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Drama-Based Science Teaching and Its Effect on Students' Understanding of Scientific Concepts and Their Attitudes towards Science Learning

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Abstract

This study investigated the effect of drama-based science teaching on students' understanding of scientific concepts and their attitudes towards science learning. The study also aimed to examine if there is an interaction between students' achievement level in science and drama-based instruction. The sample consisted of (87) of 7th grade students from a public male school in Amman-Jordan; (46) in the experimental group and (41) in the control group. A pre-post Scientific Concepts Test (SCT) and Attitudes towards Science Learning Scale (ATSLS) were administered. The results indicate that there were statistically significant differences between the study groups in favour of students in the experimental group on both study variables, with no interaction between the teaching method and the students' achievement level in science. The study recommends employing drama in teaching science.

Keywords: attitudes, drama, scientific concepts, science learning

1. Introduction and Literature Review

One of the main concerns for science educators is finding teaching strategies and methodologies that can improve students' learning and experiences in science. Over the course of science history, models have played an important role in science development. Models also have been used in teaching in classrooms aiming at improving students' learning of science (Varelas, Pappas, Raymond, Kane, Hankes, Ortiz, & Shammah, 2010). Models in science represent objects, events, ideas, phenomena, and systems (Gilbert & Boulter, 2000). Prain and Waldrip (2006) suggested various categories of the way that models can be expressed: descriptive (verbal, graphic, tabular), experimental, mathematical, and figurative (pictorial, analogous, and metaphoric), and kinesthetic or embodied gestural understandings or representations of a concept or process. The non- linguistic modes of models include static images, physical objects, human body movement and expressions, and sound effects (Varelas et al., 2010). Dramatizing of scientific ideas is a particular type of modeling. People during drama create imaginary worlds which allow them to link their own experiences with the unknown outer worlds (Henry, 2000). Bolton (1984) called belonging to two different worlds: the world of image and the world of reality, *metaxis*.

There are many efforts in categorizing drama in science education. Based on science education dimensions (i.e., science as a product, the process and nature of science, and science as an institution in society), Ødegaard (2003) suggested three categories: drama as explorative, semi-structured (role-play), and structured. Yoon (2004) categorized drama in science according to its theme: science concepts drama- represents science facts or knowledge-, science character drama-uncover scientist's life story-, science history drama- show memorable scientific event or development process in history of science-, science debate drama- deals with social issue of science and technology-, and science expression drama- focus on artistic expression using science symbols or new technology-. Yoon (2006) also introduced two types of drama in science: with scripts and without scripts. The first type includes some scripts that may be provided to students by the teacher or created by the students themselves, and then the students act/ read the script. The second type includes role play and improvisation. In role play the context or the role is described to students then they act according to their roles. In the improvisation, the context or the task is given to students then they may act in non-verbal presentations like mime or gesture or movement.

The literature on science education offers two strategies in teaching science through drama: social simulations and physical simulations. Social simulations are useful in engaging students with studying the impact of science and technology on society using some activities, such as role play, debates, and consensus conferences. Social simulations have the potential to convey affective knowledge through empathy, which helps students to understand others' points of view, as well as understand students' feelings towards scientific and technological issues (Duveen & Solomon, 1994). The second strategy employs physical simulations to convey abstract concepts and phenomena which are non-human entities and unobservable in real world, such as atoms and electrons in circuits (Metcalfe, Abbot, Bray, Exley, & Wisnia, 1984). Students in physical simulations activities can experience and explore physical, biological, and chemical processes in which such processes are sometimes dangerous, expensive, or take place very fast or very slow (Jaques, 2000; Wilhelm & Edmiston, 1998). Thus, physical simulations can offer controllable virtual realities that enable students to understand the target topics deeply (Jaques, 2000). The diverse classifications of drama in science teaching allow science educators to use any of the aforementioned categories. As such, they can choose one or adapt any other one for specific educational purpose (Yoon, 2006). According to the previous drama categorizing efforts, the drama activities introduced in the current study can be seen as hybrid of the aforementioned categories. Students in these activities acted *role play*, tried to understand the *science concept,* and *used their bodies as actors*; all of these were happened using *physical simulation* in theatrical scenes.

