

## THE EFFECT OF CONCEPT MAPPING ON EFL STUDENTS' MEANINGFUL LEARNING OF ENGLISH READING COMPREHENSION

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**Abstract.** This study investigates the effect of concept mapping on EFL students' meaningful learning of English reading comprehension. 61 high school female students were randomly assigned to experimental and control group in Karaj and their academic achievement by quasi-experimental design with pre-test and post-test was studied. The research instrument was a teacher-made academic achievement test, in which the high levels of cognitive questions (analysis, synthesis, and evaluation) were used to evaluate the meaningful learning of English reading comprehension. The data were analyzed with t test, and the results showed that concept mapping strategy has a positive effect on English academic achievement and meaningful reading comprehension in students.

### 1. Introduction

Learning and academic achievement have always been of great interest for educational systems around the world. Bruner (1966), the theorist of discovery learning, believes that the educational theories should address the question of how to learn better and more. Accordingly, educational psychologists have proposed some learning strategies for a better learning; these learning strategies teach learning methods and accurate studying.

Park (1995) defines learning strategies as the "mental activities that people use when they study to help themselves acquire, organize, or remember incoming knowledge more efficiently". There are a number of learning strategies that can help students to become more sophisticated learners, and thus better able to learn and to achieve in the classroom over the long run. These strategies include recognizing important information, note taking, summarizing and meaningful learning (Pressley, 1982; Weinstein, 1988).

One of new strategies based on Ausubel's meaningful learning is of concept mapping. Concept map was proposed to confront the non-meaningful learning and as a result of Novak and his colleagues research to find a way to offer the concept perception. According to Ausubel (1968), meaningful learning means integrating new subjects to previously learnt material into one's cognitive structure. Cognitive structure involves an organized set of principles, concepts and information that the individual has learned and is a hypothetical pyramid in which more general concepts and subjects are placed at the higher places and more detailed subjects are placed in the lower level of the mentioned pyramid. If the learner relates the new subjects to the ones learnt before in his/her cognitive structure, the learning is regarded as meaningful; however, if the new information is acquired through repeating, practice and without relating it with the previous subjects, his/her learning is regarded as rote learning. Therefore, students need encouragement to learn meaningfully. The use of concept maps can be a powerful aid to achieve meaningful learning (Novak, 1991)

Although concept maps have been demonstrated to be a powerful instructional tool in different educational areas, most studies have been focused on scientific and technical areas (Rueda, 2009), less attention has been given to theoretical areas such as literature, history and teaching second language. A lot of Iranian students have problem in English reading comprehension. Not only the high school students have this problem, but university students also do. In spite of the fact that students start Studying English from sixth grade and continue to the last year of high school, they use the meaningful learning techniques a little and the results of institutes exams, final exams, and national entrance exam show that the English level of students is low and the students are weak in applying English language.

Although researches support concept mapping as an effective method on meaningful learning, not enough steps have been taken to apply this teaching-learning method in classrooms. This study is an attempt to investigate the effect of concept mapping on English improvement and reading comprehension meaningful learning of EFL students.

### 2. Concept Map

Concept maps are tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions, (indicated by a connecting line

and linking word) between two concepts. Linking words on the line specify the relationship between the two concepts. Propositions contain two or more concepts connected with other words to form a meaningful statement (Novak, 2008). Concept maps can be applied as a learning strategy (Novak, 2004, Quinn et al, 2004), teaching strategy (Marangos & Alley, 2007) and assessment tool (Novak, 2008, Williams, 2004). Concept maps are applied in teaching and learning in different methods, one of the major methods of applying concept map is making the maps by the learners. In the process of concept mapping, the learner links the new material to familiar ones in his cognitive structure and shows it in terms of a graphic design by combining, linking and hierarchically organizing the concepts; this process contributes to meaningful learning.

