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THE EFFECT OF USING A PROGRAM DEPENDING ON ARGUMENT BASED INQUIRY APPROACH VIA "WRITE- TO- LEARN STRATEGY" ON 8TH GRADE STUDENTS' ABILITIES OF FORMING SCIENTIFIC MENTAL MODELS

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ABSTRACT: *The Purpose of this study is to investigate the effect of using a program depending on argument based inquiry approach via "write- to- learn strategy" on 8th grade students' abilities of forming scientific mental models. As well as the effect of the interaction between argument based inquiry approach via write to learn strategy method of teaching, and gender on 8th grade students' abilities of forming scientific mental models. The study was conducted on a purposive sample of 8th grade students (females and males) enrolled at public schools in Jerusalem district. The schools are: Bethany Secondary School for Girls and Al Ma'ahad Al Arabi School for Boys during the second semester of the academic year 2016\2017. The Sample consisted of 152 students of the 8th grade (71 females and 81 males). Students from both schools were assigned to experimental and control group randomly. The experimental group was taught a whole unit by the argument based inquiry approach via "write-to-learn strategy", while the control group was taught by the traditional method. The experiment lasted for two months. The researcher has prepared an instrument for the study, Self Mental Model Exam. Content validity and reliability was done for it. A pre and post test was done for all of the participants to measure the effect of using a program depending on argument based inquiry approach via "write- to- learn strategy" on 8th grade students' abilities of forming scientific mental models. The means, standard deviations, and (1-way ANCOVA) test were used in the study. The findings of the study showed that there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to method of teaching in favor of the experimental group, there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to gender in favor of males and there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to the interaction between method of teaching and gender in favor of males in the experimental group. In the light of these results the researcher recommends using the argumentation via "write-to-learn strategy" in teaching science due to its effect in improving students' skills.*

KEYWORDS: Argument Based Inquiry Approach, Write-To-Learn Strategy, Mental Models.

INTRODUCTION

During this rapidly changing society, in a time of knowledge and technological advancement, students have easy and quick access to knowledge, contents and facts. They can find information on anything they want and at any time; this revolution puts the roles of teacher under continuous investigation and development. With this issue, teaching in the 21st century

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should focus on student centered learning and development of students skills such as creative and critical thinking, problem solving, collaboration, and mental models formation.

Science is the systematic study of the structure and behavior of the physical and natural world through observation and experiment. From this definition, an emphasis of inquiry must be modeled in the classroom, just as it is practiced in the research laboratories(Herr,2008).

Science is also a way of knowing the natural world; many years of work and research in the science education community have provided a coherent, research-based vision for a new era of science education. Therefore teaching science is a dynamic field and it is gaining its importance from the National Science Education Standards (NSES) that were created to coordinate the goals and objectives for science instruction. One of the (NSES) aims is to plan an inquiry based science program for the students. This approach to science teaching motivates and engages all types of students, helping them understand the relevance of science to their lives, as well as the nature of science itself (Next Generation Science Standards (NGSS, 2013).

The National Research Council (NRC, 2000) continued its emphasis on science instruction that directly engages students in the practice of science, the proficiencies that need to be developed for all students are: to know, use, and interpret scientific explanations of the natural world, to be able to generate and evaluate scientific evidence, to understand the nature and development of scientific knowledge, and to participate productively in scientific practices and discourse.

In the past decades, numerous publications have called for inquiry based approaches to science instruction that can effectively help students develop critical reasoning capacities, including the ability of students to pose scientific questions and investigate them, to accurately record and interpret the results, and to be able to link their findings to a developing body of scientific knowledge (NRC, 2001).Understanding the nature of science and scientific inquiry is also an important goal of science education (NRC, 2000).

The rapid advance of cognitive learning theories in the past few years has led educators to realize the need for student to be more actively engaged in their own construction of knowledge. Emerging researches suggest that children's abilities to engage in inquiry and form new conceptual understanding are enhanced when they grasp the nature and construct scientific knowledge. After that, a discussion of the specific aspects of the nature of science and scientific inquiry should be held in both elementary and middle schools for students to understand (Bass et al., 2009).