Drama can be seen as one of the most inspiring and most powerful methods that can improve students' understanding of scientific concepts as well as sharpen their aesthetic experience in science. Using drama in science classrooms may increase students' inclusive growth: developmentally, academically, and socially (Moore, 2004). Vygotsky (1962) supported the notion that social interaction is crucial in the process of gaining better understanding of concepts; in this sense, drama also has a significant role in developing students' social skills. Thus, learning cannot be understood outside of the social context and social interaction (Miller, 2011; Sfard, 2003). Moreover, drama in science learning promotes engagement of learners in science activities and helps them to grasp challenging ideas (McGregor, 2012). In addition, drama accommodated learners' multiple learning styles and interests (Alrutz, 2004a).

Scientific ideas can be inspiring to everyone who has been trained to perceive the aesthetics of the surrounding nature. Drawing on Deweyan's epistemology, teaching and learning should enable students to have a meaningful experience; an experience that connects them to the world and the powerful ideas of science. In this sense, the power of drama in science teaching stems from its "unifying" and "transforming" effects that can combine the elements of Deweyan's "*educative experience*". In this unifying and transforming effects, aesthetic experience offered by drama can combine the practical, emotional, and intellectual components of the experience in *"wholeness"*. Furthermore, the aesthetic experience can change the way students see the world (Girod, Rau, & Schepige, 2003). Girod and Wong (2001) pointed out that aesthetic in science learning encourages students to engage with science ideas, increase their motivation to learn, and enhance their imagination faculties. Drama can infuse science with emotions, excitement, fun, and interaction. Such context provides a holistic experiential approach in learning science (Varelas et al., 2010).

In a revision of the literature related to drama in science instruction, Bracha's (2007) study revealed that students who have learned science through drama have shown a greater understanding of scientific concepts and preferred learning science through creative drama. The study conducted by Dorion (2009) revealed that teachers used drama to convey abstract scientific concepts through role play and pantomime. Dorion's study also stressed the power of drama in developing students' visualization abilities. Saricayir (2010) used physical simulations to investigate the effect of using drama on seventh grade students' understanding of the scientific concepts related to electrolysis of water. The results showed that drama group students gained better understanding of the target concepts than students of the control group. In a qualitative research study, Alrutz (2004a) found out that drama-based science teaching motivated students in learning science, boosted their enthusiasm for learning science, and solidified their understanding of science content. Moreover, Alrutz pointed out that drama suits students' learning styles. Other studies revealed that employing creative drama was an effective strategy in enhancing students' conceptual understanding of scientific concepts (Al bliwi, 2008; Al-Taweel, 2011; Hendrix, Eick, & Shannon, 2012). BouJaoude, Sowwan, and Abd-El-Khalick (2005) pointed out that employing drama in science teaching has the power of developing students' understanding of the nature of science. Moreover, other studies uncovered the positive effects of drama based science teaching on developing students' science processes (Al-Taweel, 2011), scientific thinking skills and scientific attitudes (Al bliwi, 2008).

2. Significance of the Study

The importance of this study stems from the importance of scientific concepts and the quality of learning/teaching of these concepts as well. Many studies showed that the way science is currently being taught does not live up to expectations. Science teaching is mostly fact-oriented and the majority of teachers focus on written examinations (Goodnough, 2001; Kamen, 1996). Leonard (2000) pointed out that "teaching by telling" is the most dominant pedagogy in which teachers ask questions and if students do not know the answer, the teachers give. Moreover, science is usually taught in ways that do not seem relevant or interesting to students (Penick, 2000). Students cannot apply science lessons to their daily life outside of school (Goodnough, 2001; National Research Council: NRC, 1998; The National Commission on Mathematics and Science, 2000; Weld, 2000).

