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The effectiveness of Using Mind Mapping on Tenth Grade Students' Immediate Achievement and Retention of Electric Energy Concepts

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ABSTRACT

The purpose of this study was to compare the effects of the Mind Maps Teaching Method and the Conventional Teaching Method on tenth graders' immediate achievement and retention of electric energy concepts in Jordan. Participants (N= 111 students; M= 52, F= 59) were randomly selected from Bani Kenanah region, north of Jordan. One group was assigned to the Mind Maps Teaching Method (n=54) and other group was assigned to the Conventional Teaching Method (n= 57). A multiple-choice physics concept test and open-ended questions were developed and used. The results showed that the Mind Maps Teaching Method was more effective than the Conventional Teaching Method in immediate achievement and retention of electric energy concepts. There was a significant difference for students' gender on immediate achievement but not on retention. The findings recommended that curriculum developers and textbook authors should consider the characteristics of brain parts and their information process in any curriculum design and textbook development. Mind mapping should not be separated from any pedagogical practice in physics instruction..

Keywords: Teaching and learning, Mind Mapping, , Immediate Achievement, Retention, Electric Energy Concepts

INTRODUCTION

Since the dawn of history, science has been largely contributed to the progress of nations. A long time ago, developed nations have become aware of this issue. They have been preoccupied with teaching sciences, utilizing efficient ways to trigger students' interest and motivation, and stimulating the thinking frameworks for both teachers and students (Ambo Saidi & Al Balushi, 2009).

Despite all the efforts deployed, locally and universally, to promote the teaching and learning process, the results of the international study TIMSS (2011) pointed out Jordanian

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students were failing to pass the standards at all the levels of competency and they had low achievement at high thinking levels. The findings mentioned above signify that Jordanian students in the field of science had acquired the necessary knowledge of some facts and concepts about data represented in linear figures, charts, and shapes; however, they were lack of procedural knowledge (Samida and Grice, 2014). These results also corroborated the findings of PISA (2009) whereby Jordanians' rate in the three highest levels of performance did not surpass 5% (OECD, 2012). In fact, this does not correspond with what the world witnessed about the increasing demands of highly competitive competencies (Samida and Grice, 2014).

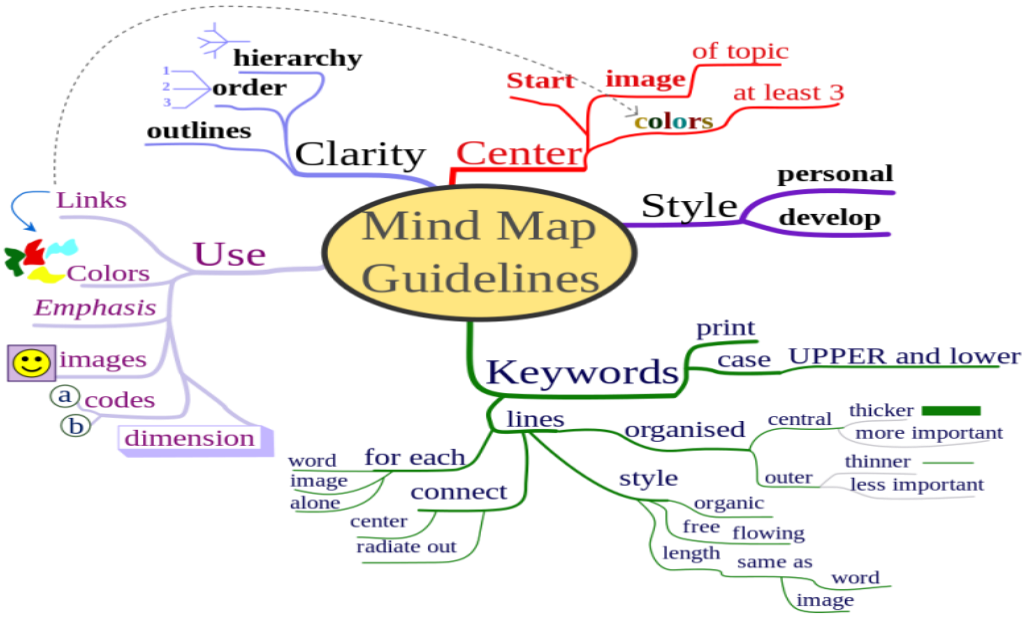
In an attempt to explain Jordanian students' weaknesses, the TIMSS (2011) findings demonstrated the existence of some flaws in the programs' applications bad teaching practices and activities, and inappropriate evaluation methods. The results also indicated that Jordanian teachers did not consider students' needs and differences. Results also showed that teachers' practices were ineffective for improving students' competences. In addition, teachers did not care about diversifying activities. The activities that they used were still grounded on theoretical knowledge, transmissive approaches, inculcating grammar, and triggering its storage (Samida and Grice, 2014).