Argument Based Inquiry approach supports a constructivist approach to learning science. According to this approach, learning is a construction based on the learner's prior knowledge. Students take in information from many sources, including personal discoveries and acquisition from teachers, books, videos, and other resources. But in constructing understanding, student must connect new information to their existing knowledge and experiences, reorganize their knowledge structures, assimilate new information to them, and construct meaning for them (Horsley et al., 1998).

Moreover, the NGSS (2013) unprecedentedly seek to interweave scientific knowledge and practices within learning experiences, of which argumentation is one such example.

Processing and synthesizing information orally is not effective as the researchers noticed from their experience in science teaching. It is crucial to adapt a teaching strategy that helps students to summarize notes, to develop their writing skills and organize their work.

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Spolsky (1999) indicated that writing is a major tool of learning and it is a problem-solving activity in which students generate their own ideas and clarify them to themselves as they try to communicate them clearly to their partners. Thus writing may involve assimilation, interpretation, and reformulation of individual opinion. Moreover it is needed to help students to gain greater control over the cognitive strategies involved in composing writing and in developing effective planning strategies. Writing- to- learn can enhance students understanding and develop their writing skills.

Kuta (2008) also revealed that students make their own records or notes in order to use them for learning the content or material, and they can later use them to study for a test. Students are directed to take specific notes in both words and pictures forms. The NRC (2001, and 2012) listed students' understanding of models and modeling as one of the major goals of science teaching.

Furthermore, Gobert et al., (2011) have suggested that teaching models and modeling should not only focus on science concepts, but should also promote sophisticated views of scientific models and modeling.

Thus, the researchers suggested that students should gain lifelong skills which will let them deal with their future learning. From this issue, developing these skills is a big challenge for every science teacher. The researcher thinks that combining two strategies, the argument based inquiry approach as a recommended approach by the NSES and the "write- to- learn strategy", could- as the researchers suggests- enhance improve their abilities of forming scientific mental models. Those two strategies can be applied in the class as concrete methods of teaching, especially science teaching, inducing students to gain lifelong skills such as formation of mental models. This study is an attempt to investigate The Effect of Using a Program Depending on Argument Based Inquiry Approach via "Write- to- Learn Strategy" on 8th Grade Students' Abilities to Form Scientific Mental Models.

LITERATURE/THEORETICAL UNDERPINNING

Argumentation

It is defined as discourse practices through which students attempt to construct, support, evaluate, or validate a claim by evidence based reasoning in science learning contexts (Erduran et al., 2006).

Erduran, et al. (2004) defined it as an authentic inquiry-based discourse that coordinates conceptual and epistemic goals across both writing and talking.

Aydeniz and Dogan (2016) stressed that engagement in argument is not only a process that includes claims, evidence, and reasoning but also a process in which students persuade their peers of the validity of their arguments.

In argument based instruction, scientific arguments become a leading framework for teaching and learning of concepts by emphasizing science not as an experimental verification, but rather, as a process of scientific argumentation and explanation. In such practices, no longer is conceptual repetition or factual accumulation the focal point; instead, the concentration is on constructing concepts through scientific argumentation. (Erduran et al., 2006).

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According to Heng et al. (2015) scientific argument is core in knowledge construction and students are needed to propose, support, criticize, evaluate, refine ideas about concepts and use scientific theories and evidence to confirm their claims.