One of the important variables that was addressed by this study is the students' attitudes towards science learning, as many studies revealed that students' attitudes towards science are declining (e.g., Department for Education, 1994; Miller, Pardo & Niwa, 1997; Smithers & Robinson, 1988). Osborne, Simon, and Collins (2003) have identified some general factors that influence students' attitudes towards science. Some of these factors are related to teachers, other are related to students' perception of the difficulty of science. Teacher related factor includes the teacher's ability and his/her willingness to accommodate to students' different cognitive styles through multiple exemplifications, use of the different types of mode of presentation, and his/her ability to take into an account students circumstances to modify learning tasks. Regarding students' perception of the difficulty of science, some studies revealed that students perceive science as a difficult subject (e.g., Crawley & Black, 1992; Havard, 1996; Hendley, S. Stables, & A. Stables 1996). Keeping the previous issues in mind, this study was conducted to investigate the effect of drama-based science teaching on students' understanding of scientific concepts and attitudes towards science learning as well.

Moreover, the importance of this study stems from the necessity to conduct research studies that deal with employing "physical simulations drama", as the Arabic studies (e.g., Al bliwi, 2008; Al-Taweel, 2011) reviewed by the researcher examine the effects of employing the "social simulations drama". Moreover, in spite of the successful use of drama in subjects such as reading, social studies, and language arts, it has not been used widely in science teaching (Alrutz, 2004,b). Also, the importance of this study stems from the need to examine the effect of drama on students' attitudes towards science learning, since there is a scarcity in studies that tackle such variable. It is somewhat surprising that is a scarcity of Arabic research studies that tackled the effects of drama, specifically physical simulations activities, on students' understanding of scientific concepts and their attitudes towards learning science.

3. Statement of the Research Problem

This study investigated the effect of inclusion of drama activities into science teaching on seventh grade students' understanding of scientific concepts and attitudes towards science learning. Specifically, the study addressed the following four sub-questions:

1) What is the effect of using drama in science teaching on students' understanding of scientific concepts?

2) Are there statistically significant differences in students' understanding of scientific concepts related to the interaction between achievement level in science and teaching using drama?

3) What is the effect of using drama in science teaching on students' attitudes towards science learning?

4) Are there statistically significant differences in students' attitudes towards science learning related to the interaction between achievement level in science and teaching using drama?

3. Method

3.1 Study Design

The current study adopted pre-test, post-test quasi-experimental design. The study comprises the following variables: two independent variables (traditional teaching and teaching using drama), two dependent variables (understanding of scientific concepts and attitudes towards science learning), and one covariate variable (students' achievement level in science: high [80-100%], average [60-79%], and low [less than 60%]). The last variable dealt with student's achievement level in science at the end of the first semester of the scholastic year 2013/2014, since the study was implemented at the second semester of the same scholastic year.

3.2 Participants and Procedures

The study sample consisted of total of (87) seventh grade students from a public male school in Amman-Jordan during the second semester of the scholastic year 2013/2014. Selection of that school was purposively; as the principal and the laboratory technician at that school expressed their intent to facilitate study implementation. The participants in this study were already distributed in two classes of seventh grade at the school where the study was implemented. For the sake of the study, one of the two classes was randomly assigned as the control group (n=41), whereas the other class was assigned as the experimental group (n=46).

For the purpose of the current study, the content of one of the units that are included in the seventh grade science textbooks has been analyzed. The selected unit is entitled “Heat". The unit includes the following main topics and concepts: three states of matter (solid, liquid, and gas) and methods of heat transfer (conducting, radiation, and convection). The author of this study taught the students in both study groups the intended scientific topics and concepts. Students in the control group have been taught traditionally. In the traditional science teaching, the students used their textbooks to read about scientific concepts, watched demonstrations, listened to lectures, and conducted the needed laboratory experiments.

