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Abstract: *This research aimed to examine the impact of caricature drawings in the acquisition of scientific concepts and attitudes of 4th grade students for basic education towards science. The sample of the research consisted of 162 students from 4th grade. The results revealed that there were statistically significant differences at ($p = .001$) between the two groups in acquisition of scientific concepts in favour of experimental group. In addition to that, females scored significantly more than males in the post-test ($p = .001$), whereas the interaction between group and gender was not significant. The results also indicated that there were statistically significant differences ($p = .001$) between the two groups in the attitudes towards science in favour of experimental group scores. The gender also has a significant impact on developing positive attitudes towards science in favour of females, whereas the interaction between group and gender was not significant. Finally, there was a statistically significant difference ($p = .001$) between pre- and post-application of students' attitudes towards science scale in favour of post-application for the experimental group. Accordingly, the research recommends the use of caricature drawings to help students' in the acquisition of scientific concept and developing positive attitudes towards science.*

Keywords: *attitudes towards science, caricature drawings, scientific concepts.*

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THE IMPACT OF CARICATURE DRAWINGS IN THE ACQUISITION OF SCIENTIFIC CONCEPTS AND ATTITUDES OF 4TH GRADE STUDENTS FOR BASIC EDUCATION TOWARDS SCIENCE

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Introduction

This century is characterized by a rapid growth in knowledge and changes in all aspects of the society, including economic, educational, cultural, scientific, technological and other systems. To ensure the advancement of quality of life, these changes require responses from these systems. Titi and Abu Shrikh (2007) emphasise that the educational system responses are the most important and act as a catalyst for other systems responses. Therefore, there is an urgent need to develop appropriate teaching methods, especially for children in the early stages of education, as these represent a formative stage in the development of the human personality. In the same context, Hilah (2009) pointed out that the teaching methods that use images and drawings are more effective in developing mental ability than the teaching methods that depend on verbal texts. Many educators noted that using images and drawings is an exciting way for teaching students because of their ability to attract attention, helping them to focus and interpret the information embedded in them (Abu Qara, 2012; Suzuri-Hernandez, 2010; Baghban, 2007; Abdullmenaem, 2000).

In this context, Qurashi (2001) emphasises on the importance of employing caricature in teaching because of its attractiveness, which makes it a strong educational stimulus that can carry more than one idea or meaning. Attia (2007) also added that caricature plays a remarkable role in the education process. It helps learners gain more awareness by stimulating higher mental abilities and processes in a comic form. Helsby (1999) noted that caricature drawings create dialectic among students and thus, encourage them to engage in discussions, participation, expression of opinions and searching for evidence. Therefore, caricature has been considered as an active learning tool that helps learners to build their own ideas and add logic to them creatively (Ayu, 2016).



As any experiment in teaching and learning science, caution must be taken, especially with the use of caricature drawings. From the researchers' point of view, the use of this type of drawings in a wrong way can create an alternative understanding of scientific phenomena among students. In this context, Qurashi (2001) stressed that caricature drawings should be designed in the curriculum objectives framework. Therefore, researchers see that the educational caricature drawings should contain humour without exaggeration and focus on the scientific meaning. Also, they should be simple without any complicated or unnecessary details, so that the students can conclude the scientific concept properly.

The educational literature documented the effectiveness of using caricature drawings in teaching and learning science subjects. Despite the insistence of some specialists that caricature belongs only to literary production, the concept of integration between subjects and the partnership between science and art has become a necessity for teaching and learning processes (Ambusaidi & Belushi, 2009; Amri, 2009; Henedy, 2009; Tufte, 2006).

Children enjoy caricature when accompanied with educational texts because it spreads joy and a sense of humour in classrooms and attracts students' attention to the topic; thus, it is an effective way to learn scientific concepts (Rule; Sallis & Donaldson, 2008; Weitkamp & Burnet, 2007; Rule & Auge, 2005).