The TIMSS report (2011) stressed the importance of focusing on the teaching methods that make students the center of the pedagogic process and animate activities that correspond to students' needs and stimulate students' high thinking levels. To concretize these recommendations, this study strives to activate the teaching theories and methods that emphasize not only knowledge processing but also knowledge usage and long retention in everyday life as well.

Among the teaching theory that is based on the brain and its processing information mechanisms. Since research studies point to the existence of a distinction between the right and left-brain hemispheres, scientists are searching for teaching methods that associate both of them to heighten the competence of the brain, to exploit brain's capacity and to make use of its benefits in various fields such as creative mind mapping, acquisition, and thinking (Awajan, 2013). Henceforth the idea of Buzan came to exploit mind mapping through an intrinsic linkage of the two hemispheres of the mind to enhance learners' acquisition and creation through the association of words, numbers, and colors (Buzan, 1995).

Mind mapping is a diagram that combines both scheme and writing. Mind mapping allows the teacher and students set out to organize a written form to make it easy for the mind to recall and retrieve information (Buzan, 1995). According to Wandersee (1987) the diagram facilitates for students the construction and organization of concepts. Similarly, Buzan (2002) considers diagrams as the easiest way to enable the mind to receive and retrieve information through linking the right hemisphere with the left hemisphere. Therefore, diagrams are able to strengthen the memory more than ten times.

We consider mind mapping as a technique relies on a chart on a particular topic in one page in an organized, sequential and artistic way. In mind mapping, words are substituted with brief and nice graphs that are easy to remember and resemble the functioning of the human brain. Mind mapping relies on drawing a diagram or chart that corresponds with the way the mind processes information. The main idea ramifies from the center to the branches based on a specific taxonomy. Buzan (2007) compares mind mapping to city maps. The center of mind mapping resembles the center of a city. The main roads ramify from the city center represent the main ideas in the thinking operation and the secondary roads represent the secondary ideas. (Figure 1) represents a simple scheme of mind mapping:



https://www.google.com.sa/search?q=mind+map&safe=active&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiP8fOduNvTAhVnBcAKHd_oAYwffQ_AUICigB&biw=1600&bih=752#imgrc=ztc3xDPlsw54-M:&spf=142

Many studies (e.g. Ambo Saidi & Al Balushi, 2009 ; Awajan, 2013; Buzan, 2002) interpreted the use of mind mapping to the following reasons:

1. Guiding learners to the highest level of concentration
2. Transforming written data into organized forms to be easy to assimilate
3. Transforming verbal communication into diagrams, symbols, and images
4. Supporting learners to organize their ideas and information in an artistic visual manner to respond to scientific data and consolidate interaction among them
5. Involving learners in building mind mapping visually and mentally in an attractive way
6. Taking learners' differences into account
7. Getting learners out of conventional routines of traditional methods
8. Triggering learners' motivation towards learning
9. Presenting data in an interesting and fascinating way
10. Operating and activating the brain parts
11. Providing learners with a generic view of the topic.

Mınd Mappıng Characterıstıcs

Mind Maps are characterized by their easiness for learning and applying. They provide learners with an organized and miniaturized content, and facilitate the flexibility of adding new information easily. They encourage invention, creation, and self-expression (Buzan, 1974). They also share the use of colors and texture in that they initiate from a center and then ramify the lines. They correspondingly use lines, symbols, additional words and imaginative charts (Buzan, 2002).

Steps of Buıldıng Mınd Maps

The process of building a Mind Map goes through several steps. Initially, a map title is placed in the center (preferably a large business newspaper is used for that), then the related headings, and then subheadings are placed. The headers and sub-headings are written in italics. To make the mind map attractive, it is better to provide images, symbols, graphics and

color. Computer mapping can be elaborated through specialized software such as Mind Mappers (Ambo Saidi & Al Balushi, 2009).