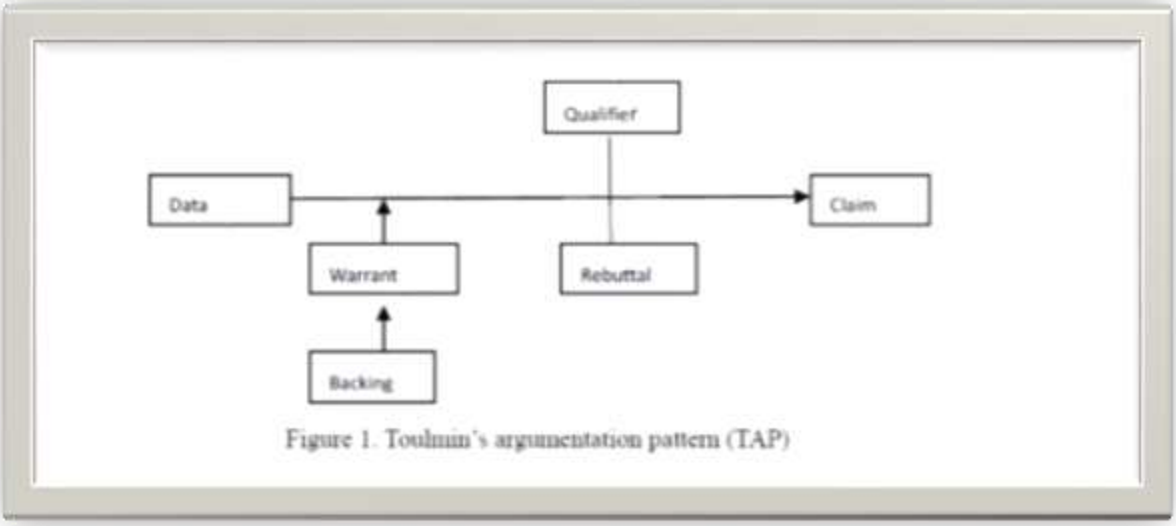

Figure1. Toulmin's argumentation pattern(Toulmin et al., 1979, p.51)

It is noted that the application of the pattern is based on the assumption that the presence of more argumentation elements indicates a better quality argument. Arguments that consist of claims supported by data, warrants, and backings are considered simple arguments, whereas arguments that consist of qualifiers and rebuttals, in addition to data, warrants, and backings, are deemed more complex and sophisticated. It is also noted that the TAP does not take into consideration the accuracy of the elements from a scientific perspective. In addition, the TAP also does not assess whether the argument, as a whole, makes sense. The dialogic or social perspective on argumentation focuses on the interactions between two or more individuals in which the participants try to persuade or convince each other of the validity of their claims. Consequently, engaging in argumentation includes the construction and critique of multiple explanations and the use of evidence (Sampson & Clark, 2009).

The construction of scientific argument requires cognitive involvements, such as analyzing and making sense of the data, generating explanations, supporting the idea, and challenging the validity of an idea. In group collaborations, students have the opportunities to explain their thinking about a phenomenon being studied, to listen to the explanation of their peers to observe the strategies of others, and to resolve different perspectives through discussions. Furthermore, group discussions involving collaborative reasoning and arguments lead to a deeper understanding of scientific concepts. Through explicating, comparing and challenging ideas, and explaining, students were able to recognize limitations, anomalies and fallacies of the concept being discussed. This situation is important and can lead to conceptual change when students try to integrate new knowledge with existing conceptual structures (Heng et al., 2014).

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Write- to- learn Strategy:

The literature of writing indicated that an important characteristic of students is their writing strategy. For example, how they cope with the complexity of writing, by dividing a writing task into subtasks, sequencing these subtasks and regulating the attention paid to sub-processes (Torrance & Galbraith, 2006).

Galbraith and Torrance (2004) also claimed that offering students writing tasks that match their preferred writing tendencies may help to reduce the cognitive load of writing and may therefore have a positive impact on students' domain learning, because writing strategies (either planning or revising) allow planning the content of the text to be conducted free of the demands of constructing well-formed and coherent texts.

As Newell (2006) pointed out that " constructivist notions of teaching and learning make a strong case for the value of writing in academic learning, yet one challenge that remains is translating that into the ways of knowing and doing in various academic disciplines" (p. 235).

Nelson (2001) argued that writing-to-learn initiatives allow students to use writing to gain authority on a subject or topic and, as they do so, to benefit by learning the ways of writing associated with the discipline.

According to Newell (2006) writing is crucial and essential part of students' activities in secondary school education. Teachers can employ writing tasks in the period as a way of making sense of information and exploring ideas.

Furthermore, Tynjala, et al. (2011) stated the importance of writing to learn strategies in ordering, explaining, or clarifying all kinds of learning material in various school subjects.