Referring to the previous context, science educators emphasise that the acquisition of scientific concepts is one of the most important goals associated with the cognitive aspect of science and that it is the basis of the knowledge. Students' acquisition of scientific concepts increases their interest in science as it enhances their scientific skills, planning different types of scientific activity that leads them to discover and learn new things (Pohl, 2011; Mohammed, 2009; Najdi, Rashid & Abdul Hadi, 2005). On the other hand, the contemporary trends in teaching science emphasise on the need to spread the scientific culture among members of the society and to develop positive attitudes towards science. As advocated by the American Association for the Advancement of Science (AAAS), educators should pay attention to the development of positive attitudes towards science especially in the early stages of education, which is a fundamental goal that represents the emotional side of the objectives of scientific education (AAAS, 1989).

Demerdash (1994) noted that learning which leads to the formation of appropriate attitudes among learners is more powerful and meaningful than learning which leads to the acquisition of knowledge only. This is because attitudes are relatively constant, and learners can retain them for a long time, whereas cognitive experiences are often forgotten over time (Qatami, 1998). Students who have positive attitudes towards science show more attention to classroom instruction and participate more in science activities (Germann, 1988; Jarvis & Pell, 2005). Therefore, attitudes towards science have attracted the attention of specialists, educators and experts. The National Assessment of Educational Progress in the USA (NAEP) assessed students' attitudes towards science. Student responses indicate that student interest in science decreases as they move through elementary school (NAEP, 1978). This decrease may be due to some reasons such as students become more interested in non-school activities when they get older, achieving low marks in school work, excessive attention to test results or lack of opportunities to enjoy school science (Yager, 1996).

In this context, Ozsahin (2009) pointed out that humour is an excellent way to attract students' attention, especially those who lose their interest or feel bored during lessons. He believes that caricature can create many opportunities for students to express themselves and their feelings freely. Therefore, caricature contributes to change in students' attitudes towards lessons by providing a positive learning environment. Basarmak (2016) agreed that caricature helps students to accept the scientific content because of its positive impact on their emotional feelings and mental states. Consequently, the idea of using caricature drawings was one of the ideas to be suggested for developing teaching methods and techniques. Despite the fact that curriculum development in countries all over the world, including Oman, is subject to higher educational policies, there are always opportunities for various educational practices and experiments. Thus, the idea of this research emerged to investigate the impact of caricature drawings on students' acquisition of scientific concepts and students' attitudes towards science (Dardier, 2001; Sammawi, 2010; Rikabi, Abdul Razzaq & Abdul Reda, 2016).

Several studies have been conducted to explore the impact of using caricature drawings in the acquisition of concepts in general and the scientific concepts in particular. In addition, many studies have investigated the impact of caricature in students' attitudes towards different subjects in general and science in particular. Sammawi (2010) investigated the impact of teaching through caricature in the acquisition of health concepts included in science textbook among 8th grade students. The results indicated that there were statistically significant differences between ($p = .05$) research groups in the acquisition of health concepts in favour of the group who studied the scientific topics using caricature drawings. Therefore, the researcher recommended including caricature drawings in science curricula.



Clary and Wandersee (2010) carried out a research aimed to explore the impact of using scientific caricatures on students' achievement of concepts in a geology course. The analysis results showed statistically significant differences ($p = .05$) in favour of experimental group scores. Accordingly, the researchers recommended the use of caricature drawings in teaching various science courses at the university education level.

According to Rule et al. (2008), teaching science in the United States of America primary schools is suffering from being neglectful, which increases over time as a result of political and economic conditions that dominate the world. Based on their beliefs in science importance and the importance of improving the quality of science teaching methods, the researchers conducted an experiment with a participation of (26) pre-service teachers. Participants worked to design educational science units for different scientific concepts such as earthquakes, fossils, crystals, glaciers and caves accompanied by caricature drawings. They also discussed and analysed the humour level and the quality of art in each drawing seeking for different suggestions to improve them. The total production of the participants was (48) caricature drawings supported by (12) educational scenarios related to the scientific concepts.

At the end of the experiment, the researchers carried out an open survey to identify participants' opinions. Results showed that participants felt that they learned many scientific concepts and facts through the caricature drawings and activities. They also remembered them easily because they were associated with a sense of humour. The participants also agreed on the effectiveness of caricature in delivering the scientific information to the students. They see that the integration between the humour in caricature drawings and the scientific content will help students, especially in the elementary stages, to achieve a deeper understanding of scientific concepts. Although the participants acknowledged the difficulty of producing science related caricature, they expressed their desire to use it in their science classes in the future.

