickly and easily recognized. Representing ideas with the use of graphics or visuals would allow for development of a holistic understanding that words alone cannot convey. According to Jonassen (1996) students manifest some of their best thinking when they would represent something graphically or visually, and thinking is a necessary condition for learning.

Zanting (2009) highlighted the advantages of concept mapping. First, it encourages collaborative learning and team knowledge mapping. It allows deep learning. A picture paints a thousand words or visual representations of ideas are usually easier to comprehend and remember. These visual representations can be used either in individually or collaborative activities in large class setting by providing the learners a partially filled concept map, or a few concepts to fill on the maps. It reflects what exactly real business uses and provides the students a sense of the real world. Lastly, it is an active assessment.

Sparks (2003) suggested that with young children it "would be more sensible to simplify concept mapping, making it a method of showing links between concepts." His argument is supported by Derbentseva (2006) which suggests that kindergarten children find it difficult to depict even simple hierarchical relationships without a visual aid, namely a map template (with boxes and lines).

4. Related Studies

In a study conducted by Inspiration Software Inc. revealed that concept mapping, when done in correct and thorough manner, is a powerful way for students to reach high levels of cognitive performance. A concept map aside from being a learning tool can also serve as an ideal evaluation tool for educators to measure the growth of and to assess student learning. As learners create concept maps, they repeat ideas in their own words and help identify ideas and concepts that are not correct; educators are able to identify what students do not clearly understand and provide an accurate and objective way to evaluate areas in which students do not yet understand the concepts fully.

Many researches done by education specialists found that concept mapping is very effective in educational settings. The use of concept maps was reported in studies to have the largest positive effect at the university level; however, modest and consistent improvements were also seen at the elementary, middle school, and high school levels.

Students with and without disabilities benefit equally from concept mapping. For instance, improvements in verbal and written abilities, reading and comprehension abilities, and other such capacities were increased when students with learning disabilities used concept mapping.

In addition, the use of concept maps during reading lessons early in the educational life of a student were exceptionally beneficial. This was revealed by the results of many studies conducted on the impact of concept mapping in the teaching-learning process. Other areas in which researchers found a positive correlation between the use of concept maps and educational learning include science, social studies, mathematics, and language arts. Using concept maps to learn mathematics, for instance, was found very useful in teaching a sometimes-difficult subject.

Besides these specific fields of study, researchers discovered that concept mapping is useful to prepare students for their studies. Such areas as taking notes and organizing question-and-answer responses were shown to work well with concept mapping. Many times, researchers found that students took less notes in class but were more effective in learning and retaining the information when they used concept maps.

A study funded by the Office of Special Education Programs, within the U.S. Department of Education, showed a slight but consistent improvement in comprehension and a moderate improvement in vocabulary when students used concept mapping

during their general studies. The students were tested using such measures as written summaries, traditional tests, concept acquisition tests, and grammar tests, along with the widely used Stanford Diagnostic Reading Test.

The ability and knowledge of educators to implement concept mapping is important to the process. An 11-year study, for instance, showed that learning results in students were more positive when teachers properly instructed them on the use of concept maps, along with providing realistic, informative, and positive ways to use them. It was also learned that computer-based methods to present concept mapping can be effective for the learning and application of educational materials. In addition, searching on the Web was shown to improve students' abilities to develop more detailed and complicated maps.

A paper written by Josianna Basque and Marie-Calude Lavoie (2006) of the LICEF Research Center (Montreal, Canada), discussed the conclusions of 39 research studies conducted between the late 1980s and early 2000s. The studies were performed on the theory, methodology, and results of *collaborative concept mapping* (CCM), a process in which students construct concept maps in small groups. Basque and Lavoie's conclusion praised the collaborative learning style of concept maps.

The traditional educational systems cannot be replaced by concept mapping since it only serves as a vehicle for better learning, more collaborative and critical discussions, and more positive advancements within the learning environment. The use of concept maps provides teachers opportunities to better assess the knowledge gained by their students. Traditional testing, such as with essay, multiple-choice, and fill-in-the-blank questions, is a valuable way to test students.

However, the practice of having students construct concept maps to determine their level and quality of learning has been found to be more effective in showing how well students understand important concepts recently learned. In fact, according to the researchers in the Department of Education at Stanford University, California, teachers and other educators find concept mapping an easy-to-use and effective method for evaluating the progress of their students.

