A Development of Analytical Thinking Skills of Graduate Students by using Concept Mapping

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Abstract

Graduate students need to have analytical thinking skills to complete research and develop new knowledge and innovation by themselves. Concept mapping is an efficient tool for analytical thinking skill development. This research focuses upon developing the analytical thinking skills of graduate students by using concept mapping. It is a classroom participatory action research which collected data in three loops from 2012-2013: Research-Based Learning (R1D1), Mind Mapping techniques (R2D2), and Cmap Software (R3D3). Data is collected by using reflective journals and cmaps from ten graduate doctoral students in the 'Comparative Higher Education' course. Research instruments are in the form of analytical thinking skill analysis, and reflective journals. The results show that teaching and learning processes, by using research-based learning with concept mapping, can help students to develop their analytical skills to a higher level. Using Cmap software can help them to analyze and organize their information from research papers and articles, develop long term memory, and integrate their information in one concept. Moreover, the design of teaching plans and the sequencing of assignment plans both have effects upon the development processes of students' analytical thinking skills.

Introduction

The development of learners' potential in the 21st century not only places great emphasis on fostering students to become academic, knowledgeable and independent, but also on that they become innovative, creative thinkers, effective doers and skillful problem solvers. In addition, their development of work and interpersonal skills are addressed. As a result, the current trends of teaching and learning pedagogies focus upon enhancing students' analytical thinking skill development, which directly leads to the development of critical thinking skills, problem solving skills and creative thinking skills (P 21, 2005). These skills are essential characteristics of graduate students. Analytical thinking skills have become one of the more important skills for students in the 21st century; particularly, in Higher Education levels, which aim for students to increase their High Order Thinking Skills (HOTS), so that they can develop themselves, build their own innovation and be effective leaders in society. Therefore, analyzing skills are regarded as essential skills for graduate students.

Teachers' experience and teaching strategies are essential for the development of students' learning processes and analytical thinking skills. Lessons which aim to develop students' analytical thinking skills require teachers to select teaching and learning pedagogies applicable to particular learning content. Teachers are also required to plan lessons and to use appropriate teaching materials, or tools, in order to develop students' analytical thinking skills. The development of analytical thinking skills will take place when students practice and develop their analytical thinking skills through the learning process within the classroom. A number of research studies, found both inside and outside of Thailand, revealed that there were several teaching and learning pedagogies that could develop analytical thinking skills. That is, students' analytical thinking skills could be fully developed with the support of experienced teachers, well-designed lesson plans and effective tools used for analytical thinking skill development.

Concept Mapping is an important tool, used for not only creating learning processes for students but also to evaluate students' overall understanding. Concept Mapping enables students to adopt 'Meaning Verbal Learning', which enhances their learning potential and further develops their analytical thinking skills. Students use concept mapping to sequence knowledge, and to build knowledge structures from most general to more specific content, which in turn leads to comprehensive understanding. In addition, concept mapping helps students to extend and create long-term memory (Novak, 1990; Novak & Wandersee, 1991). Many research studies have pointed out that there has been extensive use of concept mapping, with a diversity of students in different teaching and learning contexts; in different educational perspectives; and with different educational and curriculum development (McClure, Sonak, and Suen, 1999; Weideman and Kritzinger, 2003). Daley (2004) carried out research based upon constructivist teaching methods, by using concept mapping with graduate students. The participants were two groups of graduate students (21 students) who took an 'Adult Education Program'. One group was an experimental group, and the other was a control group. The duration of the study was one year (two semesters). The findings revealed that students used concept mapping as their learning strategies in two ways: (1) they used concept mapping to learn and to review new concepts; they mentioned that they enjoyed using concept mapping to sequence, analyze and understand information, and (2) they used concept mapping to acquire understanding of their own learning processes; concept mapping enabled them to understand how to relate

knowledge and interact with others, in order to develop their own meaning and understand how to create a body of knowledge. It can be said that concept mapping makes a substantial contribution to education.

This research aims to develop the analytical thinking skills of graduate students by using concept mapping. The questions addressed in this study pertained to whether or not using concept mapping as a learning tool, with different variables, would affect the development of graduate students' analytical thinking skills, and how to realistically create teaching and learning pedagogies which are applicable for developing graduate students' analytical thinking skills.

Literature and the conceptual framework

The conceptual framework of this study was based on 'Constructivist theory'. Many educators (Piaget, 1966; Ausubel, 1986; Bruner, 1990 and Novak; 1998) mentioned that constructivist theory could potentially develop students' thinking processes. This process will enable students to build their own body of knowledge by relating new experiences to their prior knowledge. New knowledge is an integration of those previous experiences with new concepts students gain and new learning contexts which they encounter. Students will set up concept mapping as a result of meaningful interpretation within the mind (Sauders, 1992 cited in Daley, B, J, 2004). This action is an important factor for developing students' analytical thinking skills which lead to 'Meaningful Learning' (Novak, 2008; Sunny Cooper, 2009). Meaningful learning will occur when students relate new experiences to their existing ones.