Rule and Auge (2005) also conducted a research aimed to examine the impact of using humorous cartoons in students' acquisition of scientific concepts and their attitudes towards science. The results showed that there was a statistically significant difference ($p = .001$) between the two research groups' scores in favour of the experimental group. Students in the experimental group achieved an improvement rate of 23.5% in the post-scientific concepts test compared with their scores in the pre-application, whereas the improvement rate for the control group students was 12.3%. Based on the research findings, the researchers recommended adopting teaching strategies that are based on a sense of humour in teaching science.

A research of Dardieri (2001) showed that the use of caricature drawings in teaching magnet unit concepts for 5th grade students helped in the survival of learning effect of the scientific concepts and improved the students' attitudes towards science.

In a more recent research that aimed to investigate the impact of using caricature drawings on students' attitudes towards science, Rikabi et al. (2016) reported results that confirm the positive impact of using caricature drawings on improving 5th grade female students' attitudes towards science. Therefore, researchers recommended to include some caricature drawings in science curriculum books. This research agreed with the research by Ozay-Kose (2013), which found that teaching endocrine unit topics from secondary school biology books through caricature drawings had a statistically significant effect on students' attitudes towards biology. Students agreed that caricature added fun to biology learning, attracted their attentions, helped students to ignore tension associated with learning difficult concepts and they can easily learn biology by analysing details provided by the caricature drawings.

It is clear from the above discussion that acquisition of scientific concepts and improving students' attitudes towards science are very important in science teaching and learning processes. However, most of the science curricula present and discuss various concepts in a descriptive narrative style that lacks the opportunities to enjoy learning science. Because of this, using caricature drawings is an opportunity to add joy on science teaching to 4th grade students. There is a need to facilitate their acquisition of scientific concepts to carry out different science activities and also to encourage them to love science and develop positive attitudes towards it.

Research Questions

The current research aimed to answer the following two questions:

1. Does the performance of the 4th grade students differ in the scientific concepts test due to teaching method (caricature drawings/conventional), gender (male/female) and interaction between them?
2. Does the attitude of the 4th grade students towards science differ due to teaching method (caricature drawings/conventional), gender (male/female) and interaction between them?



Methodology of Research

General Background

The research used the quasi-experimental designs, where the sample of the research was divided into two groups; the experimental group was taught science topics and concepts using caricature drawings, whereas the control group was taught the same science topics and concepts through the conventional method of teaching. Both groups were subjected to pre- and post-scientific concepts test and an attitude towards science scale (Cohen, Manion & Morrison, 2000). The research was applied during the second semester of the academic year 2015/2016.

Participants

The sample of the research consisted of 162 students of age 9–11 years selected from the 4th grade in two schools of the Basic Education Grades 1–4. The researchers chose these schools intentionally because the school administration and the science teachers were willing to help and ready to co-operate in applying the treatment for the experimental group. In addition, teaching materials and resources for science subjects and topics were available. Students were randomly selected to participate in this research. Therefore, students were obligatory to participate in this research. Six classes were selected from the two schools randomly. In addition, the treatments were distributed randomly among them. The sample was divided into two groups as shown in Table 1. The experimental group consisted of three classes of 83 students: 38 males and 45 females who studied the unit of electricity, movement and heat through the scientific activities with caricature drawings in the teacher's guide which have been designed and prepared by the researchers specifically for the purposes of this research. On the other hand, the control group consisted of three other classes, which contained 79 students: 39 males and 40 females who studied the same unit through the conventional method of teaching.

Table 1. Distribution of the sample according to the research variables.

Group	Gender		Total
	Male	Female	
Experimental	45	38	83
Control	40	39	79
Total	85	77	162

Research Instruments

To achieve the research aims, the researchers designed.

A Teacher Guide for science activities included in the 'Electricity, Movement and Heat Unit' from the science textbook for 4th grade of Basic Education. The topics and concepts of this unit were redesigned involving caricature drawings with their related activities, teaching methods and evaluation tools, which are necessary to achieve the scientific objectives of this unit (see Figure 1 as an example of a lesson plan prepared to represent a scientific concept with a caricature drawing). The teacher guide was given to a group of specialists and educators in science education for their comments and suggestions.



