THE EFFECT OF CONCEPT MAPPING AND MIND MAPPING UTILIZATION ON STUDENTS' UNDERSTANDING LEVEL: AN EMPIRICAL STUDY

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Abstract. The purpose of this paper is to investigate the effect of mind mapping (MM) and concept mapping (CM) on the understanding of challenging text. While previous studies have investigated the effect of developing concept map and mind map on students' learning, the current study focuses on the level of students' learning of new concepts through the exposure to CM and MM knowledge representation. In this paper, we conducted an experiment on 140 students at the College of Computers and Information Systems at Helwan University in Egypt. In the experimental treatment group 1, three texts not related to student's background were represented using concept maps, while in the experimental treatment group 2, the three texts were represented using mind mapping. The texts in the control group were represented through traditional text explanation. The results of the Kruskal Wallis H Test, ANOVA and MANOVA statistical analysis revealed that the mind-mapping group scored significantly higher on the summative assessment score while the concept-mapping group took the shortest time to complete the assessment, followed by the mind mapping. Students in experimental group 1 and 2 stated that it was interactive and enjoyable to get the knowledge represented in concept maps/ mind maps.

Keywords*:* concept mapping, mind mapping, experiment, knowledge representation

1 Introduction

Concepts are considered the backbone of any science. Understanding a concept paves the way to understand another concept, which in turn helps to understand another…etc. Our knowledge acquisition in any field can be measured by the amount of our understanding of a set of concepts as well as our understanding of the relationships between these concepts. Using Information technologies can improve our vision towards knowledge acquisition in terms of the accessibility, easiness and visualization of knowledge. Knowledge representation is the way in which unstructured text is represented in structured forms. There are various methods and techniques of knowledge representation. Concept-based knowledge representation is one of those techniques in which concepts, as well as the relationships among these concepts, can be defined or represented in clear and concise forms. Stewart (1979) defined concept maps as a structural way of representing relationships among concepts of a discipline, or a part of a discipline (Stewart, 1979). Stewart highlighted that concept maps, due to its flexibility, are utilized as curricular tools, instructional tools, or as evaluation tools. Novak, Bob Gowin & Johansen (1983) defined concept maps as a research tool and instructional technique that can be utilized for an effective meaningful learning. According to Ausubel's learning theory, the researchers stated that meaningful learning is achieved when learners are able to relate new knowledge to relevant concepts they own (Novak, Bob Gowin, & Johansen, 1983). Construction of concept maps includes the use of labeled concepts framed in circles or rectangles, linking words, that could be prepositions, placed on connecting directed/simple arrows to connect one concept to another, and may include the use of some graphical visualization of concepts (Åhlberg & Ahoranta, 2004). The map is usually organized in a clear simple hierarchy. Most of the concept map researches focus on the construction and development of concept maps (Cañas, Valerio, Lalinde-Pulido, Carvalho, & Arguedas, 2003; S.-M. Chen & Bai, 2010; S.-M. Chen & Sue, 2013; Coffey, Reichherzer, Owsnick-Klewe, & Wilde, 2012; Ke, 2013; Qasim, Jeong, Heu, & Lee, 2013; Valerio Arbizu, 2014) as well as evaluation of concept maps as an effective learning tools (Ben Salem, Cheniti Belcadhi, & Braham, 2013; Jetter & Kok, 2014; Kibar, Yaman, & Ayas, 2013; Kumaran & Sankar, 2013; Watson, Pelkey, Noyes, & Rodgers, 2016). According to Buzan & Buzan (1993), a mind map is a non-linear learning technique to represent knowledge using a central image that represents a main concept/issue then branching it to many branches where more related concepts are connected to it the same way as the human brain. Buzan & Buzan emphasized that the central concept should be an image because the human brain is formulated to remember an image than a word (Budd, 2004; Buzan & Buzan, 1993). Most of the mind map research focuses on the utilization of mind maps in the education process to improve the quality of learning environment and to facilitate the learning process (Budd, 2004; Radix & Abdool, 2013; Wheeldon, 2011; Wickramasinghe, Widanapathirana, Kuruppu, Liyanage, & Karunathilake, 2011; Willis & Miertschin, 2006; Zipp, Maher, & D'Antoni, 2011).

The main objective of this experiment is to investigate the effect of first-time exposure of subjects under experiment to a given piece of knowledge represented graphically, using CM and MM approaches, on their understanding and performance achievement in answering a set of given test questions. Comparing the effect of utilizing concept map and mind map knowledge representation techniques on the learner's performance in understanding a piece of knowledge was conducted in the literature but in the science domain. In this study, an experiment was designed and conducted. A selected set of challenging Arabic text was identified. Key concepts were extracted and graphically represented using CM and MM approaches and compared to the traditional text explanation as for the control group. Students' understanding was measured through a given set of test questions which was in the same order and same text across all groups. The speed of students in answering test questions was measured by the time students spent in finalizing the test questions.