5. Research Problem

This study determined the effectiveness of the use of concept mapping in improving reading comprehension skills of students at Asian College of Technology. Based on the findings of the study, a syllabus enrichment was proposed.

Specifically, the study looked into the following questions:
   a) What are the pretest scores in reading of both control and experimental groups?
   b) What are the posttest scores of both control and experimental groups?
   c) Is there a significant difference between the pretest scores of the control and experimental groups?
   d) Is there a significant difference between the posttest scores of the control and experimental groups?
   e) Is there a significant difference between the pretest and posttest scores of the control and experimental groups?
   f) Based on the findings, what syllabus enrichment can be proposed?

6. Methodology

This is a quasi-experimental study that uses the descriptive – evaluative method. The subjects of the study were forty second year education students in Asian College of Technology. Twenty students served as the control group and the other twenty served as the experimental group. The researcher made use of three articles for the three reading comprehension exercises. These are "Cool or Cold" by Brendalyn P. Ramirez, "Selfies" by Jennifer Kabbany and "Children's Mathematical Skills" from a TOEFL Book. The three reading comprehension exercises have thirty items.

A letter of request was sent to the Dean of the College of Education in Asian College of Technology. When the request was granted, the study was then conducted. Before the actual gathering of data, there was a trial run to spot the problems that may arise in the actual test taking of the respondents. The subjects of this study were divided into two groups – control and experimental groups through matching of grades. On the first session, the researcher conducted pretests of the three reading comprehension exercises for both groups. Each reading comprehension exercise in the pretest took thirty minutes. After administering the pretest sessions for both groups, the researcher gave the usual class discussions for the control group and concept mapping interventions for the experimental group. The respondents in control group were asked by the researcher to answer orally some questions pertaining to the three stories. Then after, they had individual, think-pair-share, big group activities, and free-flowing discussions without any interventions from the teacher as manifestations of their understanding of the said three stories. The respondents in experimental group were given concept mapping interventions, and the researcher

told them to highlight or conceptualize the information or thoughts they learned from those three stories by letting them remember and organize ideas and insights and relate them to their previous experiences or knowledge. Their ideas and insights of those three stories were concretely translated in personal and graphical ways. In the posttest sessions, both groups of respondents took the three reading exercises. It took one and a half hour for the three reading comprehension exercises. The reading comprehension scores of the experimental group were utilized to find-out if Concept Mapping is effective or not. This was followed with a syllabus enrichment to maximize its content towards reading interest and structural thinking skills among the second-year education students at Asian College of Technology.

7. Results and Discussion
Pretest Scores of the Control and Experimental Groups

Table 1. Pretest Scores of the Control Group and Experimental Group

Reading Comprehension Level	Control Group		Experimental Group	
	Frequency	Percentage	Frequency	Percentage
Very Satisfactory	4	20%	4	20%
Satisfactory	12	60%	15	75%
Fair	4	20%	1	5%
Total	20	100%	20	100%

Table 1 shows that most of the respondents in both the experimental and control groups have a satisfactory reading comprehension level. The data evidently revealed that both groups have a comparable reading comprehension skill prior to the introduction of concept mapping as a reading comprehension tool.

Posttest Scores of the Control and Experimental Groups

Table 2. Posttest Scores of the Control and Experimental Groups

Reading Comprehension Level	Control Group		Experimental Group	
	Frequency	Percentage	Frequency	Percentage
Very Satisfactory	6	30%	12	60%
Satisfactory	12	60%	8	40%
Fair	2	10%	0	0%
Total	20	100%	20	100%

Table 2 shows that the respondents in the experimental group got higher reading comprehension level compared to the respondents in the control group. The data clearly showed a marked increase in the performance of students in the experimental group. This marked increase in the comprehension level of the respondents in the experimental group is attributed to their utilization of concept mapping in understanding and processing the reading texts compared to the respondents in the control group that had the usual class discussions.

As Sinatra and Pizzo (1992) say that mapping is an active reading process that stimulates lazy readers to think more deeply about the ideas in the text because they must analyze and identify the interconnectedness between concepts and the hierarchy of their organization.