Activity title: Thermal conductors**Science learning outcomes:**

By the end of this lesson, students are able to:

- Identify thermal conductors concept.
- Recognizes materials that transfer heat.
- Collaborate with others during practical activities and discuss the results.
- Respond to the ideas and actions of others and appreciate their contributions.

The caricature drawing:

Tools/ materials: metallic and plastic spoons, hot water/food pot, cold water/food pot.

Procedures:

Science teacher should follow these steps:

- Allow the students to examine the caricature drawing for 3 – 4 minutes.
- Encourage students' discussion about the caricature drawings by asking them:
 - Why the girl cried to get help from her mother?
 - What was the mistake that the girl did?
 - In your opinion, the coffee cup in the girl's hand could be made of.....(discusses and complete).
- Ensure that all students have the opportunity to express their opinions, feelings and ideas.
- Direct students to examine the tools and determine the main features of thermal conductors and their effects (*Safety Warning: avoid accidents during dealing with hot water*).
- Encourage students to brain storming in order to identify the practical applications of thermal conductors in daily life.
- Help the students to review the thermal conductors concept preparing them to learn about the next concept (Thermal insulators).

Figure 1: A lesson plan for teaching thermal conductors concept with a caricature drawing.

A Scientific Concept Test for measuring the students' acquisition of scientific concepts for pre- and post-implementation. The test covered the scientific concepts from the 'Electricity, Movement and Heat Unit' under the learning levels; which were 30% knowledge, 40% application and 30% inference as cited in the students' learning evaluating document in science for grades 1-4 as issued by the Department of Educational Evaluation, Ministry of Education (2015). The pre-test was used to verify the equivalency of the scientific concept for the two research groups before the treatment was started. The post-test was used to measure the effect of using caricature drawings in acquisition of scientific concepts, which was administered to both groups after the treatment was finished. It consisted of 20 questions, distributed as 6 multiple choice questions and 14 short-essay questions. The test was given to a group of experts in science teaching to ensure its content validity. The internal consistency was calculated using the test-retest reliability coefficient, which gave the value of .88.



Attitudes towards Science Scale, which have been designed to measure 4th grade students' attitudes towards science for pre-and post-implementation. The scale consisted of 16 items distributed among three domains, which are: 1) attitudes towards the content of science subject, 2) attitudes towards educational aids and activities of science and 3) attitudes towards science teacher teaching methods. Three points Likert scale (agree, neutral, disagree) was used to measure students' attitudes towards science. To find out students' attitudes, the positive items were graded as 3 (agree), 2 (neutral), 1 (disagree), whereas the negative items were graded as 1 (agree), 2 (neutral), 3 (disagree) (Pell & Jarvis, 2001). The scale was given to some experts in science teaching and in educational psychology to ensure its content validity; their internal consistency was calculated using the coefficient of Alpha Cronbach, which gave the value of reliability coefficient of .71.

Results of Research

Before presenting the results of the research, Table 2 shows the results of testing the verification of the equivalence of the research groups in scientific concepts before the treatment.

Table 2. Two-way ANOVA test results.

Source of variation	Sum of squares	Mean squares	F, (1-158)	p
Group	4.79	4.79	.22	.64
Gender	2273.1	2273.1	253.23	.001
Group × Gender	372.85	372.85	23.55	.001
Error	2500.18	15.82		

* $N = 162$, Total test score = 40

From Table 2, it is obvious that the (F) value is not significant regarding to group variable, whereas the (F) value is significant ($p = .001$) regarding to the gender variable. In addition, the interaction between the two variables was significant ($p = .001$). Accordingly, the two groups were not equal in scientific concepts. Therefore, (ANCOVA) will be used to compare the means of two groups in post-test.

To check the equivalence of both research groups in attitudes towards science before the treatment, multivariate analysis of variance (MANOVA) test was used and the results are presented in Table 3 and 4 below.

Table 3. Wilks' lambda values.

Source of variation	Wilkes' lambda	F	Hypothesis Df	Error df	p
Group	.99	.36	3	156	.87
Gender	.56	4.43	3	156	.001
Group × Gender	1.00	.17	3	156	.92

Results in Table 3 show that the (F) values for Wilks' lambda values indicate that there are no statistically significant differences due to group or the interaction between group and gender, whereas there is a statistically significant difference ($p = .001$) regarding the gender (male/female). To determine the direction of this difference and the level of its significance, MANOVA was used. The analysis was done to students' responses to attitudes towards science scale as a whole and for each domain of the three domains: 1) attitudes towards the content of science subject, 2) attitudes towards educational aids and activities of science and 3) attitudes towards science teacher teaching methods. The results as shown in Table 4.