2 Concept Mapping and Mind Mapping Empirical Studies

Concepts maps and mind maps are used for many reasons such as students' academic achievement assessment and evaluation (Abi-El-Mona & Adb-El-Khalick, 2008; Adodo, 2013; Balim, 2013; Chiou, 2008; Holland, Holland, & Davies, 2004; Mahasneh, 2017; Martínez, Pérez, Suero, & Pardo, 2013; Nedungadi, Haridas, & Raman, 2015; Tanriseven, 2014; Youssef & Mansour, 2012),, for improving students' critical thinking (S. L. Chen, Liang, Lee, & Liao, 2011; Kaddoura, Van-Dyke, & Yang, 2016), improving students' knowledge retention and cognitive skills (Dhindsa & Anderson, 2011; Hu & Wu, 2012; Hwang, Kuo, Chen, & Ho, 2014; Ismail, Ngah, & Umar, 2010).

Chen, Liang, Lee, & Liao (2011) conducted a quasi-experimental study to test the effect of teaching using concept mapping compared to traditional lectures on students' critical thinking. Initial results indicated that students in the experimental group performed better than those in the control group; however, there was no statistically significant difference between them. After researchers controlled the age and pre-test scores, students in the experimental group had significantly higher adjusted mean scores on both inference and overall critical thinking compared with the control group. In the same regard, Kaddoura, Van-Dyke & Yang (2016) investigated the effect of concept mapping on developing nursing students' critical thinking skills. Results indicated that students in the concept-mapping group obtained higher cognitive score than those in the control group. Findings of that study recommended that integrating concept mapping in the nursing curriculum should be evaluated, as it would be an effective teaching method to develop nursing students' cognitive skills.

Research results concluded by Hu & Wu (2012) showed that concept mapping can help to reduce students' cognitive load by helping them in integrating curriculum knowledge. This agrees with research findings obtained by Gerchak, Besterfield-Sacre, Shuman, & Wolfe (2003) that concept mapping could be a valuable tool for assessing academic achievement and evaluating students' understanding in a particular field (Gerchak, Besterfield-Sacre, Shuman, & Wolfe, 2003). However, other study found out that integrating concept mapping into the learning process, web-based problem-solving approach, could add cognitive load on students. Researchers of that study justified that this could be a result of the low technology acceptance factor of concept map technology tested in the same study (Hwang et al., 2014).

In assessing the effect of the concept mapping on students' academic achievement, Martínez, Pérez, Suero, & Pardo (2013) experimented the effect of concept maps usage in teaching physics concepts applied to engineering education. Results emphasized that there was statistically significant difference between the concept map group and the control group. Students in the concept map group performed better than those in the control group. Nedungadi, Haridas & Raman (2015) integrated concept maps with online labs (Olabs). Results indicated that there was a slight difference between the scores of the students in the concept map group and those in the control group. Students in the concept maps group performed higher than those in the control group while there was no statistically significant effect of the gender difference between the two groups. Youssef & Mansour (2012) conducted a quasi-experimental study to test the effect of using concept maps on Students' Learning Achievements. Results indicated that adopting a concept mapping strategy in the nursing education can significantly enhance students' learning achievement. Research findings obtained by Chiou (2008) indicated that concept mapping can help students in understanding and integrate Accounting concepts as well as enhance students' interest in learning Accounting more than the traditional teaching methods. Similarly, in an experimental field study conducted by Attia, Sharaf Eldin, Elsayed, Nasr, & Kamal (2009) to investigate the effect of utilizing a concept mapping tool named Interaction with Content Tool (ICTOOL) on students' understanding and on improving the learning process life cycle. Results indicated that the

tool improved the understanding level of 72.8% of students. Furthermore, students stated that the tool made the learning process enjoyable (Attia, Sharaf Eldin, Elsayed, Nasr, & Kamal, 2009). In the same regard, Sharaf Eldin, Kamal, Nasr, Attia, Mohamed, Yehia et al. (2009) compared the performance of two electronic conceptual representation tools, CMAP and ICTOOL on a sample of university students. Results of the comparison revealed that both tools improved the performance and understanding level of the subjects under experiment, especially for those had poor prior knowledge before the experiment. ICTOOL was found more effective than CMAP tool by the subjects (Sharaf Eldin et al., 2009). Sharaf Eldin, Elsayed, Nasr, & Thabet (2013) proposed a new tool named ADS (Conceptual, Delivery, Student) for representing concepts and relationships of data models within a given framework. The implemented tool was tested in lectures delivery. Results indicated that the proposed tool was found to be more efficient than the utilization of normal lectures delivery method. Also, the utilization of the proposed tool decreased the gap in exam grades between students with different levels (Sharaf Eldin, Elsayed, Nasr, & Thabet, 2013).