It is essential that students have Analytical thinking development so that they can develop meaningful learning processes. According to Bloom (1969), an analysis may be classified into three parts; (1) Analysis of elements is the ability to classify and analyze significant elements, i.e. to find a summary of content and to differentiate facts and opinions, similarities and differences and causes and effects; (2) Analysis of relationships is the ability to relate concepts and reasons, i.e. to compare and analyze consistent and/or contrary or irrational information, and; (3) Analysis of organizational principles is the ability to search for principles of relationships between elements of information, i.e. to identify key matters by taking into account relevant stories and being able to summarize the relevant information into one concept. The graduate levels need to develop graduate students' analytical thinking skills, so that they can reach higher order thinking skills whilst learning. As the graduate levels mainly offer courses emphasizing the completion of research studies, Research-Based Learning (RBL) is regarded as a fundamental for learner autonomy, in seeking additional knowledge through research methodologies. It is also seen as a tool for developing knowledge seeking processes and self-directed learning, which consists of 7 levels (Figure 1). This study was conducted by using Research-Based Learning at Level 4 (research report), along with concept mapping used to analyze information gained from articles, research papers and articles.

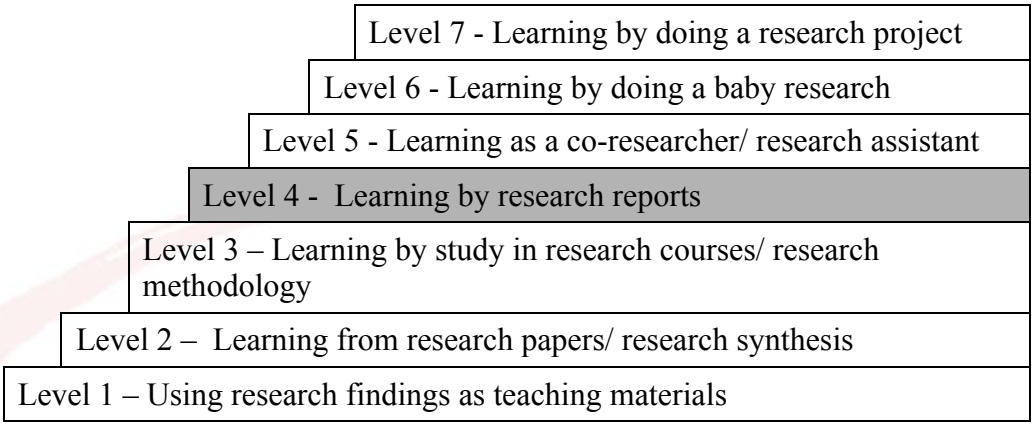


Figure 1. Research-Based Learning (RBL)
(Pitiyanuwat and Bunterm, 2002)

In addition to analytical thinking skills, a learning tool or technique is another element essential to Research-Based Learning. That is, 'Concept mapping and Mind mapping are effective tools that help develop students' analytical thinking skills.'

Concept Mapping

Concept Mapping is one of the graphic organizers developed from Ausubel's Intellectual Development Theory (David Ausubel, 1963; 1968; 1978) and the Constructivist Theory. Concept Mapping aims to provide Meaning Verbal Learning that will take place when students learn and relate information and/or new experiences to their assimilation. Key features of concept mapping are that the concept mapping is a tool used to sequence knowledge which occurs from analyzing concepts of new knowledge, and relates to each proposition by using 'linking words', or phrases, to represent the meaning of each proposition. Squares or boxes are symbols that express the meaning of each proposition, and they are linked by arrows. Concept mapping systematically reflects the concrete understanding of students. This expression is called 'Semantic Units' or 'Unit of Meaning' (Novak, J. D. & A. J. Cañas, 2008), that is a clear concept which is able to communicate its meaning to others.

Nowadays, there are instant programs developed and based upon concept mapping, which can be used as learning tools for creating systematic concept mapping. The use of these programs is compatible with concept mapping principles. The programs include functions which enable users to insert files, pictures and web links into their concept mapping. It is more convenience for users to manage information in the form of electronic files. For instance, 'Cmap Tools' developed by the Institute for Human and Machine Cognition (download from http://cmap.ihmc.us) is an instant program based upon Novak's Concept Mapping, which combines technology and the internet to help users build knowledge structures from their own understanding. However, most of instant programs are commonly developed from 'Mind Mapping' rather than 'Concept Mapping'.