STUDY PROBLEM and QUESTIONS

Educators set up great efforts to adopt modern teaching methods that seek to maximize the role of learners and make learners the core of the educational process in the classroom. However, what is prevailing in the classroom is to provide the content of knowledge in a direct lecture, dialogue or sterile discussion where the teacher plays the key role and the learner plays the role of a negative passive recipient (Mestre, 2001). In addition, conventional methods do not pay attention to the differences among students. On the basis of all students have the same learning capacities (McCarthy, 1990; Kolb, 1984).

Although education in Jordan has undergone major developments since 1988, we often find that science teaching in classroom is still carried out through direct lectures. This, of course, negatively affects students' achievement in science including physics. The results of international studies in science such as TIMSS: Samida, and Grice (2014) and PISA: Watanabe, and Ischinger, (2009) pointed out this problem. They showed that Jordan ranked the 28th in the world in science achievement and the third in the Arab world according to the PISA study (2009). It is worth mentioning that the Jordanian students' achievement in science was only 449 points; i.e., below 500 points as the level required by researchers. The results of TIMSS (2011) indicated a significant decline in the performance of Jordanian students with an average performance of 475, 482 and 449 points for the years 2003, 2007 and 2009 respectively. The international average for the same years was 474, 500 and 500 consecutively (Samida and Grace, 2014). This mirrored the impact of teachers are still adhering to the conventional teaching methods and students' unwillingness to change (OECD, 2012).

The TIMSS (2011) report stresses the necessity of focusing on efficient teaching methods and learning opportunities that are consistent with the activation of the mind to investigate research and solve problems (Samida and Grace, 2014). It also underlies the credence that teaching strategies based on mind theories and their processing of knowledge and scientific concepts warrant an efficient learning (Cuthbert, 2005; Bawaneh .et al., 2012). In light of these recommendations, this study planned to use the mind mapping as a teaching method to enhance students' immediate achievement and retention.

Mind Maps provide learners with a clear picture about the content and facilitate adding new information in a simple way, either horizontally or vertically. Mind mapping encourages innovation, creativity and concentration (Buzan, 2002). It engages students in organizing information in an artistic way. Mind mapping enables students to interact with the scientific material in a way that this interaction operates and activates all the brain parts (Awajan, 2013; Buzan, 2002).

The current study was designed to examine the effectiveness of the mind mapping method in the immediate achievement and retention of the tenth-grade students of physics knowledge.

RESEARCH QUESTIONS

This study aimed to answer the following questions:

1. Is the use of the mind mapping teaching method more effective than the conventional way in the immediate achievement and retention of the tenth-grade students of physics concepts?
2. Do immediate achievement and retention of the tenth-grade students vary according to the gender of the student?

LITERATURE REVIEW

Several studies have confirmed the effectiveness of mind maps in science education. Akinoglu and Zeynep (2007) emphasized the importance of mind maps in improving students' academic achievement and understanding concepts. Likewise, the study of Waqad (2009) pointed out the differences of statistical significance in favor of mind mapping compared to the traditional method in the performance of students of Biology at all levels of Bloom taxonomy (understanding, application, analysis, and synthesis). Similarly, Al-Fawri (2010) revealed positive impacts of mind mapping on the achievement of students in the tenth grade of Basic School in social sciences at all levels of knowledge. In the same vein, Ambo Saidi and Al Balushi (2009) confirmed that mind mapping helped students to retain information for a long time because the brain handles images more easily than written materials in processing, storage and recall. Images naturally abridge many details of the drawn scene in two directions: (1) they require for their elaboration the use of symbols and images to express different concepts, and (2) they are in themselves single images that the brain works to maintain them as wholes where the focus becomes higher even after a long time.

The study of Harkirat, Makarimi, and Anderson (2010) emphasized the importance of using mind mapping in teaching and enhancing students' mental perceptions. Mind mapping also enables to translate information and ideas in an organized, coherent and comprehensive manner. The study also showed that students could retrieve information and concepts more quickly and systematically than students who followed the conventional method. This was confirmed by Ackerman, Beier, and Boyle (2002) who demonstrated the efficient role of mind mapping in students' assimilation, application of dispensed concepts and information and long-life learning retention.

Al-Otaibi's (2016) study aimed at identifying the effectiveness of Non-Hierarchal electronic mind maps in developing the skills of visual thinking among primary-stage female learners in science course. The study consisted of two groups. The experimental group was instructed in the non-hierarchal electronic mind maps strategy, whereas the control group was taught in the traditional method of teaching. A pre- and post-visual thinking skill test was conducted. (if same test: The visual skill test was employed as pre test and post test.) The study concluded that differences of statistical indication (at indication level < 0.01) between students' average grades in both the experimental group and control group on the visual thinking skill test existed in favor of the experimental group.