The result of the posttest only proves that many learners and teachers are surprised to see how this simple tool facilitates meaningful learning and the creation of powerful knowledge frameworks that does not only allow the application of the knowledge in new situations, but also the retention of the knowledge for longer periods of time (Novak, 1990).

Furthermore, Mc Aleese (1998) said that another important function of concept map is that they allow off-loading of thinking and show the result of engaging in knowledge construction. Within this structure, he added, concepts maps are seen as an occasion to engage learners in the process of their learning.

Difference of the Pretest Scores of the Control and Experimental Groups

Table 3. Significant Difference of the Pretest Scores of the Control and Experimental Groups

Groups	Number of Students	Mean	Standard Deviation	Qualitative Description	Test Statistics		Interpretation
					Computed Value	Table Value	
Control	20	19.65	3.80	Satisfactory	− 1.40	± 2.02	Not Significant
Experimental	20	21.20	3.19	Satisfactory			

Table 3 shows that there is no significant difference between the pretest scores of the control group and the pretest scores of the experimental group. This presents the idea that both control and experimental groups are the same with their skills in reading comprehension skills.

Difference of the Posttest Scores of the Control and Experimental Groups

Table 4. Significant Difference of the Posttest Scores of the Control and Experimental Groups

Groups	Number of Students	Mean	Standard Deviation	Qualitative Description	Test Statistics		Interpretation
					Computed Value	Table Value	
Control	20	20.80	3.74	Satisfactory	− 3.45	± 2.03	Significant
Experimental	20	24.40	2.80	Very Satisfactory			

The results showed that there is a significant difference between the posttest scores of both the control group and experimental groups. It can be inferred that the use of concept maps helps improve the reading comprehension ability of the students.

According to Novak et al, (1983), studies have shown that students who are using concept mapping performs better than those non-concept mappers in longer term retention tests. That statement is further supported by Jonassen (1996) who argues that students show some of their best thinking when they try to represent something graphically, and thinking is a necessary condition for learning.

To prove the point, concept maps have been shown to support struggling readers (Horton et al, 1994) by building off of students' prior knowledge and asking them to reflect on their understanding while reading. These concept maps can be used across all subject areas and are easy to construct.

Difference of the Pretest and Posttest Scores of the Control and Experimental Groups

Table 5. Significant Difference of the Pretest and Posttest Scores of the Control and Experimental Groups

Control Group	Number of Students	Mean	Standard Deviation	Qualitative Description	Test Statistics		Interpretation
					Computed Value	Table Value	
Pretest Scores	20	19.65	3.80	Satisfactory	− 0.96	± 2.02	Not significant
Posttest Scores	20	20.80	3.74	Satisfactory			
Experimental Group	Number of Students	Mean	Standard Deviation	Qualitative Description	Test Statistics		Interpretation
					Computed Value	Table Value	
Pretest Scores	20	21.20	3.19	Satisfactory	− 3.37	± 2.02	Significant
Posttest Scores	20	24.40	2.80	Very Satisfactory			

The results showed that there was no significant difference between the pretest and posttest scores of the control group. This means that the level of reading comprehension of the respondents on the control group is substantially the same during their pretest and posttest. On the other hand, the results showed that there was significant difference between the pretest and posttest scores of the experimental group. This means that the level of reading comprehension of the respondents on the experimental group is substantially different during their pretest and posttest. This is because the experimental group had been exposed to the use of concept mapping as a reading comprehension tool which contributed to their higher level of comprehension while the control group had not been exposed to the use of that intervention.

Table 5 vividly illustrates that one of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to utilize learning patterns that are meaningful (Mintzes et al., 2000). The actual physical production, drawing, connecting, writing, and the visual aspects, in conjunction with the thought process involved in organizing the map reinforce and deepen the learners' understanding of ideas (Wilkes et al, 1999).

Furthermore, graphic organizers such as concept maps improve reading comprehension by emphasizing text structures, and they improve different aspects of comprehension, such as literal and relational comprehension, recall, and vocabulary learning (DiCecco & Gleason, 2002).

8. Conclusion

Today's computer-literate students are visual learners. Graphic organizers make them visualize ideas. The use of concept maps is an effective teaching strategy which develops their structural thinking skills. Concept maps help enhance students meaningful learning by connecting different concepts into networks of concepts and labeling relationships between these concepts making them become more obvious. Thus, concept maps make information easier for the students to remember.