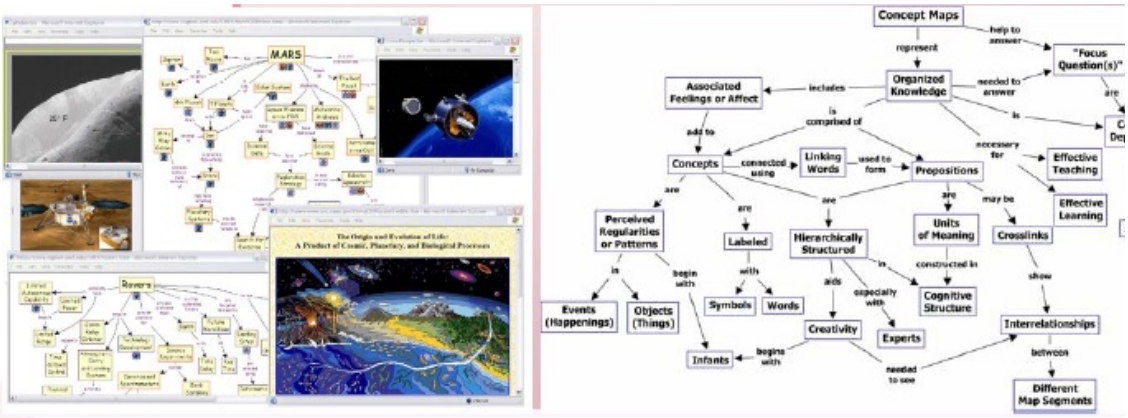


Figure 2. Cmap Tools Software (Novak, J. D. & Cañas, A. J. 2008)

It is apparently obvious that some confusion has arisen between users of Concept Mapping and Mind Mapping, as some users think that they are exactly the same because Concept Mapping and Mind Mapping share similar key features. However, Mind Mapping (Davies, Martin, 2010) focuses upon the recording of ideas, without the need for arranging thinking systems and expressing meaning through words, pictures or symbols. It draws lines from the center, and relates all lines with Nodes, similar to branches of a tree which represent information. Colors are used as mediums to reflect the understanding of segments regarding individual users. On the contrary, Concept Mapping summarizes concepts gained from analyzed information. It focuses upon relating segments within the main domain, thereby presenting relationships and information cross-links which reflect concrete understanding, and can be used to communicate with others.

Research Methodology

This longitudinal study aimed to develop analytical thinking skills of graduates. The teacher in this study used research-based learning as a medium of instruction, and used concept mapping as a learning tool with variables contained within three loops, as follows: R1D1; using concept mapping with research-based learning, R2D2; using concept mapping and mind mapping, and R3D3; using Cmap Software to create concept mapping. R2D2 and R3D3 also used research-based learning. A classroom participatory action research was conducted to collect data from graduate students who enrolled on the 'Comparative Higher Education' course in 2012-2013. Students were expected to have reading skills and be able to analyze and organize information they read from documents in websites, and from research papers and academic articles. In each semester, students' analytical thinking skills were evaluated via eight analytical thinking skills forms. Additionally, reflective journals and in-depth interviews were employed to gain more qualitative data. Then, all data was summarized to find students' analytical thinking skills. Data collected from teachers was that of reflective journals of teaching and learning, which occurred in each research loop. Lesson planning stages, teaching stages and evaluating stages were qualitatively analyzed.

Data analysis

The data analysis was divided into two parts; teachers and students regarding research loops. In the student part, students' analytical thinking skills were individually

evaluated. That is, quantitative and qualitative data were analyzed. Quantitative data included eight pieces of work created by using concept mapping. The analysis of students' work was based upon 'Bloom's elements', which comprised content analysis, relationship of information analysis, and principle analysis. The scoring criteria used in this study were adapted from Novak and

Gowin's Scoring Criteria (Novak and Gowin's Scoring Criteria, 1984). It was used to evaluate particular features of the Cmap product created by graduate students. The researcher did not make comparison of students' scores. Since RBL in this study was reported research where the majority of data was gained from students' learning autonomy, the Cmap products could not be compared to each other. The scoring criteria included: Preposition (1 point), Hierarchy (1 point), Cross-links (2 points/link), Exemplification (1 point), and Understanding the Principle (5 points).