A concept map is a powerful tool in facilitating meaningful learning (Novak & Cañas, 2006, Cañas et al, 2003, Irvine, 1995) and due to presenting a pattern and a framework to create and organize the knowledge, that not only permit utilization of the knowledge in new contexts, but also the retention of the knowledge for long periods of time (Novak & Wandersee, 1991). Concept mapping as a learning strategy changes the learning direction from a teacher-based to student-based by activating the learner in the learning process; therefore, causes an improvement in academic abilities and proficiency (Laight, 2004, Peterson and Snyder, 1998) and also increasing the students' marks (Marangos, 2000). Research has proved the effectiveness of concept mapping on meaningful learning (Novak, 2003, Trifone, 2006). Retention and retrieval (Hall and, O'Donnell 1996), perception and understanding (Kimber et al, 2007), academic achievement (Brussow and Wilkinson, 2007, Hauser et al, 2006), English comprehension and learning second language (Dias, 2010, Conlon, 2008, Liu et al, 2010, Marriott & Torres, 2008, Vaklifard & Armand, 2006, Ojima, 2006, Bahr & Dansereau, 2001, Chularut and Debakar, 2004, Koumy and Salam, 1999). Individuals, whose native language is not English, require techniques to learn better, retain longer and apply the language in new situations. Furthermore, the teachers are seeking educational methods that help the students to be activated in learning process and their achievement. Among effective factors on learning and teaching language, teaching-learning strategies have important role in learning in which concept mapping is the focus of attention.

### **3. Research Background**

Since 1976, that Novak proposed concept mapping, concept maps have been used widely in different fields. The studies have shown the significant effect of concept mapping on meaningful learning (Horton et al. 1993, Novak & Cañas, 2006, Novak, 2010). Most of the conducted studies have focused on first language and few researchers studied second language learning.

Moreira & Moreira (2011) used concept maps as an instructional tool to foster the construction of knowledge in Foreign Language Education classes. The findings of the study showed that using concept map can help students build up self-confidence on their ability to use newly acquired/learned concepts in new contexts. Liu & Chen (2010) investigated the Effects of a computer-assisted concept mapping learning strategy on EFL college students' English reading comprehension. The results suggested that concept-mapping strategy not only causes reading comprehension improvement, but also improves other reading strategies using.

Dias (2010) used concept maps for enhancing Bachelor students' English reading comprehension as L2 in Brazil. The findings showed that the construction of meaning by the creation of concept maps can be an effective reading strategy in English as an L2. Moreover, the students not only learnt how to create map by using the software CmapTools (Cañas *et al.*, 2004), but they also could empower in the development of their autonomy concerning ways to organize knowledge acquired from texts. Lee and Cho (2010) in a study on Korean students titled "Concept mapping strategy to facilitate foreign language writing: a Korean application" concluded that concept mapping was beneficial in improving Korean students writing skill in general, and in improving the organization, language use, and vocabulary in writing in particular.

In a study by Chularut & DeBacker (2004), the influence of concept mapping on achievement, self-regulation, and self-efficacy in students of English as a second language were investigated. The subjects of the study were college and high school students who were studying English in private English centers. The findings of the study showed that a group of students who used concept mapping, achieved higher scores in their self-efficacy and self-regulation in comparison to control group.

Armand & Vaklifard (2006) studied the effects of 'concept mapping' on second language learners' comprehension of informative text. The results of this study indicate that the subjects of the experimental group obtain higher scores on the comprehension questions than those of the control group. Ojima (2006) conducted a

case study of three Japanese ESL writers in Japan on the effect of concept mapping as pre-task planning. The results showed that concept mapping improved writing skills of English learners as a second language.

It should be mentioned that most academic researchers have studied concept-mapping strategy as an academic project and haven't used it in real formal classrooms. In the current study, the researcher investigated the effects of concept mapping on students reading comprehension abilities in official classroom.

#### 4. Research Goals and Hypothesis

The purpose of this study was to investigate the effectiveness of concept mapping on English improvement and reading comprehension meaningful learning of EFL students. Research hypothesis include:

H1: Concept mapping effects on students' academic achievement of English language.