9. Recommendations

Based on the findings of the study, the researchers recommend further studies on the following relevant reading strategies that can be of great help to the students, particularly in improving their reading interest and reading comprehension skills:

   a) CARE, Comprehend After Reading Everything
   b) Effectiveness of Brain Gym for Reading Comprehension Skills
   c) Silent Sustained Reading towards Accurate Comprehension
   d) Reading and Thinking Out of the Box

References

[1] Antonacci, P. A. (2001). Students Search for Meanings in the Text through Semantic Mapping. *Social Education*.
[2] Ausubel, D. (1963). *The Psychology of Meaningful Verbal Learning.* New York: Grune & Stratton.
[3] Derbentseva, N. (2006). Concept maps: Experiments on dynamic thinking. *Journal of Research in Science Teaching*.
[4] DiCecco, V. M., & Gleason, M. M. (2002). Using Graphic Organizers to Attain Relational Knowledge from Expository Text. *Journal of Learning Disabilities*.
[5] Hallenbeck, M. J. (2002). Taking Charge: Adolescents with Learning Disabilities Assume Responsibility for their Own Writing. *Learning Disabilities Quarterly*.
[6] Hyerle, D. (1996). *Visual Tools for Constructing Knowledge* . Alexandria, VA: Association of Supervisors of Curriculum Development.
[7] Jonassen, D. H. (1996). *Computers in the Classroom: Mindtools for Critical Thinking.* Eaglewoods, NJ: Merill/Prentice Hall.
[8] Jonassen, D. H., & et. al. (1997). Concept Mapping as Cognitive Learning and Assessment Tools. *Journal of Interactive Learning Research*.
[9] Jonassen, D. H., & Grabowski, B. L. (2003). *Handbook of Individual Differences: Learning & instruction.* Hillsdale, NJ: Lawrence Earlbaum Associates.
[10] Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* New Jersey: Prentice-Hall.
[11] Lovitt, T., & Horton, S. V. (2004). Strategies for Adapting Science Textbooks for Youth with Learning Disabilities. *Remedial and Special Education*.
[12] Marzano, R. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: ASCD.
[13] McAleese, R. (2008). The Knowledge Arena as an Extension to the Concept Map: Reflection in Action. *Interactive Learning Environments*.
[14] Mintzes, J. J. (2000). *Assessing Science Understanding: A Human Constructivist View.* San Diego: Academic Press.
[15] Montague, M., & Leavell, A. G. (1994). Improving the Narrative Writing of Students with Learning Disabilities. *Remedial and Special Education*.
[16] Novak, J. D. (1990). Concept Maps and diagrams: Two Metacognitive Tools for Science and Mathematics Education. *Instructional Science*.
[17] Novak, J. D. (1993). Human Constructivism: A Unification of Psychological and Epistemological Phenomena in Meaning Making. *International Journal of Personal Construct Psychology*.

[18] Novak, J. D. (1998). *Learning,Creating and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations.* New Jersey: Lawrence Erlbaum & Associates, Publishers.

[19] Novak, J. D. (2010). *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations.(2nd ed.).* Mahwah, New Jersey: Lawrence Erlbaum Associates.

[20] Novak, J. D., & Canas, A. (2006). *The Theory Underlying Concept Maps and How to Construct Them.* Pensacola: Florida Institute for Human and Machine Cognition (IHMC).

[21] Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn.* New York: Cambridge University Press.

[22] Pearson, M., & Somekh, , B. (2003). Concept-mapping as a research tool: A study of primary children's representations of information and communication technologies (ICT). *Education and Information Technologies*.

[23] Sinatra, R., & Pizzo, J. (2002). Mapping the Road to Reading Comprehension. *Teaching Pre K-8*

[24] Sparks, E. (2003). *"Is it like the school bus?" Assessment in the early years.* London: Routledge Falmer.

[25] Tsien, J. Z. (2007). The Memory. *Scientific American*.

[26] Wilkes, L., Cooper, K., & Lewin, J. (2009). Concept Mapping: Promoting Science Learning in BN Learners in Australia. *The Journal of Continuing Education in Nursing*.

[27] Zanting, A. (2009). Using interviews and concept maps to access mentor teachers' practical knowledge. *Higher Education*.