To introduce the same topics and concepts to students in the experimental group, the author designed some activities that mainly based on using students' bodies as models, benefitting mainly of the study conducted by Varelas et al. (2010). Students in these activities were invited to imagine themselves as water molecules in the micro-world. The author explained to the students that “you are going to be the models of atoms and molecules”. For the model's sake, students had to use their wrists and elbows as chemical bonds to form molecules. In the dramatic scene of molecules, as the matter can change from one state to another if heated or cooled, which changes the distance between molecules, the power of the chemical bonds, and the amount of kinetic energy the molecules have, the author guided the students in miming these changes by moving their bodies through different speeds and different spaces in accordance with each state of matter. In the solid state of matter, the students move very slow within a virtual ice cube which had been marked out on the classroom floor, while they are locked together by their elbows in a huddle. In the liquid state, the students still locked together in the virtual cube, but move faster and away from each other. In the gaseous state, the students separate from each other and diffuse in the whole classroom. Water as an exception (i.e., negative thermal expansion) was not discussed in the previous activities.

Heat transfer in liquid and gas were mimed by implying a red card as a sign of heating. Once the red card was shown to the students in a queue, the closest one to the heating source (red card) begins “vibrating” in his place faster, then leaves his place to the end of the queue and replaced by the student who comes next and so on so forth. In the solid state of matter, as the molecules do not leave their places, the first student in the queue received the red card and begins “vibrating” faster in his place, then passes the red card to the one who follows and so on so forth.

3.3 Instruments

Two instruments were used to answer the study questions: Scientific Concepts Test (SCT) and Attitudes towards Science Learning Scale (ATSLS). Both of these instruments were administrated twice within two-week time interval, before and after the study implementation. SCT is an achievement test that was developed by the researcher benefiting from the related literature (e.g., Namroti, 2001; Shaheen, 1996). The final copy of SCT includes (20) items that measure students' understanding of the scientific concepts included in the “Heat” unit in the seventh grade science textbook. Validity of SCT was examined by a panel of experts in science education. Moreover, validity of SCT was calculated using Pearson's correlation coefficient between achievement level in science of (40) seventh grade students in the first semester of the scholastic year 2013/2014 and their achievement in SCT. The coefficient was (0.80), which is suitable for scientific research. Reliability of SCT was calculated using Kuder-Richardson (KR20) formula with (0.78) coefficient. Difficulty and discrimination of SCT items was calculated and found to be (0.50-0.65) and (0.60-0.78) respectively.

The other instrument used in this study (ATSLS) was developed by Abed (2005). ATSLS includes (31) items based on Likert's five grading point scale. ATSLS included the following categories: Anxiety towards student's ability to learn science, motivation towards science learning, enjoyment of science learning, and interest in science-related activities. Here are sample items of ATSLS (Science is one of my favorite subjects, I wait science sessions impatiently, I prefer watching science- related TV programs, science is a difficult subject). Abed applied ATSLS to investigate eighth grade male students' attitudes towards science learning in Amman- Jordan. This means, initially, that ATSLS is suitable to answer the last two questions of this study. To ensure validity of ATSLS, it was reviewed by a panel of experts in science education. Reliability of ATSLS was calculated using Cronbach's alpha equation, with (0.84) coefficient.

4. Results and Discussion

4.1 Results and Discussion of Questions "One & Two" (Understanding Of Scientific Concepts)

To answer the first question of the current study (i.e., what is the effect of using drama in science teaching on students' understanding of scientific concepts?) the mean scores (M) and standard deviations (SD) of SCT results were calculated (see Table 1).

Table 1. Descriptive statistics for students' results in SCT

Group	Achievement level in science	N	Pre-test		Post-test	
			M	SD	M	SD
Experimental	High	9	8.33	2.06	15.22	1.99
	Average	17	7.30	2.71	13.59	3.36
	Low	20	6.10	1.94	12.50	2.65
	Total	46	6.98	2.39	13.43	2.95
Control	High	6	8.33	2.07	12.33	3.14
	Average	17	7.00	1.84	9.47	2.03
	Low	18	6.89	1.28	9.17	2.46
	Total	41	7.15	1.68	9.76	2.58

Table 1 shows the mean scores for students' results in SCT. The mean scores for the students in the experimental group (M=13.43, SD=2.95) and in the control group (M=9.76, SD=2.58). To examine the significance of these differences, ANOVA test was administered (see Table 2).