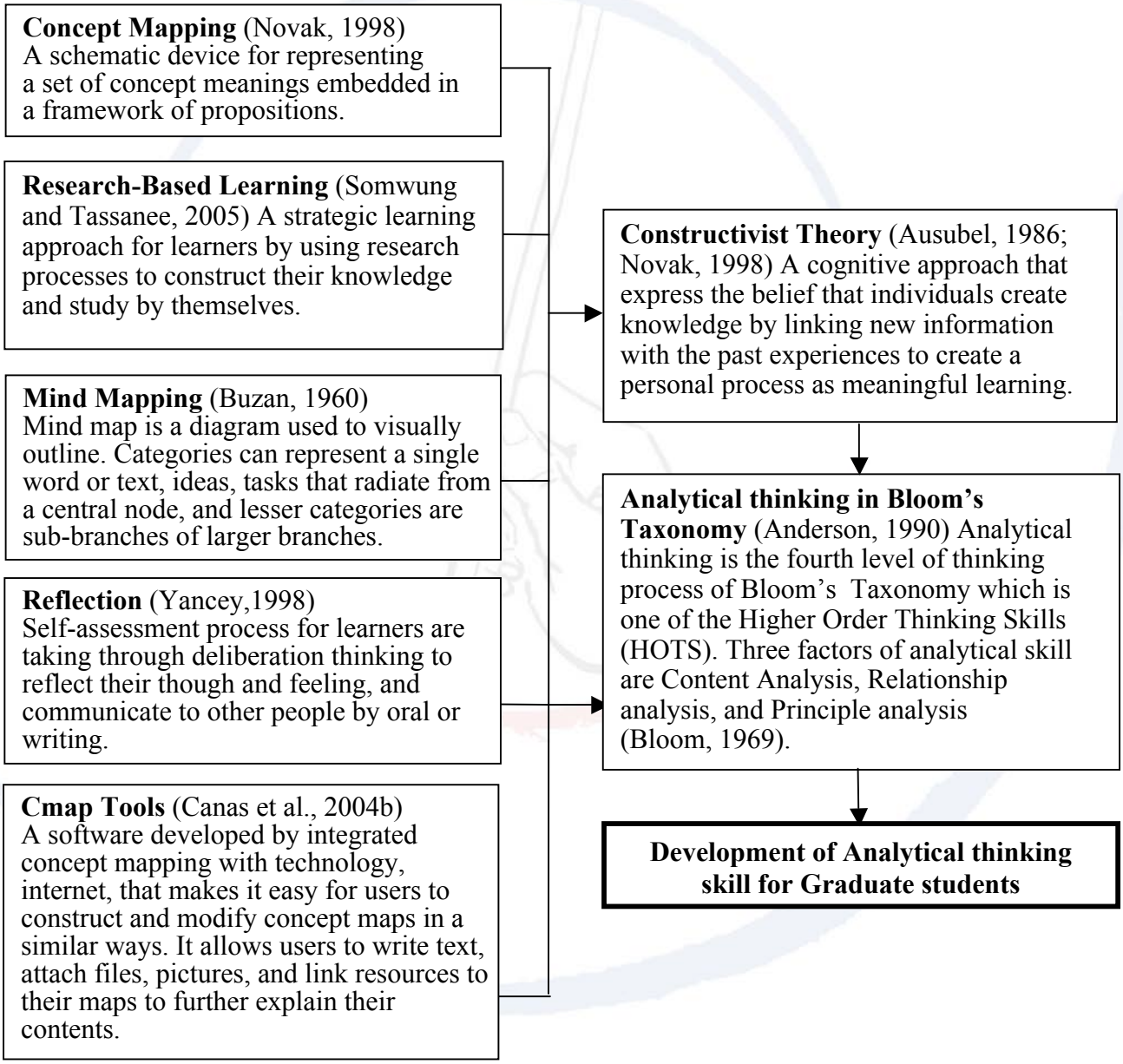


Figure 3. Conceptual Framework

Furthermore, students' analytical thinking skills which occurred from using concept mapping were qualitatively analyzed using content analysis. Data collected from students' reflective journals expressed students' before and after uses of concept mapping in their learning processes, as well as in-depth interviews also being qualitatively analyzed.

Results

The results of this study were separated into three sections with regard to the research loops, R1D1, R2D2, and R3D3, and included two parts: the evaluation of students' analytical skills in terms of process and product from concept mapping, and; students' reflective thinking from teachers' and students' points of view. The results are described, as follows:

Data was collected from students who enrolled on the Comparative Higher Education Course, an elective course offered for doctoral degree students. This course was taught by one teacher, and there were three students who enrolled in the first semester of 2012, two students in the second semester of 2012, and another five students in the first semester of 2013. Therefore, there were ten graduate students; four of them males and the other six females, and they all aged between 33-48 years old. In this study, all of the graduate students did not know about, nor had they ever used, concept mapping before. However, six of them knew about mind mapping. Half of the graduate students had experienced using mind mapping, and there was only one student who always used mind mapping in the learning process. An evaluation of students' analytical thinking skills from their Cmap products was an evaluation that summarizes particular features of map building, based upon their abilities to analyze and organize concepts and sequence relationships systematically. Table 1 indicates that graduate students had the ability to analyze 'Proposition' at an average of 39.1, with concept hierarchy at 3.25. On the other hand, cross-links appeared to be low, at an average of 1.01. The Cmap represents an understanding of concepts, at an average of 3.6.