Table 4. MANOVA test results.

Source of variation	Scale Domain	Sum of squares	Mean squares	F, (1-158)	p
Gender	1	206.52	206.52	104.46	.001
	2	58.42	58.42	21.21	.001
	3	4.78	4.78	22.41	.001
	Total	806.54	806.54	57.71	.001
Error	1	312.38	1.98		
	2	435.16	2.75		
	3	287.56	1.82		
	Total	2208.09	13.97		

It is obvious from Table 4 that the values of (F) are statistically significant at the level of ($p = .001$) for the gender in the three domains of the attitude scale and its overall score. This indicates that the two research groups were not equal in their attitude towards science before the implementing the experimental treatment of this research.

Results of Research Question One: *Does the performance of the 4th grade students differ in the scientific concepts test due to teaching method (caricature drawings/conventional), gender (male/female) and interaction between them?* The mean values and the standard deviations for both groups and gender (male/female) were calculated as shown in Table 5.

Table 5. Mean values and standard deviations of students' scores in the scientific concepts test.

Group	Gender	M	SD
Control	M	18.67	7.04
	F	21.17	5.92
	Total	19.93	6.57
Experimental	M	25.14	6.12
	F	3.69	6.30
	Total	28.15	7.68

* $N = 162$, Total test score = 40

To determine the levels of significance differences and their source and direction, ANCOVA was used to compare the means. The results are shown in Table 6.

Table 6. ANCOVA test results.

Source of variation	Type III Sum of squares	Mean squares	F, (1-158)	p	(η^2)
Group	2581.02	2581.02	63.87	.001	.29
Gender	652.57	652.57	16.15	.001	.09
Group × Gender	93.38	93.38	2.31	.13	-
Pre- score	88.28	88.28	2.08	.15	-
Error	6385.03	4.412			
Total	104304.04				
Corrected Total	9875.12				

*a. R Squared = .35 (Adjusted R Squared = .34)



The results in Table 6 show that the value of (F) is statistically significant ($p = .001$) for both group and gender, and there is no statistical significant difference in the interaction between the two variables (group and gender).

Results of Research Question Two: *Does the attitude of the 4th grade students towards science differ due to teaching method (caricature drawings/conventional), gender (male/female) and interaction between them?* The means values and the standard deviations for both groups and for gender (male/female) were calculated as shown in Table 7.

Table 7. Mean values and standard deviations of attitude towards science scale domains.

Scale Domain	Group	Gender	M	SD
1	Control	M	9.26	2.07
		F	1.90	2.02
		Total	1.09	2.20
	Experimental	M	12.34	2.06
		F	13.56	2.30
		Total	13.00	2.26
2	Control	M	8.90	2.16
		F	1.23	1.97
		Total	9.57	2.14
	Experimental	M	11.1	1.75
		F	12.5	2.13
		Total	11.8	2.08
3	Control	M	7.33	1.91
		F	8.13	1.70
		Total	7.73	1.84
	Experimental	M	8.55	1.50
		F	1.2	1.24
		Total	9.46	1.59
Total score	Control	M	25.5	5.45
		F	29.3	4.74
		Total	27.4	5.41
	Experimental	M	31.9	4.61
		F	36.3	4.36
		Total	34.3	5.08

To determine the levels of significance differences, and their source and direction, multivariate analysis of covariance (MANCOVA) was used and the results are shown in Table 8.

Table 8. Wilks' lambda values.

Source of variation	Wilkes' lambda	F	Hypothesis df	Error df	p
Group	.66	26.56	3	156	.001
Gender	.84	9.62	3	156	.001
Group × Gender	.096	2.34	3	156	.080



Results in Table 8 show that the (F) values for Wilks' lambda values indicate statistically significant differences ($p = .001$) due to group variable (control/experimental) and due to gender variable (male/female), whereas the result for the interaction between group and gender was not significant. MANCOVA test was used to determine the direction of these differences and their significance levels for each domain of the attitude towards science scale and its total score according to group and gender variables. The results were as shown in Table 9.