In assessing the effect of the mind mapping on students' academic achievement, AbiElMona & AdbElKhalick (2008) conducted an experiment to test the effect of using mind mapping on the eighth graders' learning achievement. Results indicated that mind mapping had a positive impact and students in the mind mapping group obtained statistically significant learning gains compared to those in the control group. Same findings were obtained by Adodo (2013) where mind mapping was experimented as an adopted self-regulated learning strategy. Results showed that mind mapping improved students' learning achievements, creative and critical thinking skills. A similar quasi-experimental study conducted by Tanriseven (2014) on a sample of pre-service teachers to compare the impact of mind mapping utilization for task planning compared to the traditional method. Results revealed that there was statistically significant difference between the two groups in favor of the mind mapping group over the control group. Pre-service teachers stated that planning using mind mapping had positive effects on the use of self-regulation strategies. Balim (2013) investigated the effect of using mind mapping on students' knowledge retention and academic achievement. Results indicated that there was a significant difference between the concept mapping group and the control group in the academic achievement. Students in the mind maps group performed better in knowledge retention scores and academic achievement than those in the control group. Mahasneh (2017) compared the effect of electronic mind mapping on students' academic achievement. Results of the conducted quasi-experiment revealed that there was statistically significant difference between the two groups in performance scores in favor of the electronic mind mapping group over the control group given the traditional classroom instructions. In an experiment conducted by Holland, Holland & Davies (2004) to investigate the effect of using mind mapping and a mind mapping software called "MindManager" on students' academic performance. Students were allowed to use the software and then responded to a set of questions. Students provided positive feedback about the software as they found it easy and useful in understanding concepts and organizing knowledge.

Research findings concluded by Dhindsa & Anderson (2011) showed that mind mapping teaching approach had a more positive impact on the quality of students' cognitive knowledge structure than students taught with traditional teaching method. Ismail, Ngah & Umar (2010) investigated and compared the effect of mind mapping with cooperative learning (MMCL) and cooperative learning (CL) on programming performance, problem-solving skill and metacognitive knowledge on computer science students. Results suggested that mind mapping with cooperative learning method (MMCL) was preferred in improving students' programming performance, problem-solving skill and metacognitive knowledge compared to CL and traditional methods.

In the current study, we aimed at, instead of lecturing students about the advantages of concept/mind mapping and training them to develop their own concept/mind maps, we provided them with a piece of knowledge, that they know how challenging and complicated to be understood using the traditional ways, represented in concept/mind mapping and tested their understanding and speed in answering a given set of test questions.

3 Material and Method

In the current study, an experiment was conducted to compare the effect of utilizing concept mapping and mind mapping knowledge representation techniques on the learner's performance in understanding key concepts exist in three selected texts as well as understanding the relationship between those concepts. A similar study was conducted by Aydin (2015) to investigate the effect of utilizing technology-supported mind and concept mapping on learning science concepts as well as seeking students' opinions on preparing mind and concept maps. Experiment results

revealed that, in terms of understanding concepts, students in the concept map group performed better than students in other groups, while students in both mind map and concept map groups stated that developing concept maps and mind maps was fun and instructive (Aydin, 2015). In the current study, to the best of the authors' knowledge, no such experiment was conducted before in the literature to understand a challenging text presented in concept/mind mapping.

3.1 Research Questions

The current research problem is "what is the effect of CM/MM text representation on students' understanding of concepts and what are students' opinions on such practices?" Seven research questions under the research problem were developed and investigated in this study as follows:
RQ (1): For formative assessment, is there a statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?
RQ (2): For summative assessment, is there statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?
RQ (3): For the total score, is there statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?
RQ(4): Would the time students spend to finalize model A of the experiment (CM) in treatment group 1 is less than the time students would spend to finalize model B of the experiment (MM) in treatment group 2?
RQ(5): Would the time students spend to finalize model C of the experiment (traditional explanation text) would be the largest time overall other treatment groups as no graphs were used?
RQ (6): Would the model of the experiment affect the time students would spend to finalize the test questions?
RQ (7): Would the model type of the experiment affect both time and the total score?