There are standards for good writing; these standards were published by the Common Core State Standards in the United States. They indicated that students at early ages should gain writing skills and construct meaningful paragraphs. The skills are: to write an opinion that introduces the topic, state their opinion, provide reasons to support the opinion, use linking words to connect between opinion and reasons, and provide a concluding statement (Common Core State Standards, 2010).

Arum and Roksa (2014) found that the presence of writing activities during the study period will positively influence students' lives after graduation by helping them to find an employment or by increasing their opportunities to write CVs about themselves.

Mental Models:

Scientific models are defined as "specially organized representations which show aspects of mechanism, causality, or function to illustrate, explain, and predict phenomena" (Schwarz et al., 2009, p.634).

They are also defined as "representations that either explain or predict a scientific process or phenomenon which can be an object, a mechanism, or an event, and is the target. A model has various levels of abstraction of the target depending on its purpose. A non-model, however, does not represent a target and does not serve the modeling purposes. For instance, a photo of a panda does not have a corresponding target and has limited explanatory power" (Lee et al., 2015, p.3).

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Schwarz et al., (2009) claimed that if students were engaged in model-based activities, their views toward scientific modeling process will be improved.

Gobert et al., (2011) also assisted that students' understanding of scientific models will support their learning. Furthermore, The NRC (2012) listed students' understanding of models and modeling as one of the major goals of science teaching.

Despite the variation in aspects of scientific models, Pluta et al. (2011) suggested there are four main aspects:

1- The nature of models: it reflects the content of the model, its level of complexity and abstraction or its general characteristics.

2- The nature or process of modeling: it indicates the construction of models and their changing nature.

3- Evaluation and revision of models: which refers to the criteria used to evaluate a model and if it helps to achieve the purpose from it.

4- The purpose of models: This indicates the utility of models in scientific learning and understanding. Some models may be used to communicate, predict, explain, or to test hypotheses.

Modeling helps to provide students with strong power to let them be able to understand complex systems, to learn concepts, and to predict hypothesis about phenomena (Hashem & Mioduser, 2010).

Learning science by modeling is a widely used approach. Although, students' previous knowledge might be contradicted to the scientific models, since the models they form are highly influenced by their beliefs, students will find it hard to learn concepts related to models (Chi, 2005).

In order for students to construct a model, they have to build a network of concepts and principles with clear inter-relations between them (Jacoboson & Wilensky, 2006).

However, some researchers claimed that modeling did not contribute to a lot of understanding, since it increases the complexity and cognitive load on students (Gobert, 2003).

Mental models contribute to meaningful learning which is defined as the ability of the learner to use his acquired knowledge to solve problems with relevant knowledge, then to use his available mental models to solve the problems regarding the nature of the problem. This means that the teacher have to create the active learning environment which help the learners to use their mental models, test them, decide to let them stay and reinforced, or to leave them and construct new ones. Furthermore, students' understanding must be assessed using problem-based learning in which the students are expected to show behaviors related to understanding such as calculating, predicting, and explaining processes. Since students' understanding requires the fact that students should remember knowledge, then they should have the ability to use them carefully (Michael, 2004).

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METHODOLOGY

The researcher used the experimental method by the quasi-experimental design due to its relevance and appropriateness to achieve the purposes of the study.

Population of the Study

The population of the study consisted of all of the students who are enrolled in 8th grade at East Jerusalem District government and private schools (4690) students, in which (2483) of them are females, and (2207) are males) in the second semester of the academic year 2016\2017 as the researcher got these data from the ministry of education of East Jerusalem District.

Sample of the Study

The sample of the study consisted of 152 students of the 8th grade (71 females and 81 males) in Bethany Secondary School for girls and Al-Maad Al-Arabi School for boys respectively. The researchers selected these two schools as a purposive sample due to the following reasons:

- The schools are close to the researchers' place of work.
- The administration of both schools accepted the implementation of the research in their schools.
- The presence of different sections of the same class within both schools. Thus, this will help the researchers assign control and experimental group in each school in order to fit with the methodology of the study.

In each school, both an experimental and control group were assigned randomly by toss.