H2: Concept mapping effects on students' meaningful learning of English reading comprehension

#### 5. Methodology

##### 5.1 Participants

Sixty-one female students in third grade of high school in Karaj city who were studying during the school year 2013-2014 were selected through purposive sampling and were randomly assigned in experimental and control groups. Their field of study was literature and human science. Official restrictions and not intending to interrupt current educational schedule were the reasons why we applied purposive sampling.

##### 5.2 Instructional materials

English language book 3, which is a third grade high school textbook, was selected as the instructional material. This book is reading base one, 65% of which is composed of reading, comprehension and vocabulary. The book is composed of 6 lessons, each including a 6 to 7 paragraph - reading, vocabulary, language function, grammar and pronunciation. The focus of the research was reading comprehension.

For each lesson the researcher and teacher, using the software Cm tools designed a concept map. A linguist expert and four experts of the English teaching group approved the maps. The maps were of hierarchical type in which major and more general concepts were placed in higher locations and special and more detailed concepts were placed in lower place. These maps were regarded as the standard maps (see Figure 1).

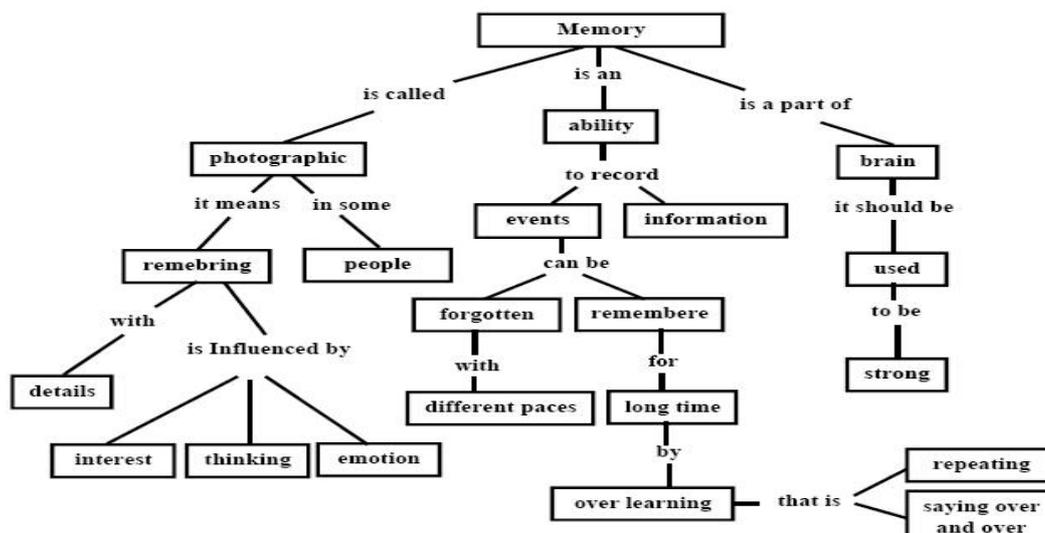


Figure 1. Example of criterion concept map constructed by researcher and teacher.

### 5.3 *Measurement tool*

Teacher-made academic achievement and criterion-referenced test were used to measure learners' academic achievement and meaningful learning. The test questions were designed based on Bloom's classification of cognitive domain (1956) in levels of knowledge, understanding, application, analyzing, composition and evaluation. The questions were multiple choice, short-answer, match, and concept map design and incomplete concept mapping template. Concept map and analyzing, synthesis and evaluation level questions were applied to assess the meaningful learning. The following steps were taken to propose the academic achievement test:

1. Preparation the instructional objectives for each lesson
2. Designing table of contents for each part of the book: In this stage, the proportion of each part of the content, reading, vocabulary, language function, grammar and pronunciation was specified based on the allocated time and volume and then the proportion of each part in the number of the related questions was determined (10 parts, 40 questions).
3. Designing two dimensional table of specification of objective and content: The table included two entries; the row of the table showed sections of each lesson, the columns showed the levels of Bloom's cognitive classification and the table cells showed the proportion of each part of the test's total score. In order to certify content validity of the academic achievement test, the questions were designed based on objective -content table and after final designing of the questions; the test was approved by five experts in English language experts. The test reliability was calculated with Kuder-Richardson20 which was 0.93.
4. Evaluation of the Questions: Five experts in English language educational group studied the test questions and some corrections were done. Furthermore, the test was primarily performed for the students of two classes (40 students), coefficients of difficulty and discrimination were calculated and the weak questions were revised and corrected.