Table 1:
Assessment of critical thinking skills of learners by concept mapping products

Concept mapping Characteristics	Analytical Thinking score													
	Mean (R1D1)				Mean (R2D2)			Mean (R3D3)						Total Mean
	1	2	3	Total Mean	4	5	Total Mean	6	7	8	9	10	Total Mean	
1) Proposition	62.38	38.38	29.5	43.42	43.5	26.75	35.13	69.38	23.63	28.5	36.63	35.5	38.73	39.1
2) Hierarchy	4.75	3.63	3.13	3.84	3.5	2.88	3.19	3	2.25	2.38	2.38	3.63	2.73	3.25
3) Cross links	0	1.88	0.63	0.84	0.75	0.25	0.5	4	0	4.5	0	0	1.7	1.01
4) Exemplification	3.25	0.63	0	1.29	1	0.63	0.82	0.5	0	0	0	0.13	0.13	0.75
5) Understanding the principle	3.38	4	2.88	3.42	3.75	2.63	3.19	4.75	5	2.75	3.5	5	4.2	3.6

The results of the analysis of reflective journals of teacher and students, together with the Cmap products which have effects upon the development of students' analytical

thinking skills; by using Concept mapping and Research-based learning in R1D1, Mind mapping in R2D2, and Cmap Tools Software in R3D3, which are summarized as follows:

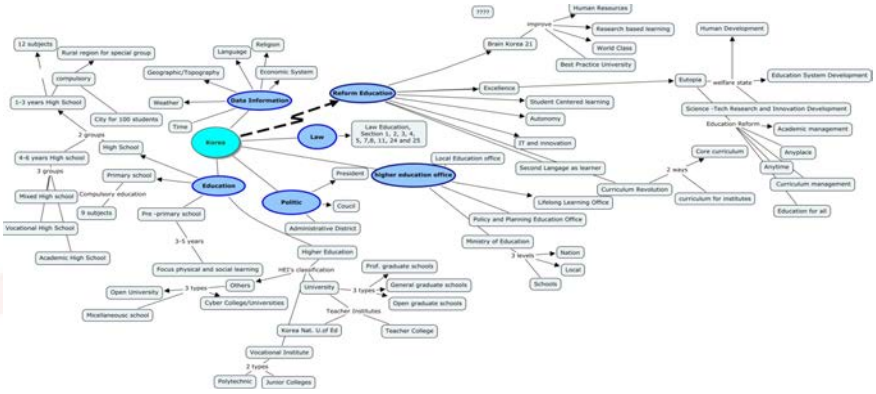
Teachers: With regard to reflection, it was found that teachers had to select schooling materials which were not too unsophisticated in content, and were suitable for a period of time that permitted students to gradually develop the analysis process. However, studying sources of information in which the contents were too small, too narrow or had little diversity, resulted in a lack of in-depth information and a lack of synopsis of other concepts, otherwise needed to integrate information building within concept mapping. For example, building concept mapping from only one article could probably not be substantially summarized. The overall image and linkage of knowledge could not be seen as building concept mapping from research documentation, teaching, or study information from multiple sources.

Students: It was found that concept mapping was a good tool for learning. It helped to develop the process of critical thinking in students, especially during the working process. It helped students to analyze documents systematically, and reflect upon their understanding of the concepts of learning in each subject, concretely and clearly. Furthermore, the development of building concept mapping in students could increasingly be better formed, in accordance with the understanding of this method. With regard to the reflection results of students, it was found that applying concept mapping was useful, resulted in students having the necessary analytical processes needed to classify information, and it led to the outlook of larger sets of information available for good memorization. The overall image of contents could be more obvious and easier for presenting information. In addition, some students have adopted such techniques to supplement other subjects, as well.

The problem of usability: It was found that students who did not previously know of concept mapping developed confusion with mind mapping, as they both had similar processes for creating maps. However, mind mapping was concluded by highlighting the main details of each concept, rather than a summary of concepts and coherence of the concepts. Students who had basic use of mind mapping performed better than those who had never experienced that basis before. In addition, most software which students opted for was typically developed on the basis of mind mapping concepts, more so than concept mapping, and this resulted in students being easily confused between both concepts.

Brainstorming Software
(https://bubbl.us.)