3.2 Sample

College students in three classes were voluntarily asked to participate in the experiment. 140 students voluntary participated. Out of all, 44 students were tested using concepts represented in concept mapping. 47 were tested using concepts represented in mind mapping and the remaining 49 students were tested using the traditional text explanation way.

3.3 Design

In order to measure students' understanding and perception of getting concepts represented in non-linear writing form, a challenging text in the Arabic language was selected. The Arabic language was specified in the test experiment in the current study due to the sensitive and challenging nature of the Arabic language. One of the most challenging text in the Arabic language is the Quranic text in the Muslims' Holy book. The selected Quranic texts address a complicated issue in Islam related to the Inheritance or the dividing and calculation of succession. Having the importance of this issue to a broad category of Muslims who seek the understanding of the key concepts and relationships among those concepts in the specified Quranic text, they had to read a lot of different complicated explanation books published by famous Islamic scholars. Those books implicit different point of views. They also consult various domain experts whose judgment and thoughts might be affected by some external influences such as culture and political issues. In the present study, normal learners, computer science college students, were chosen to be the center of the experiment. To ensure the external validity of the experiment, and in order to generalize the study findings, the experiment was meant to be on a sample of students who have normal prior knowledge on the experiment-selected topic. Students having an Islamic Studies related education (i.e. students of Sharia or Daawaa college) were excluded because of their strong prior knowledge and related education. Quranic verses related to Inheritance issue in "Al-Nisaa" chapter [verses 11,12 and 176] were represented in three different representation methods. Key concepts in the selected texts were extracted. Relationships between those concepts were identified and visually represented in two forms, concept mapping and mind mapping. For this purpose, three models of the test experiment were developed, the first model was developed using concept maps to represent key concepts and relationships between those concepts into 3 concept maps, the second model was developed using mind mapping to represent the three verses in one comprehensive mind map where 3 branches were developed, one for each verse. The verses in the control group were represented using the traditional way of explanation text, where the verses are illustrated in conventional ways using explanation/interpretation text obtained from an online source. The concept maps and the mind map were developed using Edraw Max software. All the three versions of the experiment models

were developed in the Arabic language. The three models were pilot tested. Based on the received feedback, they were modified. Each model includes two sections of questions. The first section contains questions related to the experiment while the second section includes demographic data of the respondent. A set of eight multiple test choice questions were developed for formative assessment of students' knowledge obtained after reading the graphs/ explanation text. One multiple-choice question in addition to an open-ended question was developed for summative assessment where the student needs to relate more than one graph or representation section together to answer the two questions by doing some simple calculations. The questions section follows each representation method in each model. The test questions were reviewed by a domain expert to ensure the accuracy. The three models were distributed in hard copies to 140 students in three classes at the college of computers and information systems at Helwan University in Egypt. The models were randomly assigned to the three groups in the experiment. Two classes were treated as two treatment groups while the third class was considered as the control group. The concept map model was assigned to a class which was identified as treatment group 1, the mind map model was assigned to a class which was identified as treatment group 2 and the third model was considered as the experiment control group. The same set of questions were used for all models. The only change was in the knowledge representation method used in each model. To avoid priming any negative feeling from the respondents, demographic data section was placed at the end of the model to collect information about respondent 's gender, age, specialization and if he/she has a prior knowledge about the experiment topic (Inheritance). Students' feedback regarding the experiment was collected in separate sheets for experimental groups 1 and 2.

4 Results and Discussion

4.1 Descriptive Analysis

SPSS was used to generate the descriptive results of the data as shown in Table 1. Three models of the experiment were distributed to 140 students in three classes, 44 students in Model A (CM), 47 students in Model B (MM) and 49 students in the Model C (Traditional explanation text) respectively.

Variable	Frequency	Percentage
Model		
Model A(CM)	44	31.4
Model B(MM)	47	33.6
Model C(Traditional text explanation)	49	35.0
Gender		
Male	79	56.4
Female	55	39.3
Missing	6	4.3
Age		
<=20 years	89	63.6
From 21 – 29	51	36.4
Specialization		
General	102	72.9
Computer Science	24	17.1
Information Systems	6	4.3
Other (programming engineering/Information	8	5.7
Prior knowledge		
No	116	82.9
Yes	24	17.1

Table 1: Descriptive results

Results showed that 59.0% of respondents were male and 41.0% were female. 63.6% of them aged less than or equal 20 years old while the reaming 36.4 aged from 21 to 29 years. For the specialization of students under experiment, 72.9% had general specialization, as they were not specialized yet while 17.1% specialized in computer science, 4.3% specialized in Information systems while a 5.7% indicated to other specialization (programming

engineering/Information technology). 82.9% of respondents had no prior knowledge about the topic under experiment, Inheritance issue, while 17.1% had some prior knowledge about it. Each question in the experiment had a score value of 1 or zero.