### 5.4 *Research design and procedures*

The methodology is a quasi-experimental design with a pre-test and a post-test. Concept mapping as a learning strategy was regarded as the independent variable; meaningful learning and academic achievement were regarded as the dependent variable and were assessed through an academic achievement test. The experimental group was instructed by concept map strategy and the control group was instructed by current methods of teaching, asking and answering. To control the effective factors on the students in control and experimental group from high school grade, field of study, previous year average, gender and age the school of studying and teachers have the same conditions. The research was performed in 4 steps:

1. Preparation Stage: In this stage, activities such as instructing the teacher, preparing the lesson plan, preparing the concept maps, preparing academic achievement test and selecting the sample were performed.
2. Pre-test: Before exposing the students to any instruction, a teacher made test was administered to the selected subjects to be sure of their homogeneity.
3. Training stage: Instruction by concept map method was performed through 12 (60-minute) sessions, every two weeks during a school year. In the first session, the students became familiar with concept map, its features, how to make it and some related examples. In second and third sessions, first, the teacher with the cooperation of students read the text and explained complex words. Then, students were asked to specify main and related ideas of the text. The teacher wrote main and related concepts on the board and asked students to make a concept map individually. In these sessions, teacher helped students in concept mapping. In the following sessions they were assigned to create the concept map as homework, regarding the following stages:
  - Selecting the major concept of the text (using a question on the topic of the text)
  - Listing some text concepts and arranging them from more general to detailed
  - Specifying the relationship of the concepts
  - Linking the concepts to each other by directed and non-directed lines
  - Adding a word or statement to the line to present the relationship between the concepts
  - Hierarchically organizing the concept mapping

In the following sessions, the students made the maps. The process of the other sessions included collecting students' maps, assessing the previous learning based on the concept mapping (two or three students presented their maps), returning the previous maps through oral and written feedback and instructing the new lesson. A point was allocated to each concept map as a part of class activity (see Figure 2). The control group students were instructed to the same lesson through the traditional method of teaching (e.g., giving lectures for teaching vocabulary and grammar, reading the text).

- Assessment Stage (post-test): At this stage, the students of two groups participated in the final exam for measuring their achievements, their meaningful learning of reading comprehension of the book texts; the allocated time was 90 minutes.