Table 2. Tests of Between-Subjects effects for students' results in SCT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre-SCT	125.07	1	125.07	22.86	0.00
Group	225.90	1	225.90	41.29	0.00*
Achievement level in science	31.71	2	15.86	2.90	0.06
Group*Achievement level in science	2.98	2	1.49	0.27	0.76
Error	437.67	80	5.47		
Total	12862.00	87			
Corrected Total	950.23	86			

*Statistically significant difference (α=0.05).

It can be seen in Table 2 that the differences in the mean scores of students' results in SCT are statistically significant (F=41.29). Table 3 shows the adjusted means for students' results in SCT in the two study groups.

Table 3. Adjusted means for students' results in SCT

Achievement level in science	Group		M
	Control	Experimental	
High	11.54	14.43	12.99
Average	9.51	13.44	11.47
Low	9.27	13.09	11.18
Total	10.11	13.66	11.89

Results in Table 3 show that the differences are in favor of students who learned the target concepts using drama. As can be seen in Table 3, the adjusted means for students in the experimental group (M=13.66) is larger than the adjusted means for students in the control group (M=10.11). These results show that the drama activities have the power to improve students' understanding of scientific concepts compared with students who learned the same scientific concepts using the traditional way of teaching. This result came into accordance with other research study results (e.g., Bracha, 2007; Saricayir, 2010; Shannon, 2012).

Regarding the second question (i.e., are there statistically significant differences in students' understanding of scientific concepts related to the interaction between achievement level in science and teaching using drama?) Table 2 shows that the differences are not statistically significant (F=0.27). Table 3 shows that the adjusted means are higher for the students in the experimental group comparing with their counterparts in the control group, regardless of the formers' achievement level in science. Making a double comparison between students' results in SCT in each achievement level in science shows the following:

- Result of high achiever students in the experimental group (M=14.43) is higher than their counterparts in the control group (M=11.54).
- Result of average achiever students in the experimental group (M=13.44) is higher than their counterparts in the control group (M=9.51).
- Result of low achiever students in the experimental group (M=13.09) is higher than their counterparts in the control group (M=9.27).

These results show that drama activities have the power to improve understanding of scientific concepts for students in all achievement levels in science.

Results pertaining to the first two questions revealed that students in the experimental group, regardless of their achievement level in science, gained a better understanding of scientific concepts compared with students in the control group. This result comes in accordance with the results of some studies (e.g., Al bliwi, 2008; Al-Taweel, 2011; Hendrix et al., 2012). The current results can be interpreted by the power of drama in science teaching. Drama provided students with learning aids that motivated them to think of highly abstract concepts creatively. Students in the experimental group imagined themselves as tiny particles and imagined how to be a particle in solid, liquid, and gas states. These activities enabled students to understand the three states of matter and enabled them to understand deeply how the matter changes form one state to another. This interpretation confirms the findings of Dorion's (2009) study that drama enabled students to visualize the highly abstract concepts of the states of matter. Above all, drama may provide students with metacognitive awareness which results in meaningful learning of the target scientific concepts. Furthermore, drama activities necessitated students to learn the scientific concepts with their peers. This cooperation enabled students to watch each other through moving as tiny particles meanwhile they developed their communication skills. Vygotsky (1962) supported the notion that social interaction is crucial in the process of gaining better understanding of concepts. Thus, learning cannot be understood outside of the social context and social interaction (Miller, 2011; Sfard, 2003). Moreover, drama in science learning promotes learners to engage in science activities and helps them grasp challenging ideas (McGregor, 2012). As a result, students were able to scrutinize, evaluate, and adjust their learning. It can be said that the aforementioned learning context have the power to change students' stereotypes about scientific concepts and science learning as well. In accordance with Deweyan notions of "aesthetic experience", this learning context changed the way how students view the surrounding world (Girod et al., 2003).