Table 2: distribution of the participants of the study

Name of the school	Control group	Experimental group	Total
Al-Maad Al-Arabi School for boys	41	40	81
Bethany Secondary School for girls	36	35	71

Instruments of the Study

To achieve the objectives of the study the researchers used an instrument:

- Mental Model Exam.

The researchers followed these procedures for preparing the instrument and for checking its validity and reliability.

Mental Model Exam

The researchers built the mental model exam by analyzing the content of the 8th grade science book unit (Light and Spectacles) and its models, then the researcher adopted two questions

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from Lee, Chang, and Wu's (2015) mental models exam . Another two questions were constructed by the researchers according to specific criteria related to the nature of the unit.

Validity of the Exam

The first draft of the test was submitted to several specialists including Arabic language teachers, science teachers and supervisors, and a list of Al-Quds University Educational Sciences Doctors. All of their modifications were taken into consideration.

Reliability of the Exam

The exam was given to a pilot study composed of 16 females of 8th grade students studying at Orthodox School of Bethany in East Jerusalem in order to calculate the reliability coefficient of the exam using Chronpach Alpha which equals (0.812). The test was also used to check student understanding of its items, and to calculate the time needed to finish it.

In addition to these two instruments, the researcher prepared a teacher's guide to teach the Light and Spectacles unit using argumentation and write- to- learn strategy using the literature review and related studies that were mentioned previously. The teacher's guide was shown to science teachers of the 8th grade, supervisors, and Al-Quds University Educational Science Doctors and all of their adjustments were taken into consideration.

RESULTS/FINDINGS

Table 1: Means and standard deviation for learners' scores in the pre and post mental model exam according to method of teaching (experimental, control)

Group	Mean		Standard Deviation		N
	Pre	**Post**	**Pre**	**Post**	
Experimental	12.61	22.12	5.57	4.83	75
Control	11.32	14.11	6.55	6.48	75

*Note: two females students from the control group were absent during the application of post mental model exam.

Table 1. shows that there are apparent differences in the mean scores of learners in the pre and post mental model exam according to method of teaching (experimental, control).

Table 2: Means and standard deviation for learners' scores in the pre and post mental model exam according to gender (male, female)

Gender	Mean		Standard Deviation		N
	Pre	**Post**	**Pre**	**Post**	
Male	13.32	20.08	7.07	6.91	81
Female	10.40	15.75	4.29	6.35	69

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*Note: two females students from the control group were absent during the application of post mental model exam.

Table 2. shows that are apparent differences in the mean scores of learners in the pre and post mental model exam according to gender (male, female).

To check if these differences in mean scores of learners in the pre and post mental model exam according to method of teaching and gender are of statistical significance, (2-way ANCOVA) was applied using these data. The results are shown in table 3.

Table 3: (2-way ANCOVA) results for the learners' mean scores in the mental model exam according to method of teaching, gender, and the interaction between them

Source	Sum of Squares	df	Mean Square	F	Sig.
Pre-test	0.59	1	0.59	0.021	0.88
Method	2393.07	1	2393.07	85.43	0.00**
Gender	608.11	1	608.11	21.71	0.00**
Method * Gender	132.39	1	132.39	4.72	0.031**
Error	4061.46	147	28.01		
Corrected Total	7261.33	149			

** Significant differences

Results related to method of teaching

This table shows that F value for the method of teaching is (85.43) for the differences in the mean scores of learners in the mental model exam according to method of teaching (experimental, control). Also the significant level for the method is (0.00) which is less than the significant level ($\alpha = 0.05$). Thus there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8^{th} grade students' abilities to form mental models due to method of teaching.

To identify the source of these differences, adjusted means and standard errors were used as shown in table 4.

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Table 4: Estimated Marginal means and standard errors of learners' post mental model exam scores according to method of teaching (experimental, control)

Method of Teaching	Mean	Std. Error
Experimental group	22.02[a]	0.61
Control group	13.96[a]	0.61

It is clear from this table that the adjusted mean scores for the experimental group (22.02) are much bigger than the control group (13.96). This indicates that the differences are in favor of the experimental group.