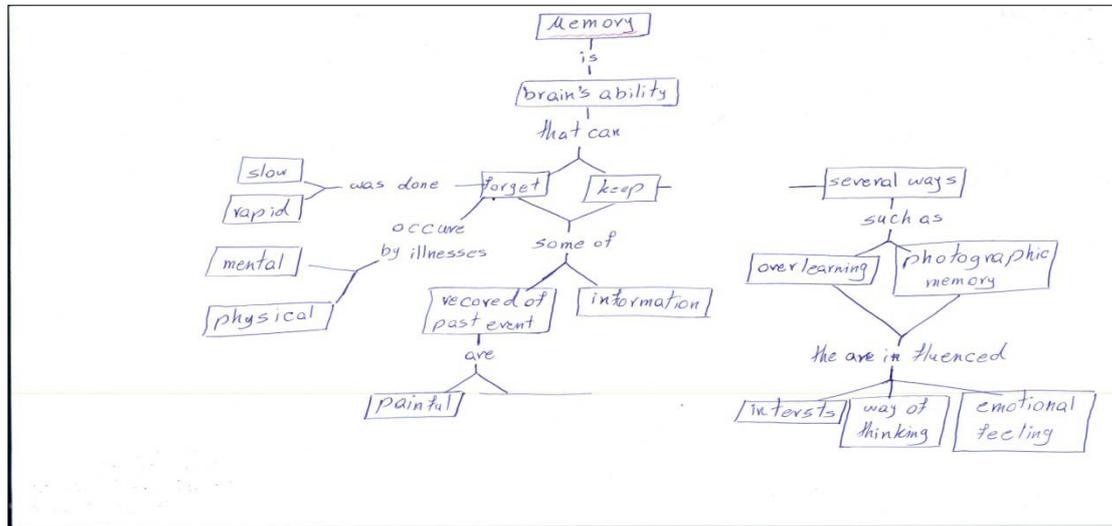


Figure 2. Example of concept map constructed by a student.

## 6. Results

Mean, standard deviation and *t-test* were used to statistically analyze the data and research hypothesis. To discuss the differences between two groups' English post-test, first the differences between two groups in pre-test were compared with a *t-test*. The results of *t-test* to compare the difference between two groups, have been shown in table 1. The results show that there is no significant difference between them ( $0.05 < p$ )

Group	N	Mean	Std. Deviation	t	Df	Sig.
Experimental	31	7.74	2.29	1.55	57	0.124
Control	28	6.89	1.83			

Table 1. The results of *t-test* to compare the control and experimental groups in the Pre-test Scores.

Regarding the first hypothesis of the research, "Concept mapping effects on students' academic achievement of English language", the results of the *t-test* to compare the two groups, are presented in table 2. Because the level of significance of the table (0.026) is less than 0.05 Alfa, the research hypothesis regarding the effect of concept mapping on academic achievement of English language is approved. Since the mean of the experimental group, which was exposed to independent variable, is 13.19 and the mean of the control group, which was not exposed to this variable, is 11.31, this increase can be attributed to the impact of the independent variable.

Group	N	Mean	Std. Deviation	t	Df	Sig.
Experimental	32	13.19	3.5	2.28	59	0.026
Control	29	11.31	2.9			

Table 2. The results of *t-test* to compare the control and experimental groups in language learning achievement.

Regarding the second hypothesis, "concept mapping effects on students' meaningful learning of English reading comprehension", the results of *t-test* to compare the two groups, are presented in table 3. Regarding the fact that the level of significance in the table (0.0001) is less than 0.05 Alfa ( $p < 0.05$ ), the research hypothesis regarding the effect of concept mapping on meaningful learning of English reading comprehension is approved.

Since the mean of experimental group, which was exposed to the independent variable, was 13.53 and the mean of the control group, which was not exposed to this variable, was 6.95, this increase of the mean can be attributed to the impact of the independent variable.

Group	N	Mean	Std. Deviation	t	Df	Sig.
Experimental	32	13.53	4.36	7.875	41.549	0.0001
Control	29	6.95	1.7			

**Table 3.** The results of t-test to compare the control and experimental groups in meaningful learning of reading comprehension.

## 7. Discussion

Applying concept map as a learning strategy was effective improvement of academic achievement and meaningful learning in language learning. The students in the experimental group who were taught by concept map strategy and created it got better scores in academic achievement test in comparison with the control group who were taught by traditional (lecture) method. Since students participated actively in the construction of knowledge and were encouraged to present their perception in the text in terms of concept mapping, their learning was improved. The results of this research are in accordance with that of (Dias, 2010, Vakilifard & Armand, 2006, Chularut & Debakar, 2004, Brussow & Wilkinson, 2007, Trifone, 2006, Mesrabadi *et al*, 2008).