In the same context, Balım's (2013) study aimed to investigate the impact of using mind maps and concept maps on students' learning of concepts in science courses. 51 students participated in this study, which used a quasi-experimental research design with pre-test/post-test control groups. The study was carried out in the sixth-grade science course unit of 'Light and Sound' in a primary school with two experimental groups and one control group. The first experimental group used technology-assisted mind mapping, the second experimental group used technology-assisted concept mapping, and the control group used traditional classroom instruction. After the intervention in the experimental groups, concept tests and open-ended questions related to the unit were used as post-tests for all groups?. According to the data obtained from concept tests, all groups' understanding of concepts was equivalent. Significantly, students in the second experimental group (technology assisted concept mapping) reported positive opinions stating that learning through concept maps was useful and engaging.

Recently, Hariyadi, Corebima, and Ibrahim's (2018) study aimed to measure the benefit of summarizing and questioning in the Reading-Questioning-Answering Learning Model integrated with mind mapping on the genetic learning outcomes. This study was a correlational research that analyzed via multiple regressions. Mind mapping, summarizing

and questioning positioned as predictors, and genetic learning outcomes positioned as a criterion. The research results showed a strong correlation (97.4%) between mind mapping, summarizing, and questioning in the learning outcomes. The value of the relative contribution of each predictor (questioning, mind mapping, and summarizing) was 58.74%, 39.76%, and 1.50% respectively. The value of the effective contribution of questioning, mind mapping, and summarizing was 57.21%, 38.73%, and 1.46% respectively. Thus, the contribution of questioning was higher than that of mind mapping and summarizing on the genetic learning outcomes.

Nevertheless, Wickramasinghe and his colleagues (2007) did not find significant statistical differences between the use of mind mapping and the conventional method for medical students at the University of Colombo in Sri Lanka even though students who studied under mind mapping suggested that it was a useful way to summarize and remember information. This result was somewhat consistent with those of Farrand, Hussain, and Hennessy's (2002) study that targeted first and second-year medical students. Their findings revealed that many students, especially males, who studied under mind mapping, did not prefer it at all, and were more reluctant to adopt it. This was supported by their diminished motivation for learning compared with the students who studied in the traditional way.

IMPORTANCE OF THE STUDY

The importance of this study is to try to improve Jordanian students' achievement in physics by employing an innovative teaching method based on a strong theoretical framework that seeks to activate the brain to its maximum potential. This study also attempts to inform the Ministry of Education stakeholders –educators, planners, curriculum designers and supervisors about these results. Thus, stakeholders can consider the study results in the design of curricula and textbooks for various stages, and holding workshops to train teachers and educators in mind mapping mechanisms. The training can aid teachers to use these mechanisms appropriately in the classroom. The relevance of the study also resides in its attempt to use mental maps not only for students' evaluation but also for their training to use them properly in studying various subjects.

OPERATIONAL DEFINITIONS

A mind map: is a structured planning that includes a central concept from which ramifies the main ideas to embrace information from the most comprehensive to the least comprehensive. A mind map contains pictures, symbols, and drawings. In this study, mind maps of the power unit (target content) were designed and arbitrated.

Immediate Achievement: The progress made in achieving the objectives of a dispensed content in physics entitled "Electrical Power Unit" by tenth-grade students during the academic year 2015-2016. Immediate achievement was measured by a score obtained by students in the achievement test. Achievement test was prepared by the researcher and provided, after the completion of the teaching of the course directly.

Retention: The extent to which a student acquired and retained concepts, knowledge, and skills during his study of the subject of electrical energy after being subjected to planned educational experiences. It was measured by a score obtained by students in the achievement test prepared by the researcher and the provider after two months from the completion of teaching the prescribed course.

LIMITATIONS OF THE STUDY

1. This study was limited to the tenth-grade students of Bani Kenana Brigade Schools in Jordan.
2. The study was conducted in the second semester of the academic year 2016/2017.
3. The study was limited to the subject of electrical energy in the tenth-grade course approved by the Jordan Ministry of Education.
4. Validity and consistency of the study tools (the designed scientific subject and the achievement tests).

METHODS

The population of this study comprised all 10th-grade students (male and female) enrolled in Bani Kenanah educational directorate from Irbid Governorate in the 2016/2017 academic year. In order to implement this study in a naturalistic school setting, existing intact classes were used (Obiedat, Kayed, and Adass, 2016).