Results related to gender

Table 3 shows that F value for the gender is (21.71) for the differences in the mean scores of learners in the mental model exam according to gender (male, female). Also the significant level for the gender is (0.00) which is less than the significant level ($\alpha = 0.05$). So there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to gender.

To identify the source of these differences, adjusted means and standard errors were used as shown in table 5.

Table 5: Estimated Marginal means and standard errors of learners' post mental model exam scores according to gender (male, female)

Gender of Student	Mean	Std. Error
Male	20.07[a]	0.60
Female	15.91[a]	0.64

According to this table, the differences in the adjusted mean scores are in favor of males, as shown that the adjusted mean for males are (20.07) while the adjusted mean of females are (15.91).

Results related to the interaction between method of teaching and gender:

It is clear from table 3 that the F value for the interaction between group and gender is (4.72) for the differences in the mean scores of learners in the mental model exam according to the interaction between method of teaching and gender. Also the significant level is (0.03) which is less than the significant level ($\alpha = 0.05$). So there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to the interaction between method of teaching and gender.

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To identify the source of these differences, adjusted means and standard errors were calculated as shown in table 6.

Table 6: Estimated Marginal means and standard errors of learners' post mental model exam scores according to the interaction between method of teaching and gender

Method of Teaching	Gender of Student	Mean	Std. Error
Experimental	Male	23.15[a]	0.84
	Female	20.88[a]	0.90
Control	Male	16.98[a]	0.84
	Female	10.94[a]	0.90

This table shows that the differences are in favor of males in the experimental method of teaching.

DISCUSSION

Results related to method of teaching:

Results evidenced that there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to method of teaching in favor of the experimental group.

The researchers believe that using the scientific argumentation model via "write-to-learn strategy" as a teaching method for two months with the experimental group has been proved to be challenging in developing the abilities of students to form mental models. This explains the importance of this approach in the externalization of students' critical thinking and developing mental skills. Students were debating and justifying claims using evidences in a writing manner, this enabled them to understand and experience multiple perspectives that are based on evidence.

These results agreed with Gobert et al. (2011) results which showed that there were statistically significant differences in students' understanding of models due to teaching method. The results also correspond with Buckley et al (2004) who proved that there was a statistically significant difference found between the control and the experimental group in understanding of biology concepts in favor of the experimental group which taught by modeling. Furthermore, the results agree with Schwartz and Skjold (2012) who proved the effectiveness of teaching about the nature of scientific models for future elementary and secondary science teachers.

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Results related to gender:

Results showed that there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to gender in favor of males.

Both genders were exposed to the same conditions of learning, but the males' scores in the post mental model exam were higher than the females' scores. They also formed sophisticated and correct models which fit with the scientific models.

However, Chittleborough and Treagust (2009) found that female students demonstrated a more scientifically sophisticated view of models. Also Liu et al., (2011) proved that female students were more likely to have higher scores in understanding epistemic knowledge of science such as the nature of scientific enterprise and the measurements in science.

Results related to the interaction between method and gender:

Results showed that there are statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of 8th grade students' abilities to form mental models due to the interaction between method of teaching and gender in favor of males in the experimental group.

Males of the experimental group scored more than females in the experimental group, and showed the abilities to form scientific mental models accurately. The researcher suggests that these differences are due to the nature and physiology of males, males tend to have more sophisticated models which help them to understand and predict different conditions, and they have more mental imagination of the real world.

None of the previous studies that the researcher surveyed checked the interaction between method and gender on abilities of students to form scientific mental models.

CONCLUSION

- To use the argumentation via "write-to-learn strategy" in teaching science due to its effect in improving students' skills.
- To train science teachers how to teach argumentation to students and to write teaching objectives that engage students with written argumentative activities as well as assessing students' performance and progression toward the objectives and receiving feedback from students about the effectiveness of this approach in their learning and understanding.
- To design activities in the curriculum and teacher's guide book this includes written argumentative tasks and write-to-learn activities.

Future Research

- More studies should be done on the interaction between method of teaching and gender on student's self-regulation and mental models skills.
- To conduct similar studies using this approach on different variables and different ages.

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