The formative score variable was calculated by adding the scores of eight questions from Q1 to Q8 for each respondent. Results showed that value of the formative score variable ranged from 1 to 8. 20 students (14.3%) obtained full score 8, 43 students (30.7%) obtained 7, 35 students (25.0%) obtained 6, 24 students (17.1%) obtained 5, 8 students (5.7%) obtained 4, 6 students (4.3%) obtained 3, 3 students (2.1%) obtained 2 and 1 student (0.7%) obtained 1. The summative score variable was calculated by adding the scores of two questions Q9 and Q10 for each respondent. Results showed that value of the formative score variable ranged from 0 to 2. 88 students (62.9%) obtained full score 2. 33 students (23.6%) obtained full score 1 and 19 students (13.6%) obtained full score 1. The total score variable was calculated by adding the formative assessment and summative assessment scores for each respondent. Results showed that the value of the total score ranged from 1 to 10. Most dominant scores were 9, 7, 8, 10 and 6 respectively. 37 students (26.4 %) obtained 9, 37 students (20.0%) obtained 7, 26 students (18.6%) obtained 8 while only 17 students (12.1%) obtained 10 and 14 students (10.0%) obtained 6. Other scores had the less frequency number of students obtained, less than 8 students per each.

4.2. Findings Related to Research Questions

RQ (1): *For formative assessment, is there a statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?*
In this case, the dependent variable is the formative score and the independent variable is the model of the experiment. The normality of the dependent variable was explored in SPSS but the data was not normal (p-value = 0.000>0.050). Multiple data transformations were conducted such as log, log10, Arsin, 1/Y, Sqrt(Y) and Y2 but normality was not achieved. Having three groups of respondents in the experiment, a Non-Parametric data analysis test was conducted, namely, K-independent samples, Kruskal Wallis H Test. Kruskal Wallis Test: Ranks results revealed that concept-mapping group ranked the top in the formative score. This is due to the easy nature of the concept map where concepts can be read easily as well as its relationship to other concepts in the map. With a significance level of 0.05, the results of the Kruskal Wallis H Test revealed that there was no statistically significant difference in the formative score among the three groups (p-value =0.352<0.050). This rejects RQ (1).

RQ (2): *For summative assessment, is there a statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?*
The normality of the dependent variable was explored in SPSS but the data was not normal (p-value = 0.000>0.050). Multiple data transformations were conducted such as log, log10, Arsin, 1/Y, Sqrt(Y) and Y2 but normality wasn't achieved. Having 3 groups of respondents in the experiment, a non-parametric data analysis test was conducted, namely, K-independent samples, Kruskal Wallis H Test. Kruskal Wallis Test: Ranks results showed that mind mapping group ranked the top in the summative score with a significance level at 0.05, the results of the Kruskal Wallis H Test revealed that there was statistically significant difference of summative score among the three groups (p-value =0.026>0.050). This agrees with RQ (2) that for summative assessment, where learners need to analyze the text and graphs to connect relevant concepts in order to perform some mathematical calculations to answer the indirect questions, there is a statistically significant difference between the groups.

RQ (3): *For the total score, is there a statistically significant difference between the comprehension levels of students in treatment group 1, treatment group 2 and the control group?*
The normality of the dependent variable was explored in SPSS but the data was not normal (p-value = 0.000>0.050). Multiple data transformations were conducted such as log, log10, Arsin, 1/Y, Sqrt(Y) and Y2 but normality was not achieved. Having three groups of respondents in the experiment, a non-parametric data analysis test was conducted, namely, K-independent samples, Kruskal Wallis H Test. Kruskal Wallis Test: Ranks results showed that concept mapping group and mind mapping group ranked approximately the same in the total score. With a significance level of 0.05, the results of the Kruskal Wallis H Test revealed that there was no statistically significant difference of the total score among the three groups (p-value =0.964>0.050). This rejects RQ (3).

RQ (4): *Would the time students spend to finalize model A of the experiment (CM) in treatment group 1 is less than the time students would spend to finalize model B of the experiment (MM) in treatment group 2?*

RQ (5): *Would the time students spend to finalize model C of the experiment (traditional explanation text) would be the largest time overall other treatment groups as no graphs were used?*
The descriptive result reveals that the shortest time was spent by model A (CM model) with an average time of 17 minutes followed by model B (MM model) with an average time of 25 minutes while the longest time was spent by students in the control group, model C (traditional text explanation) with an average time of 31 minutes. This agrees with RQ (4) and (5).