The population of this study is representative of almost all the existing social classes in Jordan, in terms of gender, age, nationality and native language. Students come from different towns within the Bani Kenanah Education Directorate. They are in the age group ranging from 15.5–16.5 years. Students are also homogenous in terms of their nationality, mother tongue (Arabic), exposure to English as a foreign language, and educational system and cultural background. Students in the selected schools were from an approximately equivalent socio-economic status as defined by the Ministry of Education of Jordan.

a) Sample

Four schools including 10th grade students participated in the experiment during the 2016/2017 academic year. Classes were randomly selected from each school. In total 111 students participated to the study. Table 1 shows participants' distribution according to the teaching methods and schools.

Table 1: Participants' Distribution by Teaching Methods, and Schools

Group		School	Number
Experimental	M	Ezzreet Basic School for Boys	22
	F	Sahem Secondary School for Girls	32
	Total	2	54
Control	M	Harima Secondary School for Boys	30
	F	Abulougass Basic School for Girls	27
	Total	2	57
Total		4	111

Classes were selected based on who was enrolled in each school without any discriminating factor. All students in the defined population has an equal and independent chance of being selected (Gay & Airasian, 2003). The four schools were also randomly selected from all the schools including the tenth grade where physics was taught in heterogeneous classes with no grouping or ability tracking. Four teachers (2 male and 2 female assistant researchers) taught one class. All teachers had major in physics. In addition all of the teachers had similar teaching experiences. All of them had a minimum of four years of teaching experience under the Jordanian Ministry of Education and had taught heterogeneous classes. The teachers and the education supervisor who helped researchers (assistant researchers) in the experimental groups were exposed to three days (two hours a day) of training on Mind Mapping.

b) Study Design

A quasi-experimental design was employed with two types of teaching methods: Mind Mapping for the experimental group and the conventional one for the control group. The dependent variables were the Immediate Achievement and Retention of Electric Energy Concepts.

c) Study instrumentation

This study employed two research tools for investigation:

(1) The teachers' guide to the mind mapping teaching method: The researcher redesigned the content of the scheduled "electrical energy unit". The teachers' guide was based on the book of the tenth grade Basic School which was approved by the Jordanian Ministry of Education for the 2016/2017 academic year. Thus, the guide was compatible with the mind mapping method and the lesson implementation mechanisms. Teachers in the experimental group were provided with a copy of this guide after being validated by a panel of seven experts. Experts were teachers, educational supervisors, and university professors; two of them holding Ph. D. in Education, science teaching methods and Physics; three are holding MA degrees in Education, science teaching methods and Physics; and two of them holding a bachelor in physics and a high diploma in science teaching methods. Most of the recommendations and feedback approved by more than half of the Experts board were taken into consideration.

(2) The achievement test: An achievement test was designed (Appendix I) based on the specification table for the content of the target unit (Electrical Energy) from the tenth-grade physics textbook approved by the Ministry of Education in Jordan for the 2016/2017 academic year. The test aimed at measuring students' immediate achievement and retention among the 10^{th} grade students in Jordan. The test consisted of two parts. The first part contains 20 multiple-choice questions; and the second part includes two open-ended questions. Open-ended questions were designed to enable students to provide their answers using mind mapping. A panel of seven experts of the teachers' guide referee team validated the achievement test.

Four multiple-choice questions from the first draft (it was 24 items) based on the experts' recommendations and implemented open-ended questions to make them clear and straightforward. The researcher also applied the test to a random sample of 35 tenth-grade students, calculated the reliability factor through Cronbach Alpha equation and reached (0.78). This result is considered acceptable for scientific research purposes (Al-Kellani and Al-Shraifeen, 2011).

IMPLEMENTATION OF THE ACTUAL STUDY

After ensuring the validity and reliability of the study instruments, identifying a study population and a study sample was the next step. The researcher considered the following aspects:

a) Training for Teachers

The study sample was divided into two groups: the experimental group and the control group. The experimental group was tested with the mind mapping and the control group was tested with the conventional teaching method. Prior to the practical implementation of the study, the selected teachers were exposed to a two-day training workshop carried out for four hours per day with a total number of eight training hours. At the end of the first training day, the researcher asked one volunteer teacher to present any lesson for the actual study during

the second day of the training workshop. Teacher chose the lessons from the booklets provided by the researcher. A group discussion for both teacher-teacher, researcher-educational, and supervisor-teacher were carried out in order to get feedback about Mind mapping. The training was held in coordination with Bani Kenanah Provincial Directorate of Education. The purpose of this training is to enable each sample teacher to master the treatment teaching method of mind mapping. The teachers were informed that they would be part of an experiment in which new instructional methods would be tested. Teachers worked with the new methods and learned how to use them with their students. In the present study, the focus was on the "Electrical Energy Unit". Regular classroom visits were scheduled by the researcher in coordination with the Directorate of Education, school administrations, and teachers to follow up on the actual implementation of the study in the classroom.