One of the significant results of the current study is that all students in the experimental group get benefit of drama activities regardless of their achievement level in science. This result is highly important for students in average and low achievement levels. This result is due to the ability of drama to convert abstract concepts to concrete ones. Moreover, drama was found to be effective in tolerating students' individual differences, learning styles, and their multiple intelligences (see Alrutz, 2004a; Bracha, 2007).

4.2 Results and Discussion of Questions "Three &Four" (Attitudes towards Science Learning)

To answer the third question of the study (i.e., what is the effect of using drama in science teaching on students' attitudes towards science learning?) the mean scores and standard deviations for students' results in ATSLS were calculated (see Table 4).

Table 4. Descriptive statistics for students' results in ATSLS

Group	Achievement level in science	N	Pre- test		Post- test	
			M	SD	M	SD
Experimental	High	9	105.22	25.20	118.00	19.24
	Average	17	108.29	18.88	128.65	14.07
	Low	20	97.60	14.95	117.00	11.14
	Total	46	103.04	18.94	121.50	14.81
Control	High	6	119.83	19.13	114.83	15.70
	Average	17	114.29	23.28	115.06	26.80
	Low	18	99.89	17.36	99.39	22.67
	Total	41	108.78	21.39	108.14	24.46

Table 4 shows the mean scores for students' results in ATSLS. The mean scores for students in the experimental group (M=121.5, SD=14.81) and in the control group (M=108.14, SD=24.46). To examine the significance of these differences, ANOVA test was administered (see Table 5).

Table 5. Tests of Between-Subjects effects for students' results in ATSLS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre-ATSLS	10871.97	1	10871.97	45.60	0.00
Group	4447.91	1	4447.91	18.66	0.00*
Achievement level in science	750.65	2	375.33	1.57	0.21
Group* Achievement level in science	130.15	2	65.08	0.27	0.56
Error	19071.96	80	238.40		
Total	1192373.00	87			
Corrected Total	37654.28	86			

*Statistically significant difference (α=0.05).

As shown in Table 5 the differences in the mean scores for students' results in ATSLS are significant (F=18.66). Table 6 shows the adjusted means for students' results in ATSLS in both study groups.

Table 6. Adjusted means for students' results in ATSLS

Achievement level in science	Group		M
	Control	Experimental	
High	106.44	118.31	112.38
Average	109.97	127.13	118.55
Low	102.88	121.85	112.37
Total	106.43	122.43	114.43

Results in Table 6 show that the differences in students' attitudes towards science learning are in favor of students who learned the target concepts using drama. As can be seen in Table 6 the adjusted means for students in the experimental group (M=122.43) is larger than the adjusted means for students in the control group (M=106.43). These results show that the drama activities had improved students' attitudes towards science learning comparing with their counterparts who learned science traditionally.

Regarding the fourth question of this study (i.e., are there statistically significant differences in students' attitudes towards science learning related to the interaction between achievement level in science and teaching using drama?) Table 5 shows that the differences are not statistically significant (F=0.27). Table 6 shows that the adjusted means are higher for the students in the experimental group comparing with their counterparts in the control group, regardless of the formers' achievement level in science. Making a double comparison between students' results in ATSLS in each achievement level shows the following:

- Result of high achiever students in the experimental group (M=118.31) is higher than their counterparts in the control group (M=106.44).
- Result of average achiever students in the experimental group (M=127.13) is higher than their counterparts in the control group (M=109.97).
- Result of low achiever students in the experimental group (M=121.85) is higher than their counterparts in the control group (M=102.88).

These results show that teaching using drama activities is effective in improving students' attitudes towards science learning regardless of their achievement level. This result is in agreement with the findings of the study conducted by Hendrix et al. (2012). The current result can be interpreted in light of the results of the first two questions. This is to say that the benefits of drama in improving students' learning of scientific concepts positively changed their attitudes towards science learning. Improving students' attitudes towards science learning can be interpreted as a result of the power that drama has in changing students' perception of scientific concepts. These preconceived notions included the notion that scientific concepts are abstract, difficult to be learned, and can be learned only by high achiever students. Most average and low achiever students mistakenly believe that science concepts are elitist. The improvement of students' attitudes towards science learning is critical for average and low achiever students since those students who usually find difficulties in learning science. The aforementioned interpretation is in agreement with other studies (Alroutz, 2004a; Girod & Wong, 2001) that drama can increase students' motivation, boost their enthusiasm, and refine their aesthetic sense.