NovaMind 5 Software
(www.novamind.com)



Florida Institute for Human and Machine Cognition (IHMC) (www.ihmc.us)

Figure 4. Examples of concept mapping by learners (R1D1)

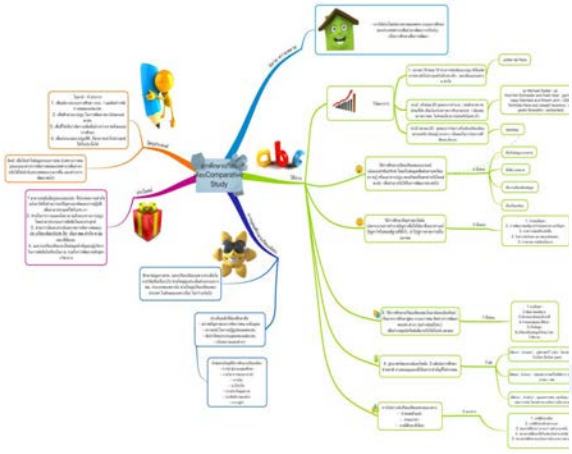
R2D2: Using Concept mapping with Mind Mapping. This research had the hypothesis that schooling management, in allowing students to practice the use of mind mapping and concept mapping in the same semester, would develop the necessary critical thinking skills required of students and help them to clearly understand the differences between both concepts. The researchers determined that students need to start practicing the use of mind mapping before the first half semester, and then switch to concept mapping.

The results showed that both concept mapping and mind mapping were learning tools which could develop the critical thinking skills of students, as well underline the objectives and outline the different contents needed. Applying these techniques required time and constant practice. However, only half a semester was not enough, and students could neither understand nor consider the differences between both concepts. Furthermore, software which was free mainly was developed from mind mapping. It could be utilized and understood more than software developed from concept mapping, resulting in students selecting to learn mind mapping more that concept mapping.

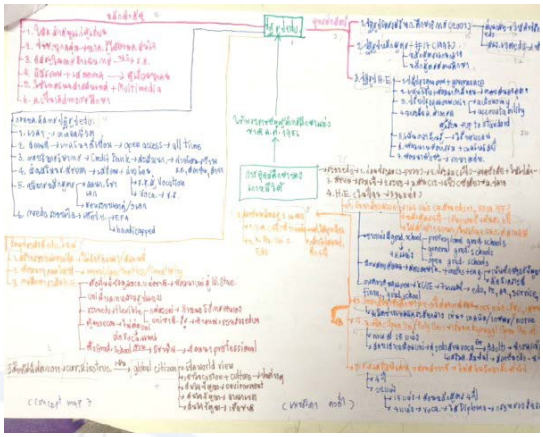
Teachers: It was found that schooling management, when using both tools, required time in the first period for students to have an opportunity to practice self-learning for a while. Otherwise, students would neither have sufficient expertise nor understanding.

Students: It was found that two students in this group had a learning problem with both concepts in the same period, primarily because those students had never understood or used concept mapping or mind mapping to build mind mapping in the first period that students were unfamiliar with. Thus, applying the existing ways, such as taking notes, was integrated into the map building technique. Furthermore, when the students became accustomed to using mind mapping it was difficult to change to using concept mapping. Using software also had great affects against the motivation for creating maps because the software developed, based upon the concept of mind mapping (such as Novamind, Imindmap), was interesting and easy to use; as opposed to the software developed based upon the concept of concept mapping (such as IHMC). Thus, the map created had combinations of both concepts and included previous experience of students. In addition, students held onto the use of mind mapping until concept mapping could no longer be applied correctly in principle. This reflected that learning and practice with the use of both learning tools required much time, to learn and practice. However, although mind mapping had a purpose and an

objective differing from concept mapping, it was a tool that equally developed critical thinking for students.



Imindmap software



Note taking mixed mind mapping

Figure 5. Examples of concept mapping by learners (R1D1)

R3D3: Using Concept mapping with Cmap Tools Software. The findings in R1D1 and R2D2 reflected that software had a tremendous impact upon the use of concept mapping, because most programs developed from the concept of mind mapping made students easily confused with concept mapping. Therefore, the research of R3D3 assumed that concept mapping, using software developed according to the concept of concept mapping, was only a single tool used to help develop critical thinking skills of students, and help their understanding of the principles and creation of the map as being the correct map.

The results showed that the Cmap product evaluation, and the reflection of students for using the Cmap tools software as a learning tool, helped students develop critical thinking skills in an efficient way, and made students correctly understand the principles of concept mapping, and thus enabled better development.

Teachers: It was found that Cmap tools software, used as a learning tool with complexity of usability, required training to recommend its use and emphasize to students the need to practice with the system and develop expertise. It helped students to become familiar with, and reduce bias towards, the complexity of the program. Moreover, teachers need to immediately provide feedback to students after submitting each new cmap product, so that students would have a clear understanding and subsequently develop the critical thinking process, as required.