Participant teachers were trained explicitly to use this method in teaching about electricity. They were exposed to the modalities of using the new teaching method and training their students to use it in learning. The procedures of selecting groups and assigning group members were explained to the teachers. Finally, the researcher and the teachers had a meeting for feedback and assessment regarding the application of the teaching method. For the control group teachers, the researcher asked them to run their classes as usual (without any intervention in teaching methods) without any guides or information, just used the same achievement test before starting the Electricity Unit (pre-test) and after finishing the unit (post-test).

b) Teaching with mind mapping

The researcher carried out the experiment on some teachers whose schools were selected randomly for the experimental group. These teachers used the mind mapping method during the Electrical Energy Unit.

Teachers were provided with a teachers' guide, which was built by the researcher and validated by a group of experts. The guide runs as follows:

1. The teacher starts the lesson by asking a set of questions as provided in the guide. The teacher uses the brainstorming method to collect as many ideas and information as possible (divergence thinking).
2. The teacher leads an effective dialogue and discussion with the students to classify all the ideas and information collected in the previous stage. These discussions and dialogues need to be based on the learning outcomes of the content of the lesson (Convergent thinking).
3. In the first two lessons of the unit, the teacher works on building mind mapping with the students. The teacher teaches students both the scientific content and how to create mind maps in a funny and interesting way.
4. In the following lessons, the teacher gives students the opportunity to build mind maps after the activation of brainstorming and the classification of ideas and information (convergence thinking). Students individually build mind maps and then to share them with their groups (Think - Share). At the end, each group presents one agreed-upon mind map, and the teacher surveys students as a facilitator of learning.
5. In the last two lessons, the teacher divides students into groups, asks them to read the lesson, and express ideas and information in mind maps. Each group presented the mind map they had constructed. Finally, the teacher draws a mind map representing the ideas and information included in the lesson, taking into consideration the maps completed by the students.
6. During the various lessons, the teacher provides different levels of mind maps in order to assess students' understanding of subjects and ideas. Sometimes mind maps contain misconceptions, and students must correct them. Mind maps may also comprise empty

spaces, and students must fill them up. Students must connect ideas to each other, or must replace words with images or expressive graphics.

TREATMENT PROCEDURES

- In conducting this study, obtaining a Recommendation Letter asking for assistance from the Jordanian Ministry of Education.
- Selecting the sample from the population and assigning participants to the two teaching methods based on the steps discussed earlier.
- Randomly selecting treatment schools in coordination with the Bani Kenanah Provincial Directorate of Education. Providing training for teachers in treatment schools on how to implement the instructional booklets.
- Prior to the actual practical implementation of the proposed content teaching, an achievement test was administered as a pre-test for all study sample students. The achievement test applied two weeks before the actual teaching started.
- In the early of April 2017, the actual implementation of the instructional content (Electricity) was employed. Two teaching methods used in the all-male and female schools of the study sample. The researcher followed up the teachers by making regular communication with them either by field visits or by phone.
- After completing the teaching of the instructional content to all groups of the study sample, the achievement test was re-administered as a post-test, (22-26 May 2017).
- The SPSS program used to analyze data. Valid statistical analyses were provided.

RESULTS

The purpose of this study was to investigate the effect of Mind Mapping on Immediate Achievement and Retention among 10th-grade students in Jordan. We took into consideration students' gender moderate variable as a secondary independent variable. Data were collected through the analysis of information gathered from the achievement test.