Regarding the impact of concept mapping on meaningful learning, the results showed that the scores of students in the experimental group have significant differences in higher cognitive levels (analysis, synthesis, evaluation). This shows the impact of concept mapping in facilitating the meaningful learning. Meaningful learning means that the learner can organize the information and assimilate them in his/her knowledge framework. Creating the concept mapping requires understanding, recognizing the main concepts, linking the concepts with previous ones, establishing new bonds and organizing the concepts. This process causes meaningful learning and applying higher-level cognitive functions. The results of the research are in accordance with the findings of Moreira, & Moreira, 2011, Liu *et al*, 2010, Conlon, 2008, Ojima, 2006, Erdem *et al*, 2009, Novak, 2003, Novak & Cañas, 2006.

During concept mapping in reading comprehension, the learners learned and used learning strategies like recognizing important information, summarizing, reviewing, expanding and organizing the concepts and text structures and presenting the concepts in the form of showing. Also finding out the topic and the concepts of the text causes the concentration of the students and reviewing the text for several times. Therefore, it causes the transformation of the information to long-term memory, retaining and recalling the materials. Creating the concept map helps learners to retrieve old information already learned and combine them with new knowledge to learn more new vocabulary and concepts and also their use in new situations. On the other hand, the process of creating concept map requires the activating of learner in learning process and interaction with instructional materials. Activating the learner in the process of learning causes the improvement of academic learning and increasing the students' scores (Laight, 2004, Peterson. & Snyder, 1998, Marangos, 2000)

Creating the concept map is a feedback for both the teacher and students to recognize the knowledge and understand the subject and point out the learning deficiencies. Furthermore, assessing the students' learning by the map and considering a score for drawing the concept map was an external motivation for the students and they recognized the impact of the mapping on deeper understanding of the text and on their ability to better retain and recall the vocabularies.

This research showed the impact of concept mapping on deep and meaningful learning of the English language, achieving higher cognitive levels, activation of learner in the learning process; it is suggested that learners apply the concept map to deepen and strengthen their learning and teachers improve students' learning and academic achievement using concept map as a teaching strategy, learning task and assessment tool.

## 8. Limitations of the Study

As all other interventional studies, this study had some limitations. Due to some Ministry of Education's strict rules, the researcher could only use a small sample size. The sample was a nonrandom and affected the generalization of the study. Second, the study took place in an official classroom in the school with only two hours of English study in a week. Creating the concept map of a course is difficult and time consuming and needs lots of hard work. Because both the students and teacher had to finish the book on time based on the Ministry of Education's schedule, therefore they paid less attention to concept mapping activities.

## 9. Summary

This quasi-experimental study aimed at the effects of concept mapping on students' meaningful learning of English reading comprehension. The experimental group received concept mapping as a reading strategy in teaching. While the control group taught with traditional method. Teacher made achievement tests were given to the students to evaluate their meaningful learning and achievements. Test marks showed that those of experimental group significantly did better comparing to control group. It is hoped that the findings of this study will help improve reading comprehension in EFL classes and help teachers to promote their knowledge and find different ways of teaching reading strategies. Further studies need to be done to approve the findings of this study due to some before mentioned study limitations.

## 10. Acknowledgements

This study is a part of my dissertation research. Special thanks go to Dr. Golnar Mehran for her assist in this study. Special thanks go to the teacher (Maryam Mohammadi) and the students for their cooperation.