RQ (6): *Would the model of the experiment affect the time students would spend to finalize the test questions?*
In this case, the dependent variable is the time and the independent variable is the model of the experiment. In order to test the effect of the model type on the time, One-Way ANOVA test was conducted as it can be utilized when having more than two groups of data. Two assumptions were tested, normality and homogeneity of the dependent variable (time). Time variable was found to be normally distributed according to Kolmogorov-Smirnov as the p-value is greater that significance level (p-value= <0.090 0.05) which fails to reject the null RQ that data was normally distributed. Homogeneity was achieved using Levene's test of homogeneity as the p-value is greater that significance level (p-value= <0.252 0.05) which fails to reject the null RQ that there is homogeneity among groups. ANOVA test results indicate that the model type has a significant effect on the time (sig. =0.000 > 0.05) which agrees with RQ (6).

RQ (7): *Would the model type of the experiment affect both time and the total score?*
In this case, the dependent variables are both the time and the total score and the independent variable is the model of the experiment. A multivariate analysis MANOVA test was conducted. Since the significance value of MANOVA Box's Test of Equality of Covariance Matrices is more than alpha, 0.05, so cannot reject the null RQ (Covariance between time student spent to answer the test questions A or B or C and the total score would be same for all the students in all groups irrespective of their model) and MANOVA can be performed. Results indicate that Pillai's Trace result for the model variable is significant (0.000 >0.05). Levene's test of equality of error variances shows that there is homogeneity of the dependent variables; the total score and time score among the three groups (Sig. of the total score =0.768 <0.05; Sig. of time spent =0.252 <0.05). MANOVA tests of between-subjects effects indicate that the model variable only had a significant effect on the time spent (Sig. of the model on time spent =0.000 >0.05) while it has no significant effect on the total score (Sig. of the model on the total score =1.000 <0.05). This partially rejects RQ (7).

5 Conclusions

In this study, an experiment was conducted on a sample of college students. Three models of the experiment were developed. Each model represents concepts, extracted from three Quranic verses, in a different way. In model A, concepts were graphically represented using concept maps. In model B, concepts were graphically represented using a mind map. In model C, traditional illustration text explanation of the three Quranic verses was given. These concept maps and mind maps were created by the researchers. Students didn't construct these maps. Students' performance and speed in answering the test questions were evaluated. Research questions were tested. Regarding the model type, although there was no statistically significant difference between experimental and control groups in the formative assessment score and the total score, there was a statistically significant difference in summative assessment score for the favor of mind mapping group. There was also a statistically significant difference in the time students spent to finalize answering the test questions depending on the model type. Students in the concept mapping group spent the shortest time to finalize the test questions (average time= 17 minutes). Students the mind mapping group spent an average time of 25 minutes to finalize the test questions. Students in the control group spent the longest time to finalize the test questions (average time= 31 minutes). In other words, students in the concept mapping group spent approximately half the time spent by students in the control group. Taking into consideration both the summative score and time, students in concept mapping and mind mapping groups performed better than those in the control group. These findings emphasize that having knowledge represented in CM or MM would significantly affect learners' understanding level and speed. Such knowledge representation methods have positively affected students' perception about the understanding of key concepts implicit in challenging texts in an easy and better way than the traditional ways. Students stated that it would be interesting and constructive to get other courses represented and taught using such representations. When combining easiness of concept mapping and its related understanding in short-time duration, the instructor may construct concept maps to provide a complicated piece of

knowledge to students. This would highly improve the learning process. For future work, the experiment can be improved by asking students to develop their own maps as well as measuring students' performance before and after the experiment.

References

Abi-El-Mona, I., & Adb-El-Khalick, F. (2008). The Influence of Mind Mapping on Eighth graders' Science Achievement. School Science and mathematics, 108(7), 298-312.

Adodo, S. O. (2013). Effect of Mind-Mapping as a Self-Regulated Learning Strategy on Students' Achievement in Basic Science and technology. *Mediterranean Journal of Social Sciences*, 4(6), 163-172. doi:10.5901/mjss.2013.v4n6p163

Åhlberg, M., & Ahoranta, V. (2004). What Do Concept Maps Reveal about Pupil's Learning and Thinking. *Annual conference of National Association for Research in Science Teaching*, Vancouver, Canada.

Attia, S., Sharaf Eldin, A., Elsayed, A., Nasr, M., & Kamal, A. M. (2009). Effect of Using A Graphical Conceptual Representation Tool on Student Understanding. *Fifth International Conference on Scientific Research and its Applications*, 21-24 December (2009), Cairo University, Egypt.