5. Conclusion and Recommendations

This study explored the effect of using drama activities on students' attitudes towards science learning and their understanding of the scientific concepts related to the three states of matter and methods of heat transfer. Results attained in this study support using drama activities to bring about positive changes in students' attitudes towards science learning and their understanding of scientific concepts. The overall pattern observed in the present study is consistent with the findings from other studies (e.g., Alrutz, 2004a; Brach, 2007; Saricayir, 2010).

The findings of the current study support the notion that drama is a powerful strategy that can change "completely" the traditional view of science class from being rigid and boring to being lively and entertaining. Learning in such new context became an authentic aesthetic experience. According to Deweyan's aesthetic experience (Dewey, 1934), drama activities convert students' ordinary experience of scientific concepts to an aesthetic experience. In such experience, learning became a kind of "wholeness engagement" where emotions, intellect, and practice react together simultaneously. Furthermore, the aesthetic experience can change the way students see the world (Girod, Rau, & Schepige, 2003). Girod and Wong (2001) pointed out that aesthetic in science learning encourages students to engage with science ideas, increase their motivation to learn, and enhance their imagination faculties.

Drama can introduce an experiential approach in learning science (Varelas et al., 2010). Students in drama activities used their bodies as a learning tool. In these activities they used their bodies actively to construct, transform, and express for themselves what meant to be a molecule in a solid matter, liquid, and gas. This learning context enabled students to express and construct the scientific meaning of concepts in a funny conversation with their peers and teacher. In such learning context, students' attitudes towards science leaning are highly probable to be changed positively, which may refer to the role of drama activities in creating collaborative learning, reducing or eliminating students' anxiety towards their ability to learn science, and increase their motivation towards science learning. Drama activities in this study were designed to create collaborative learning context which enable students to generate the scientific meaning of concepts. Sheridan, Byrne, and Quina (1989) pointed out that anxiety about learning science in collaborative learning reduced or eliminated for several reasons: First, collaborative learning tends to be supportive rather than competitive. Collaborative learning create environment in which students show fairness, kindness, and responsibility. Second, students share ideas in fear-free environment in which peers can engage in discourse, debate ideas, and share thoughts without anxiety. Third, in collaborative learning teacher and students become allies in learning process, in which the teacher is not an authority but rather a guide for learning.

One of the remarkable results of the current study is that the average and low achiever students in science were benefited from drama activities. Oliver and Simpson (1988) found a strong relationship between the three affective variables: "students' attitude towards science", "motivation to achieve" and "self-concept" and their achievement in science. Hence, drama activities may positively affect students' self-concept, specifically for low achiever students and average achiever students. This result offer hopeful news regarding such group of students. Those students have deeply mistaken preconceives about scientific concepts, they label science as elitist subject, and believe deeply that scientific concepts are something very difficult to be learned, except for clever students. Drama activities for those students may revolutionize the life in science classroom and convert it to one full of enthusiasm and enjoyment. In light of current results, it can be concluded that drama has positive effects on improving students' understanding of scientific concepts and it has positive effects on changing students' attitudes towards science learning as well. In the long run, drama-based science learning may be viewed as one of the promising strategies that can be used to improve students' understanding of scientific concepts and enhance their attitudes towards science learning.

Since the sample of the study included only male students, more studies are needed to be conducted on female students to identify similarities and differences in the outcomes. Moreover, other studies are needed to explore the effectiveness, if any, of drama-based science teaching on other variables such as its effect on students' understanding of the nature of science and its ability to change students' preconceived notions about the nature of scientific concepts and science in general.

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