In order to answer the first question “Is the use of the mind mapping teaching method more effective than the conventional method in the imediate achievement and retention of the tenth-grade students of physics?”, the descriptive statistics (M, SD) were conducted. The results are presented in table 2:

Table 2. *Means and standard deviations of students’ Immediate Achievement and Retention of Electric Energy Concepts*

		N	Mean	SD
Immediate Achievement	Mind Mapping	54	17.09	1.84
	Conventional	57	14.22	2.57
	Total	111	15.62	2.65
Retention	Mind Mapping	54	14.09	1.83
	Conventional	57	13.03	1.81
	Total	111	13.54	1.89

Table 2 presents the overall means and standard deviations of each post-test score between the groups of teaching methods. The mean scores of the conventional group

recorded immediate achievement (M = 14.22, SD = 2.57) and the Mind Mapping group (M = 17.09, SD = 1.84), with a difference (2.87). The mean scores of the conventional group recorded retention (M = 13.03, SD = 1.81) and Mind Mapping (M = 14.09, SD = 1.83), with a difference (1.06). To ascertain the validity of the differences, the researchers performed the ANOVA analysis. The results are presented in Table 3.

Table 3. *The Results of ANOVA for the Immediate Achievement and Retention in Electricity among Teaching Methods*

		Sum of Squares	df	Mean Square	F	Sig.
Immediate Achievement	Between Groups	227.536	1	227.536	45.047	.000
	Within Groups	550.572	109	5.051		
	Total	778.108	110			
Retention	Between Groups	31.011	1	31.011	9.325	.003
	Within Groups	362.467	109	3.325		
	Total	393.477	110			

Compared to the pre-test scores on Immediate Achievement and Retention in Electricity, the results showed that the impact of the teaching method on Immediate Achievement was statistically significant: $F = 9.325$, $p < 0.05$. It can be interpreted that teaching methods have the main effect on students' Immediate Achievement and Retention in Electricity.

In order to answer the second question: "Do immediate achievement and retention of the tenth-grade students vary according to the gender of the student?", the descriptive statistics (M, SD) were conducted. The results are presented in table 4.

Table 4. *Means and standard deviations of students' Immediate Achievement and Retention of Electric Energy Concepts and gender*

		N	Mean	SD
Immediate Achievement	Male	52	14.94	2.87
	Female	59	16.22	2.31
	Total	111	15.62	2.65
Retention	Male	52	13.44	1.95
	Female	59	13.64	1.84
	Total	111	13.54	1.89

Table 4 presents the overall means and standard deviations of each post-test scores based on students' Immediate Achievement and Retention in Electricity and gender. The mean scores of the Immediate Achievement reported male (M = 14.94, SD = 2.87) and female (M = 16.22, SD = 2.31) with difference (1.28). The mean scores for the Retention reported male (M = 13.44, SD = 1.95) and female (M = 13.64, SD = 1.89) with a difference (0.20). The results of the retention showed that the differences between the means are very small. In other words, the means of male and female are closer to each other.

In order to verify the differences are statistically significant for students' gender on Immediate Achievement and Retention in Electricity, the results can be interpreted. The results (table 5) showed that there is a statistical difference for students' gender on Immediate

Achievement: F = 6.714, p < 0.05 whereas the results showed that there are no statistical differences for students' gender on Retention, F = .313, p = .577.

Table 5. *The Results of ANOVA for the Immediate Achievement and Retention in Electricity among students' gender*

		Sum of Squares	df	Mean Square	F	Sig.
Immediate Achievement	Between Groups	45.146	1	45.146	6.714	.011
	Within Groups	732.963	109	6.724		
	Total	778.108	110			
Retention	Between Groups	1.125	1	1.125	.313	.577
	Within Groups	392.352	109	3.600		
	Total	393.477	110			

DISCUSSION

The results of the first question indicated the effectiveness of mind maps on the immediate achievement and retention of 10th-grade students in electrical energy concepts. This can be attributed to the fact that mind mapping is based on constructivism theory, which is based on the effective organization of knowledge and skill building by the learner himself through his previous experiences and peer work. The student is the core of the educational process and the teacher is a facilitator and a motivator. Afana and Al-Jaish (2009) confirmed that mind maps activate both the left and right sides of the brain to retain the overall structure of knowledge for long period of time. Mind maps also provide an opportunity for students to learn through dissection and interaction to connect physics concepts with each other, to form new relationships and to enhance retention. In addition, most learners are visual (65%), and therefore the formation of structured schemes of thinking is inherent in the human mind. Mandour (2009) found that students learn better when the concepts are delivered in a visual way.

Mind maps also organize the relationships, and link between ideas and information. This makes it easier for students to remember information and ideas for both immediate achievement and retention (Al-Otaibi, 2016; Hariyadi, Corebima, and Ibrohim, 2018). In the same context, mind maps allow students to see the whole picture of the subject and increase the chance to remember ideas and information (Awajan, 2013; Balım, 2013). In addition, these maps are very rich in images, drawings, and shapes with different and attractive colors. Thus mind maps produces the best ways to transfer and remember knowledge and information. 90% of the inputs of the brain originate from the sense of visual sources, where the brain has an automatic response to the symbols and images that have a significant influence on recalling ideas and information (Bozan, 2002).