Aydin, G. (2015). The Effects of Technology-Supported Mind and Concept Mapping on Students' Construction of Science Concepts the Effect of Mind Mapping in Science Education. *Anthropologist*, 20(1-2), 166-176.

Balim, A. G. (2013). The Effect of Mind-Mapping Applications on Upper Primary Students Success and Inquiry-Learning Skills in Science and Environment Education. *International Research in Geographical and Environmental Education*, 22(4), 337-352. doi:10.1080/10382046.2013.826543

Ben Salem, S., Cheniti Belcadhi, L., & Braham, R. (2013). Using Concept Maps in Knowledge Assessment of Short and Open Answer Questions. *System Theory, Control and Computing (ICSTCC)*, 2013 17th International Conference.

Budd, J. W. (2004). Mind Maps as Classroom Exercises. *The Journal of Economic Education*, 35(1), 35-46.

Buzan, T., & Buzan, B. (1993). *The Mind Map Book*. 1993.

Cañas, A. J., Valerio, A., Lalinde-Pulido, J., Carvalho, M., & Arguedas, M. (2003) Using WordNet for Word Sense Disambiguation to Support Concept Map Construction. Vol. 2857. *Lecture Notes in Computer Science* (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (pp. 350-359).

Chen, S.-M., & Bai, S.-M. (2010). Using Data Mining Techniques to Automatically Construct Concept Maps for Adaptive Learning Systems. *Expert Systems with Applications*, 37(6), 4496-4503.

Chen, S.-M., & Sue, P.-J. (2013). Constructing Concept Maps for Adaptive Learning Systems based on Data Mining Techniques. *Expert Systems with Applications*, 40(7), 2746-2755.

Chen, S. L., Liang, T., Lee, M. L., & Liao, I. C. (2011). Effects of Concept Map Teaching on Students' Critical Thinking and Approach to Learning and Studying. *Journal of Nursing Education*, 50(8), 466-469. doi:10.3928/01484834-20110415-06

Chiou, C.-C. (2008). The Effect of Concept Mapping on Students' Learning Achievements and Interests. *Innovations in Education and Teaching International*, 45(4), 375-387.

Coffey, J. W., Reichherzer, T., Owsnick-Klewe, B., & Wilde, N. (2012). Automated Concept Map Generation from Service-Oriented Architecture Artifacts. In A. J. Cañas, J. D. Novak & J. Vanhear (Eds.), *Concept Maps: Theory, Methodology, Technology*. Proc. of the Fifth Int. Conference on Concept Mapping. Valletta, Malta: University of Malta.

Dhindsa, H. S., & Anderson, O. R. (2011). Constructivist-Visual Mind Map Teaching Approach and the Quality of Students' Cognitive Structures. *Journal of Science Education and Technology*, 20(2), 186-200.

Gerchak, J., Besterfield-Sacre, M., Shuman, L. J., & Wolfe, H. (2003). Using Concept Maps for Evaluating Program Objectives. In *Proceedings of the Frontiers in Education Conference*.

Holland, B., Holland, L., & Davies, J. (2004). An Investigation into the Concept of Mind Mapping and the Use of Mind Mapping Software to Support and Improve Student Academic Performance: University of Wolverhampton.

Hu, M. L. M., & Wu, M. H. (2012). The Effect of Concept Mapping on Students' Cognitive Load. *World Transactions on Engineering and Technology Education*, 10(2), 134-137.

Hwang, G. J., Kuo, F. R., Chen, N. S., & Ho, H. J. (2014). Effects of an Integrated Concept Mapping and Web-based Problem-Solving Approach on Students' Learning Achievements, Perceptions and Cognitive Loads. *Computers and Education*, 71, 77-86. doi:10.1016/j.compedu.2013.09.013

Ismail, M. N., Ngah, N. A., & Umar, I. N. (2010). The Effects of Mind Mapping with Cooperative Learning on Programming Performance, Problem Solving Skill and Metacognitive Knowledge among Computer Science Students. *Journal of Educational Computing Research*, 42(1), 35-61. doi:10.2190/EC.42.1.b

Jetter, A. J., & Kok, K. (2014). Fuzzy Cognitive Maps for Futures Studies-A Methodological Assessment of Concepts and Methods. *Futures*.