Students: It was found that during the first use of Cmap tools students spent most of their time completing the first cmap product, and spent less time when they had more expertise. The reflections of students found that concept mapping helps students to use critical thinking for extracting the essence of knowledge, and that they must try to analyze the relationships of the relevant information, resulting in further development of the critical thinking process.

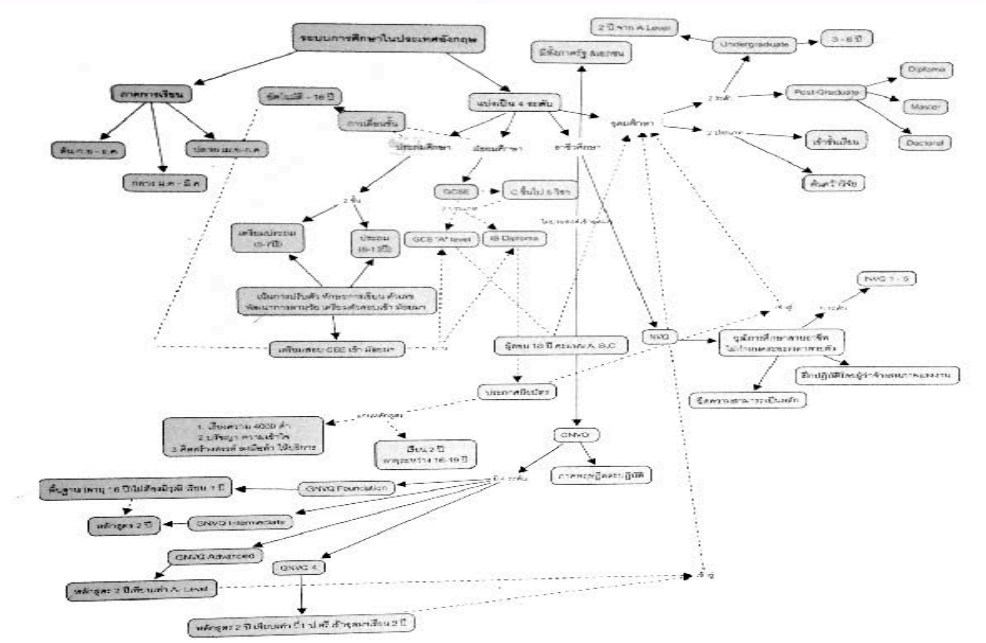
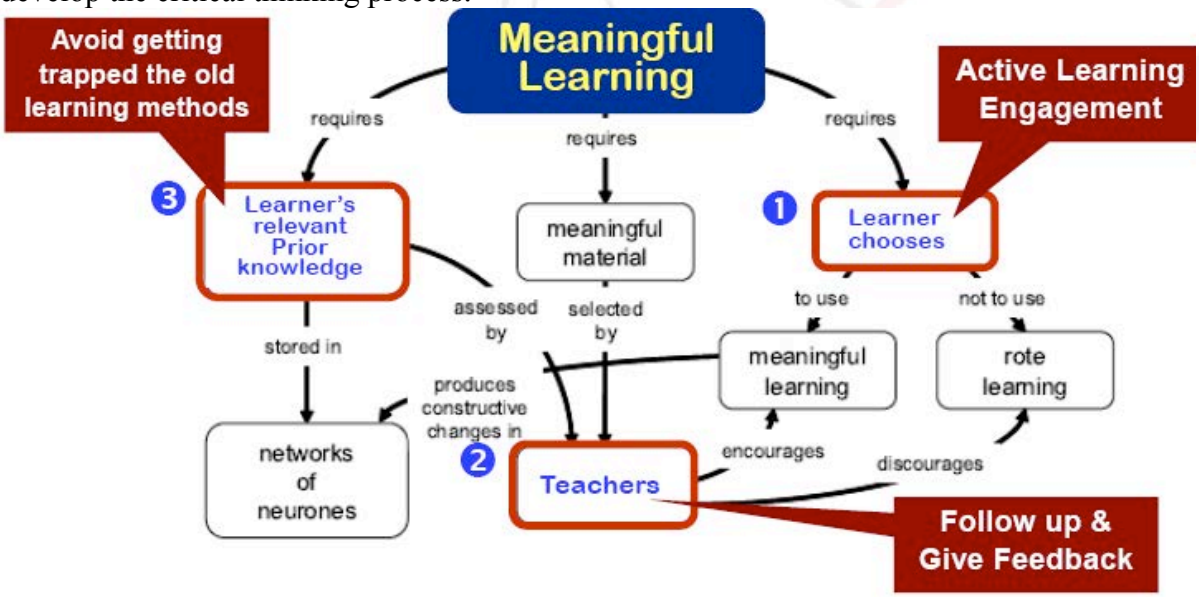


Figure 6. Examples of Concept mapping by learners (R3D3)

Conclusion and Discussion

The research results, as aforementioned, reflected that using concept mapping was deemed as a good learning strategy for the development of critical thinking of students, especially at the graduate level, since concept mapping allowed students to practice their ability to solve problems and think critically. Moreover, it helped develop educational achievement by creating positive attitudes for students, in a course that focuses upon content (Daley, BJ, 2004). It helped students to reduce anxiety about remembering the contents and changing their focus to understanding, interpretation of extracting the essence and analysis of information linkage, and understand the principles of knowledge. This would enable students to gradually develop the critical thinking process.