Table 9. MANCOVA test results.

Source of variation	Scale Domain	Type III Sum of squares	Mean squares	F, (1-158)	p	(η^2)
Group	1	332.35	332.35	73.68	.001	.32
	2	196.90	196.90	48.48	.001	.24
	3	11.90	11.90	43.57	.001	.22
	Total	1831.29	1831.29	77.49	.001	.33
Gender	1	82.30	82.30	18.25	.001	.10
	2	77.02	77.02	18.96	.001	.11
	3	61.08	61.08	23.99	.001	.13
	Total	658.61	658.61	27.87	.001	.14
Pre-scores	1	.14	.14	.04	.84	
	2	5.48	5.48	1.90	.17	
	3	2.21	2.21	1.41	.24	
	Total	17.63	17.63	1.35	.25	
Error	1	712.70	4.51			
	2	641.70	4.06			
	3	402.21	2.55			
	Total	3733.94	23.63			

The (F) values in Table 9 are statistically ($p = .001$) for the group variable in all three domains of the attitude towards science scale and its overall score in favour of the experimental group. In addition, the results showed that (F) values are statistically significant ($p = .001$) for the gender variable in all three domains of the attitude towards science scale and its overall score.

Discussion

The purpose of this research is to examine the impact of caricature drawings in students' acquisition of scientific concepts and their attitudes towards science. For this purpose, students' scores in the research tools were compared regarding to group and gender.

The results showed that there was a statistically significant ($p = .001$) for group variable in favour of experimental group students. The results of the current research agreed with a number of previous studies such as Sammawi (2010), Clary and Wandersee (2010), Rule et al. (2008), Rule and Auge (2005) and Dardieri (2001).

This is may be due to use of caricature drawings with experimental group which have encouraged the students gradually to express their thoughts without restriction or concern (Helsby, 1999; Kauffman, 1997). The students were excited to receive the caricature drawings prepared for the scientific concepts every time. They examined each caricature drawing to determine the relations between its parts and components. This helped to stimulate their thinking processes and encouraged them to exchange ideas in a learning environment far from boredom and mental stress that often exist in traditional teaching methods. Therefore, students acquired the scientific concepts in a smooth and enjoyable way rather than forcing them to memorize the information which can affect their understanding of the scientific concepts and their ability to apply them in new educational or life situations. These support the findings of others (Ayu, 2016; Dardieri, 2001).



During this research experiment, the co-operative teachers named a few benefits of using caricature in teaching scientific concepts, such as providing them with indicators to identify the growth and development of scientific concepts among the students. The caricature drawings also helped them to discover individual differences among students and their learning patterns (Ozay- Kose, 2013). The drawing also facilitated them to introduce difficult and complex scientific concepts in a simple way unlike the written texts and illustration pictures posed in the science book.

The caricature drawings helped to develop the electrical circuit concept with the students in the experimental group and therefore helped them to understand the concept applications up to the electrical circuits types (series and parallel). The students were able to identify and differentiate between the circuits types easily even if they were shown different components or in a different order of their parts. Students were happy to remember each caricature personality and its funny details that represent the scientific knowledge and employ it in new learning situations. Later, students were able to distinguish between the two circuit types through abstract symbols, even without showing them the circuit diagram; for example, lines were used to represent the rays of each bulb, so that the number of these lines reflected the light intensity and the students were able to discover the circuit type through them. As well as their abilities to solve, verbal issues have developed without any need to sensory materials or images, which represents the highest levels of concepts acquisition (Bruner, 1974).

In contrast, most of the control group students were confused between the circuit type (series and parallel) concepts. Despite the science teachers' attempts to connect it with the concept of parallelism in mathematics, this did not work for most students. The discussion with science teachers revealed that the students connect the meaning of parallel with the arrangement of the electrical wires in the electrical circuit rather than the arrangement of the lamps. This may be due to their former learning about parallelism using straight lines, which explains why students' attention goes to lines that represent the circuit wires. In addition, educational literature has identified 'opposite terms' as one of the concept learning difficulties (Ambusaidi & Balushi, 2009; Labib, 2004; Zeitoun, 1999).