Kaddoura, M., Van-Dyke, O., & Yang, Q. (2016). Impact of a Concept Map Teaching Approach on Nursing Students' Critical Thinking Skills. *Nursing & Health sciences*, 18(3), 350-354. doi:10.1111/nhs.12277

Ke, Z. (2013). Research on the Approach of Automatic Construct Concept Maps from Online Course. *Information Technology Journal*, 12(24), 8020-8024. doi:10.3923/itj.2013.8020.8024

Kibar, Z. B., Yaman, F., & Ayas, A. (2013). Assessing Prospective Chemistry Teachers' Understanding of Gases through Qualitative and Quantitative Analyses of their Concept Maps. *Chemistry Education Research and Practice*, 14(4), 542-554.

Kumaran, V. S., & Sankar, A. (2013). An Automated Assessment of Students' Learning in e-Learning Using Concept Map and Ontology Mapping Advances in Web-Based Learning. In *ICWL 2013* (pp. 274-283): Springer.

Mahasneh, A. M. (2017). The Effect of Using Electronic Mind Mapping on achievement and attitudes in an introduction to educational psychology course. New Educational Review, 47(1), 295-304. doi:10.15804/tner.2017.47.1.23

Martínez, G., Pérez, Á. L., Suero, M. I., & Pardo, P. J. (2013). The Effectiveness of Concept Maps in Teaching Physics Concepts Applied to Engineering Education: Experimental Comparison of the Amount of Learning Achieved with and without Concept Maps. *Journal of Science Education and Technology*, 22(2), 204-214. doi:10.1007/s10956-012-9386-8

Nedungadi, P., Haridas, M., & Raman, R. (2015). Blending Concept Maps with Online labs (OLabs): Case study with Biological Science. In *ACM International Conference Proceeding Series.*

Novak, J. D., Bob Gowin, D., & Johansen, G. T. (1983). The Use of Concept Mapping and Knowledge Vee Mapping with Junior High School Science Students. *Science Education*, 67(5), 625-645.

Qasim, I., Jeong, J. W., Heu, J. U., & Lee, D. H. (2013). Concept map Construction from Text Documents using Affinity Propagation. *Journal of Information Science*, 39(6), 719-736. doi:10.1177/0165551513494645

Radix, C.-A., & Abdool, A. (2013). Using Mind Maps for the Measurement and Improvement of Learning Quality. *The Caribbean Teaching Scholar*, 3(1).

Sharaf Eldin, A., Elsayed, A., Nasr, M. M., & Thabet, M. (2013). A Proposed Visualization Tool for Multilayer Conceptual Representation. *IJCSI International Journal of Computer Science Issues*, 10(5).

Sharaf Eldin, A., M. Kamal, A., Nasr, M., Attia, S., Mohamed, M., Yehia, S., & Elsayed, A. (2009). A Performance Evaluation for Conceptual Representation Tools. In *9th IEEE International Conference on Advanced Learning Technologies* (ICALT), 15-17 July 2009., Riga, Latvia.

Stewart, J. (1979). Concept Maps: A Tool for Use in Biology Teaching. American Biology Teacher, 41(3), 171-175.

Tanriseven, I. (2014). A Tool that can be Effective in the Self-Regulated Learning of Pre-Service teachers: The Mind Map. *Australian Journal of Teacher Education*, 39(1). doi:10.14221/ajte.2014v39n1.1

Valerio Arbizu, A. (2014). Extracting Knowledge from Documents to Construct Concept Maps. Indiana University.

Watson, M. K., Pelkey, J., Noyes, C. R., & Rodgers, M. O. (2016). Assessing Conceptual Knowledge Using Three Concept Map Scoring Methods. *Journal of Engineering Education*, 105(1), 118-146. doi:10.1002/jee.20111

Wheeldon, J. (2011). Is a Picture Worth a Thousand Words? Using Mind Maps to Facilitate Participant Recall in Qualitative Research. *The Qualitative Report*, 16(2), 509.

Wickramasinghe, A., Widanapathirana, N., Kuruppu, O., Liyanage, I., & Karunathilake, I. (2011). Effectiveness of Mind Maps as a Learning Tool for Medical Students. *South East Asian Journal of Medical Education.*

Willis, C. L., & Miertschin, S. L. (2006). Mind Maps as Active Learning Tools. *Journal of Computing Sciences in Colleges*, 21(4), 266-272.

Youssef, H. A. M., & Mansour, M. A. M. (2012). The Effect of Concept Mapping on Students' Learning Achievements and Interests in Taif University. *Life Science Journal*, 9(SUPPL.2), 346-353.

Zipp, G. P., Maher, C., & D'Antoni, A. V. (2011). Mind Maps: Useful Schematic Tool for Organizing and Integrating Concepts of Complex Patient Care in the Clinic and Classroom. *Journal of College Teaching & Learning* (TLC), 6(2).