## References

- Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart and Winston.
- Bahr, S., & Dansereau, D. (2001). Bilingual Knowledge Maps (BiK-Maps) in Second Language Vocabulary Learning. *Journal of Experimental Education*, 70(1), 5-24.
- Bloom, B. S. (1956). *Taxonomy of Educational Objectives; the Classification of Educational Goals* (1st ed.). New York: Longmans Green.
- Brüssow, S.M. & Wilkinson, A. C. (2007). *Generative Learning and Assessment Strategies: An Investigation into Concept-mapping*. Assessment Design for Learner Responsibility 29-31 May <http://www.reap.ac.uk>
- Bruner, J. S. (1966). *Toward a Theory of Instruction*. Cambridge, MA: Harvard University Press.
- Chularut, P. & DeBacker, T. K. (2004). The Influence of Concept-mapping on Achievement, Self-regulation, and Self-efficacy in Students of English as a Second language. *Contemporary Educational Psychology* 29(3), 248-264.
- Cañas, A. J., Coffey, J. W., Carnot, M. J., Feltovich, P. J., Feltovich, J., Hoffman, R. R., & Novak, J. D. (2003). *A Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support*. Pensacola, FL: Institute for Human and Machine Cognition. [www.ihmc.us](http://www.ihmc.us)
- Cañas, A. J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., Lott, J, Carvajal, R. (2004). CmapTools: A Knowledge Modeling and Sharing Environment. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept Maps: Theory, Methodology, Technology*. Proc. of the First Int. Conference on Concept Mapping (Vol. I, pp. 125-133). Pamplona, Spain: Universidad Pública de Navarra.
- Conlon, T. (2008). Practical Text Concept Mapping: New Pedagogy, New Technology. In A. J. Cañas, P. Reiska, M. K. Åhlberg & J. D. Novak (Eds.), *Concept Mapping: Connecting Educators*. Tallinn, Estonia & Helsinki, Finland: Tallinn University.
- Dias, R. (2010). Concept map: A Strategy for Enhancing Reading Comprehension in English as L2. In J. Sánchez, A. J. Cañas & J. D. Novak (Eds.), *Concept Maps: Making Learning Meaningful*. Proc. of the Fourth Int. Conference on Concept Mapping. Viña del Mar, Chile: Universidad de Chile.
- Erdem, E., Yılmaz, A. & Oskay, O. O. (2009). The effect of Concept Mapping on Meaningful Learning of Atom and Bonding. *Procedia Social and Behavioral Sciences* 1 (2009) 1586–1590