As another example, students in the experimental group were able to classify a collection of caricature drawings that represent energy sources into renewable sources and unrenovable sources based on the differences shown in each drawing in a comic way. Brainstorming have led students to more than just categorise them according to the three domains mentioned in the science textbook (do they decrease if used?, do they affect the environment? and their cost 'expensive/cheap') and they added a new classification domain 'rely on them in the Sultanate of Oman 'large/small''. Students' performance in the test confirmed that students have acquired the scientific concepts of "renewable and non-renewable energy sources". Furthermore, they began to expand and go deeper in its details for more understanding, which reflects the constructivism theory principles in learning.

The caricature drawings also helped the students to understand the concepts related to heat transfer (conduction, convection and radiation). The details of each caricature contributed to bringing the scientific concept closer to the students' minds. One student linked the concept of 'convection' with her observations about the caricature in her own words by saying: 'That the water that heats up holds itself and escapes away from the heat up' which explain how the thermal convection occurs in liquids. However, the students in the control group faced some difficulties in understanding the difference between the convection and the radiation concepts and sometimes even the conduction concept, possibly due to similarity in the concept terms. The student may know the verbal meaning of each conceptual term, but he cannot connect them correctly.

The science teachers agreed that some pictures, which are used to illustrate the concepts of heat convection and heat radiation in science schoolbook, were not appropriate. As an example, the picture that represents the thermal conductivity may create an alternative understanding among the students because there is no direct contact between the body and the heat source, which is more like to be radiation rather than conductivity.

In addition to that, the experiment of heating an amount of sawdust in a glass of water, which was specified to illustrate and observe the thermal convection, did not gave the desired results. Most of the students were not satisfied with the circular motion of sawdust, which reflects the movement of liquid particles when heated because it is not clear enough. The experiment was also confusing to most of the students because it used a solid material 'sawdust' to illustrate the thermal convection that applies only on liquids and gases.

For the gender difference in acquisition of the scientific concepts, the results showed statistically significant difference in favour of female students. This result support the findings of (Momani, Dolat & Shalloul, 2011) but disagree with other previous studies (Qubajja & Adess, 2014; Heah, 2011; Saleh, 2011, Ahmed, 2006). Female students were better than males in the acquisition of scientific concepts, which may be due to several reasons such as

- Females are more able to verbalize than males (Abou Al-Nasr, 2012). They also better in language than



males in general (Voyer & Voyer, 2014). Males tend to shorten the expression, which affect the meaning of the scientific concept definition and its accuracy, whereas females can express more accurately and more extensively than males. In this research, the caricature drawings provided an opportunity for females to express the scientific concepts without any concern or restriction.

- Some caricature drawings topics such as benefits and dangers of electricity at home, static electricity on cloths, food, body energy and human temperature measurement, were important to females. Therefore, they were interested in learning and understanding those scientific concepts. Females are more interested in topics that touch their needs and their daily life at home than males who are self-centred and prefer to spend time outside home (Murphy, Ambusaidi & Beggs, 2006; Momani, Dolat & Shalloul, 2011).
- Females at this age are more mature in behavior, quieter and less responsive to distractions than male (Abou Al-Nasr, 2012; Hawarana, 2010; Gurian & Stevens, 2007). These features helped females to concentrate more on the scientific concepts in each caricature drawing which gave them a better result.

However, the differences between male and female students in science learning is very wide and complicated. The quantity and quality of factors that affect science learning for both genders make it an area that still needs more investigation.

Regarding students' attitudes towards science variable, the results of the current research showed that there was statistically significant difference in the group variable in favour of the experimental group. This result agreed with a number of previous studies such as (Rikabi et al., 2016; Ozay-Kose, 2013; Clary & Wandersee, 2010; Attia, 2007; Rule & Auge, 2005).

This could be explained that using the caricature drawings had positive impact on students' attitude towards science. For attitudes towards the content of science subject domain, using caricature drawings added fun and suspense to the content during science classes and presented science to students in an innovative and attractive way (Nasser, 2015; Clary & Wandersee, 2010; Ozsahin, 2009). In addition, caricature drawings were effective in teaching complex content and bringing it closer learners minds (Raj, 2013). The caricature drawings also had a positive impact on the students' feelings during science lessons and they improved students' emotional moods to make them accept the scientific content more (Papanastasiou & Papanastasiou, 2004).