Developed from Novak's Concept map of Meaningful learning (after 1998)

Development of teaching strategies: Concept mapping could help improve the teaching quality of teachers to be more effective, because they had to plan their teaching very well. Preparing document materials with synthesized contents helped students, who were inexperienced in using concept mapping, to more easily summarize the subject matter. The priority of contents in the synthesized documents was conducted according to the sequence of profundity as well. It would support students to more easily understand the contents and the method of building concept mapping. However, teachers should realize that understanding the procedures and practices needed to create concept mapping, for students who never had the experience before, would take a longer time to build a Cmap product for each sheet. Nevertheless, the period of time would gradually decrease as the number of applications and the expertise of the users increased. Moreover, the major challenge for teachers in higher education was to change their teaching methods to be appropriate for the methods of adult student learning. Using concept mapping helped teachers to more deeply understand the 'contructionism' pattern, whereby it became a tool used to reflect the understanding of students. Furthermore, it encouraged people to change the thinking process of students in the long run (Daley, 2004). In addition, applying technology to create cmaps was deemed as the major challenge for teachers and students, for understanding and using software to create maps suited to the learning objectives and contents, and for teaching the software. This was because software was mainly developed based upon the concept of mind mapping for the purpose of brainstorming, recording and summarizing the content. It focused upon key words of the content, rather than a summary of the essence of the concept and analysis of linkages of the relevant concepts, in order to conclude the overall principle of the contents. Using Cmap Tools was not only to build cmaps as the correct principles of concept mapping, but was also to allow teachers to use other functions of the software for learning activities in the classroom, such as brainstorming, or as a source of self-learning by also attaching files with pictures to link them into created cmaps (Novak and Cañas, 2008). Developing evaluation strategies: The results reflected that Cmap products for each sheet could reflect the understanding of students regarding the concrete contents. It also reflected that students had a clear understanding of the contents, and enabled teachers to resolve or explain and help increase the understanding of students for each point. It was deemed that the evaluation of students was obvious and rapid (Novak, and Cañas, 2008). However, it was noticed, in the evaluation of critical thinking skills of students, that they did have an understanding of the contents studied. Thus, it was essential for students to practice and have a clear understanding of the principles of concept mapping beforehand. Thus, they would be evaluated without interference variables, since the major drawback of using this learning tool was the effect caused by the software used to create the cmap software for most students.

Developing critical thinking skills of students: The research on analysis from cmap products with the reflection of individuals showed that reflection was the evaluation of critical thinking skills of students in the thinking process. They had the same reflection that, which despite in the beginning they felt they were impractical and uncomfortable with due to unfamiliarity, when they gradually practiced they found that concept mapping helped to develop their critical thinking process, because they had to read the documents at least two times – first, when reading the overall content to understand the contents, and then to read them for a second time to conclude the synopsis of the content. After that, in the relationships of information and conclusions of significant principles, the contents would be sequenced. The development of the

thinking process required time and continuity. Learning for only one semester was not enough, if students used it to learn other subjects and develop their critical thinking and better development, continuously and respectively. However, using concept mapping had to arise from the interest of students. They had to consider naturally active learning engagement as being important, because meaningful learning would occur when students decided to learn by themselves, so that they could finally change the learning method from rote learning to meaningful learning. At the same time, teachers had to monitor the progress of students for creating cmaps, and give immediate feedback so that students could develop the learning process by themselves and to their full potential.

Another important observation in the R2D2 research found that the learning processes of students still adhered to the existing ways of learning, such as note taking. Thus, students could not overcome the original methods of the development of the critical thinking process. These reflected in that the role of teachers was highly critical to the learning processes of students, in terms of teaching, assessment, and the development of the learning processes of students.

Recommendation

The three research results reflect that the selection of good learning tools, such as concept mapping, affect the real learning processes of students. Therefore, schooling in higher education should be further developed, especially in the social sciences, and include the study of utilization from the package program, in order to develop the schooling process for critical thinking in higher education, and for the continued utilization of other functions of Cmap Tools software in higher education schooling.

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