- Hall, R. & O'Donnell, A. (1996). Cognitive and Affective Outcomes of Learning from Knowledge Maps. *Contemporary Educational Psychology*, 94-101.
- Hauser, S., Nückles, M. & Renkl, A. (2006). Supporting Concept-mapping for Learning from Text. Proceedings of the 7th International Conference on Learning Sciences, Bloomington, Indiana. International Society of the Learning Sciences 243 – 249.
- Horton, P.B., McConney, A.A., Gallo, M. Woods, A.L. Senn, G.J. & Hamelin, D. (1993). An Investigation of the Effectiveness of Concept Mapping as an Instructional Tool. *Science Education*, 77(1), 95-111.
- Irvine, L. (1995). Can Concept Mapping be used to promote Meaningful Learning in Nurse Education? *Journal of Advanced Nursing*, 21(6), 1175–1179.
- Kimber, K., Pillay & H., Richards, C. (2007). Technoliteracy and Learning: An Analysis of the Quality of Knowledge in Electronic Representations of Understanding. *Computers & Education* 48. 59–79
- Koumy, E., & Salam, A. (1999). Effects of three Semantic Mapping Strategies on EFL Students' Reading Comprehension. (ERIC Document Reproduction Service No. ED 435 193).
- Laight, D. W. (2004). Attitudes to Concept Maps as a Teaching/Learning activity in Undergraduate Health Professional Education: Influence of Preferred Learning Style. *Medical Teacher* 26(3), 229-233.
- Lee, Y. & Cho, S. (2010). Concept Mapping Strategy to Facilitate Foreign Language Writing: a Korean Application. Retrieved December 3, 2010 from <http://aatk.org/html>
- Liu, P. L., Chen, C.J., Chang, U. J. (2010). Effects of a Computer-assisted Concept Mapping Learning Strategy on EFL College Students' English Reading Comprehension. *Computers & Education*, 54, 436–445.
- Marriott, R. C. V., & Torres, P. L. (2008). Enhancing Collaborative and Meaningful Language Learning through Concept Mapping. In T. Sherborne, S. J. Buckingham Shum & A. Okada (Eds.), *Knowledge Cartography* (pp. 47-72): Springer London.
- Marangos, J. & Alley, S. (2007). Effectiveness of Concept Maps in Economics: Evidence from Australia and USA. *Learning and Individual Differences* 17, 193–199.
- Marangos, J. (2000). The effectiveness of Collaborative Problem Solving Tutorials in Introductory Microeconomics. *Economic Papers*, 19(4), 33–41.
- Mesrabadi, J. Fathi Azar, E. & Ostevar, N. (2008). The Efficacy of Provision of Concept Maps Preparation through per-planned Individual and Cooperative Methods as an Instructional Strategy. *Quarterly journal of Educational Innovations*, No.24, 83-92.
- Moreira, M. M. & Moreira, S. M. (2011). Meaningful Learning: use of Concept Maps in Foreign Language Education. *Aprendizagem Significativa em Revista/Meaningful Learning Review – V1(2)*, pp. 64-75.
- Novak, J. D. (2008). Concept Maps: What the Heck is This? Excerpted, rearranged (and annotated) from an Online manuscript by J. D. Novak, Cornell University, original manuscript was revised in 2008. available at: <http://cmap.ihmc.us/Publications/ResearchPapers/TheoryCmaps/TheoryUnderlyingConceptMaps.htm>
- Novak, J. D., & Cañas, A. J. (2008). The Theory Underlying Concept Maps and How to Construct Them. Technical Report IHMC CmapTools 2006-01, Pensacola, FL: Institute for Human and Machine Cognition. Available at: <http://cmap.ihmc.us/docs/theory-of-concept-maps>
- Novak, J. D. (2003). The Promise of New Ideas and New Technology for Improving Teaching and Learning. *Cell Biol Educ*, 2: 122-132.
- Novak, J. D., & Wandersee, J. (1991). Coeditors, special issue on Concept Mapping. *Journal of Research in Science Teaching*, 28(10).
- Novak, J. D. (2004). Reflections on a Half-Century of Thinking in Science Education and Research: Implications from a Twelve-Year Longitudinal Study of Children's Learning. *Canadian Journal of Science, Mathematics, & Technology Education* 4(1),23-41.
- Novak, J. D. (1991). Clarify with Concept Maps. *The Science Teacher* 58(7):45-49
- Ojima, M. (2006). Concept mapping as pre-task Planning: A case study of three Japanese ESL Writers. *System*, 34 (4), 566-85.
- Park, S. (1995). Implications of Learning Strategy Research for Designing Computer-assisted Instruction. *Journal of Research on Computing in Education*, 25(4), 435–456.
- Peterson, A.R. & Snyder, P.J. (1998). Using Concept Maps to Teach Social Problems. Analysis. paper presented at the Annual Meeting of the Society for the Study of Social Problems on 20 August. Columbus State Community College, San Francisco. 5-28.

- Pressley, M. (1982). Elaboration and Memory Development. *Child Development*, 53, 296–309.
- Quinn H.J., Mintzes J.L. & Laws, R.A. (2004). Successive Concept-mapping. *Journal of College Science Teaching* 33(3), 12-16.
- Rueda, U., Arruarte, A., Elorriaga, J. A., Herran, E. (2009). Learning the attachment Theory with the CM-ED Concept Map Editor. *Computers & Education*.52, 460–469
- Trifone, J. D. (2006). To What Extent can Concept Mapping Motivate Students to Take a More Meaningful Approach to Learning Biology?. *The Science Education Review*, 5(4), 2006
- Vakilifard, A. & Armand, F. (2006). The Effects of Concept Mapping on Second Language Learners' Comprehension of Informative Text. In A. J. Cañas & J. D. Novak (Eds.), *Concept Maps: Theory, Methodology, Technology*. Proc. of the Second Int. Conference on Concept Mapping (Vol. x, pp. xxx-xxx). San Jose, Costa Rica: Universidad de Costa Rica.
- Weinstein, C. E. (1988). *Elaboration Skills as a Learning Strategy*. New York: Academic Press.
- Williams, M. (2004). Concept-mapping - a Strategy for Assessment. *Nursing Standard* 10(19),33-38.