For the attitudes towards educational aids and activities of science domain, caricature drawings have helped the students to get rid of shyness and hesitating to participate (Ozsahin, 2009). It should be noted that some of students produced their own caricature drawings and shared them with their classmates and science teacher, which indicate the positive impact of caricature in the psychology of students, encouraging them to express their understanding through their own drawings, which stimulate other students to participate in classroom activities. In this context, Tawalba and Obaidat (2012) emphasise that children's drawings are representative and expressive works that reflect their knowledge in a way that distinguishes them from each other. Children's drawings are considered as a communication language through which children can express their thoughts with positive or negative emotions (Haddad & Mahna, 2000).

The caricature drawings simply removed the feeling of weariness from the students' minds. This feeling, which often controls the students during the conventional classes, leads them to be passive recipients for the information and not interested in participating in learning activities (Kilic, 2016; Ozsahin, 2009).

Regarding students' attitude towards science teacher teaching methods domain, it could be that the caricature drawings have added humour and fun to the ways that teacher taught science to students. Methods of teaching science are one of the most factors that influence student attitudes towards the subject (Papanastasiou & Papanastasiou, 2004; Wahr & Hamouri, 2008). Caricature drawings also helped to form a powerful communication tool between students and their teacher, improving the students' perception of the science teacher and his role in teaching and learning (Basarmak, 2016).

For the gender variable, the results also showed that there was a statistically significant difference between male and female students of the experimental group students in favour of female students, whereas the interaction between the two variables group and gender was not significant. These results discarded with Murphy and Beggs (2003) in manner of female and male preferences of science topics. Although the unit included topics about energy, electricity, movement and heat, females' attitudes towards science were more positive compared with male. On the other hand, (Raj 2013) indicates that caricature drawings improved males' attitudes towards Turkish language lessons more than females among 7th grade students. From the observations during classes visits and



conclusions that have been collected depending on discussions with the cooperating teachers, the significant differences between males and females in favour of females' responses to the attitude towards science scale can be explained as follows:

- Females are more interested in the aesthetic aspects and more attracted to colours (Judy, 2005).
- Females are more capable of observing details than males (Murphy & Beggs, 2003). This may be the reason that makes females more concentrated and focusing on the small details in each caricature drawing than the males, who are often distracted by the whole image in general. Female students understood the meaning of each drawing deeper, which make them feel satisfied about their performance in science.
- Directing females to focus on a particular thinking path is easier compared with males, which makes females understand the science topics faster and thus make them feel comfortable and self-confident (Benn, 2005). This may be due to the physical and mental nature of the majority of males at this age and the difficulty of maintaining their focus on a specific thing for long periods. Researches proved that the emotional centers in the brain develop faster and earlier in females than in males, so females are quieter and more focused (Gurian & Stevens, 2007).

Conclusions, Recommendations and Implications

The conclusions from the above results are:

- Using caricature drawings considerably influences 4th grade students' acquisition of scientific concepts and attitudes towards science.
- Female students' performance substantially influenced compared with male students' performance in both research variables.
- Better understanding of scientific concepts are among the students who study science topics through the caricature drawings.

From the research results, researchers were convinced of the positive impact of caricature drawings in the students' acquisition of scientific concepts and their attitudes towards science. In addition, researchers observed that students in the experimental group were very excited about caricature drawings. It encourages them to learn science in an innovative and unusual method that employs a sense of humour, which helped to form a positive learning environment. Students felt that they are closer to their teacher than ever, and they were not afraid of making mistakes or presenting their unordinary ideas or questions in science classes. Consequently, the current research recommended the following:

- Holding training courses and workshops for science teachers and supervisors to familiarize them with the educational benefits of using the caricature drawings in teaching science.
- Qualifying the pre-service teachers with the needed skills to produce the educational caricature.
- Encouraging the opportunities for a co-operation between science, art and IT teachers to design caricature that serve different scientific topics for all grades.
- Exploiting students' talents in designing and preparing scientific caricature.
- Conduct further researches using caricature drawings and exploring their effect on
 - Students' achievement in different educational levels.
 - Students' interest in different topics, such as health and science ethics.
 - Teachers' perceptions and beliefs about this tool.
- Conduct a similar research on different grades and at different levels of achievement.

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