In a similar vein, Ambo Saidi and Al Balushi (2009), Awajan (2013), Buzan (2002), and Balım (2013) revealed the following outcomes of the use of Mind Maps:

1. Engaging students to the highest level of concentration.
2. Supporting students to organize ideas and information in an artistic visual manner to respond to scientific data and to improve interaction.
3. Taking learners' diversity into consideration.
4. Getting learners out of routine because the method is inventive and non-conventional.
5. Presenting data in an interesting and fascinating way.

These results are consistent with the results of some other studies. Akinoglu, and Yasar (2007) and Balım (2013) emphasized the importance of mind maps in improving students'

academic achievement and understanding concepts. Likewise, the study of Waqad (2009) pointed out significant differences in favor of mind maps compared to the traditional way in the performance of students of Biology at all levels of Bloom taxonomy (understanding, application, analysis, and synthesis). The result was confirmed by Ambo Saidi and Al Balushi's (2009) study that mind maps helped students retain information for a long time because the brain handles images more easily than what written materials do whether in processing, storage or recall. Images naturally abridge many details of the drawn scene in two directions: (1) they require for their elaboration the use of symbols and images to express different concepts, and (2) they are in themselves single images that the brain works to maintain them as wholes where the focus becomes higher even after a long time.

The study of Harkirat, and his colleagues (2010) emphasized the importance of using mind mapping in teaching and enhancing students' mental perceptions as well as their ability to translate information and ideas in an organized, coherent and comprehensive manner. The study also showed that students could retrieve information and concepts more quickly and systematically than students who followed the conventional method. This was confirmed by Ackerman and his colleagues (2002) who demonstrated the role of mind mapping in students' assimilation, information, application of dispensed concepts and long-life learning retention.

Nevertheless, Wickramasinghe and his colleagues (2007) did not find significant statistical differences between the use of mind mapping and the conventional method for medical students at the University of Colombo in Sri Lanka even though students who studied under mind mapping suggested that it was a useful way to summarize and remember information. This result was somewhat consistent with the results of Farrand, Hussain, and Hennessy (2002) study which targeted first and second-year medical students. Their findings revealed that many students, especially males, who studied under mind mapping, did not prefer it at all, and were more reluctant to adopt it. This was evidenced by their diminished motivation for learning compared with the students who studied in the traditional way.

In the same context, the result of the first question was not consistent with that of the Trevino study (2005). Trevino (2205) aimed at investigating the effect of the use of mind maps in biology. The results indicated that there were no statistically significant differences between the mind maps strategy and the traditional method.

Regarding the second question, the results of this study showed that there were statistically significant differences between males and females in favor of females on immediate achievement. This result can be explained by the fact that females spend longer hours in studying than men because of the nature of the Jordanian environment. Females spend more time at home while males spend most of their time outside home. Thus male students are less likely to follow their lessons. Although there were no statistically significant differences between males and females on students' retention, the female mean was higher than the male. This can be explained by the fact that the researcher did not inform students of both sexes about the test, so they did not have the opportunity to review the content. In addition, the female concentration on immediate achievement in the first stage resulted in obtaining the highest scores in the test rather than only understanding and applying physics concepts.

CONCLUSION

The results of this study revealed that the use of mind maps helped students perform significantly better in immediate achievement and retention of electric energy concepts. results provided substantial support to mind maps and invited curriculum developers and textbook authors to take into account the characteristics of brain parts and information processing through mind maps investment. Educational supervisors and teachers are also

recommended attending training workshops to use mind maps during physics lessons. In a nutshell, mind maps provided strong support for improving students' immediate achievement and retention of physics concepts.

PEDAGOGICAL IMPLICATIONS and RECOMMENDATIONS

Based on the results of this study, curriculum developers and textbook authors are recommended to implement mind mapping in the curricula they design. Mind mapping should be employed in instructional, curriculum, and textbook design to improve science learning. The implementation of mind mapping does not incur any cost. The overwhelming efficiency makes this method a good candidate for inclusion in pedagogical development. Teachers should be informed about the usage and importance of mind mapping and they can plan the instructional activities accordingly. In short, when favorable strategies are used, it is highly probable that this method may cause a significantly better achievement and retention in science.

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