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Experiments Strategies Applied to Science Teaching in Jerusalem Area

Tahani ALI-RWEIDE
Charles University

Abstract: This study investigates the experiments' aims and strategies followed by Jerusalem high school science teachers. The research extends the completed research concerning science East Jerusalem teachers' beliefs in using experiments. The research sample composed of 196 high school science teachers from East Jerusalem schools. A questionnaire was distributed accompanied by interviews with four science teachers. The effects of the independent variables of gender, scientific degree (including educational qualification for teaching), and experience were examined. It was found that teachers practice experiments mostly to achieve scientific knowledge in learning, applying cooperative work and scientific research. The dominant strategy used in applying experiments depends on teacher, less than student dependent learning strategy. Therefore, none of the independent variables had an effect on the teachers' strategies.

Keywords: Experiments Strategies in Science Teaching, Aims from applying Experiments, Palestinian Science Teachers, Jerusalem High Schools

Introduction

The study investigates the aims and strategies followed by Jerusalem high school science teachers. It completes the work of the author about using experiments of Palestinian high school science teachers in Jerusalem area which shows that teachers' beliefs about using experiments are positive (Ali-Rweide, 2019). Ali-Rweide mentions barriers which affect doing experiments like school circumstances and lack of labs, crowded curriculum, large students' number in classes and danger of some experiments. All of these barriers may affect the aims that science teachers try to satisfy from conducting experiments, and strategies used for that. On the other hand, strategies used in teaching varies due to teachers and subjects they teach. Consequently, this research will look for Jerusalem high school science teachers' aims from practicing experiments and strategies that they use to satisfy that through answering the following questions:

1. What are the main aims of practicing experiments according to high school science teachers?
2. What are the main strategies used by high school science teachers in practicing experiments?
3. Are there statistical significant differences in the strategies used by high school science teachers according to the independent variables, gender, experience and scientific degree?

Literature Review

Throught history, eexperiment is one of the most effective methods that many science teaching educators and philosophers emphasised. Aristo in the third century BCE argued for learning through practice (Dewey, 1916). Comenius in the 17th century emphasized, in The Great Didactic book, on using experiments in teaching science and physics. Moreover, many researchers recently call for using experiments in teaching science.

Aims from doing experiments

Nichols & Stephen (2013) indicate the importance of experiments in answering scientific questions, examining or testing hypothesis and developing creative learning activities. In addition, Wahyuni & Analita (2017) applied

guided-inquiry experiments, on 38 undergraduate biology students in the Bbiology Education Department of the Islamic Institute (SII) of Tulungagung. They noticed that students developed scientific analytical skills after they completed the courses. Similarly, Bennett (2001) studies the effectiveness of using experiments by using a sample of twelve high qualified physics and chemistry teachers, three principles and supervisors in Ireland. Using experiments for Bennett was aiming at increasing students' motivation and enjoyment through their work; giving motivation to teachers and students while they perform work; giving students the opportunity to acquire and develop many abilities as practical skills and hand techniques; encouraging observation and precise description; discovering clarifying or explaining a concept, a law or a principal; testing or experimenting a scientific phenomenon; developing some scientific trends like mental openness and objectivity; developing experimental work such as designing experiments; collecting data and explaining results, and feeling like scientists as being able to solve problems.

Lavonen, Jauhiainen, Kopnen, & Kurki-Suonio, (2004) adapted on 98 physics teachers for both control and experimental groups, in Finland, shows that science teachers agree that experiment is important in teaching; 95.4% think that students learn physical concepts through experiment, 52 teachers out of 53; think that experiments raise students' external motivation; 29.1% think that experiments allow using of manual techniques and 29.8% think that students learn about the nature of physics. Hikmat & Khalaf (2016) study the effect of using dry laboratory in chemistry for high school students in Baghdad, stressed the importance of practical work for gaining scientific methods and trends while using tools. All the above studies foster the importance of using experiments in learning scientific knowledge and developing skills and trends. The strategies used by teachers will by turn follow this general aim.

Strategies followed experiments

The strategies vary in applying experiments. Some depend basically on teacher as the dominant actor of the teaching-learning process. Others give students more opportunity to share in the process. Many studies over the globe discuss this issue.

Hofstein & Lunetta (2003) `find that most experiments in lab manuals explained in a detailed illustrative way. It does not give students a space for thinking. Adding to that, students engaged in inquiry activities is neglected. This is confirmed by the results of Angel, Guttersrud and Henriksen (2004) showing that students' suggestions are neglected in teaching, presentations are used to clarify the phenomenon or concept repeatedly; experiment steps are given to students and not designed by them. A study of Aljaabari (2005) in Jerusalem area shows that there is a lack in students' participation in doing experiments according to high school science students' beliefs.

Brown & Melear (2006) as a completion for the Salish I Project shows that student dependent teaching strategy is rarely used, even after three years of teaching experience. This merge with Kang & Wallace (2005) which shows that teachers often use experiments to confirm theories, facts and concepts, while experiments steps are descripted by teachers in advance. The result of Lee (2004) about change of beliefs and practices for six science teachers shows that teachers describe materials and methods used in experiments. They make small groups and wait for short answers from students. All the previous studies confirmed that experiments are presented in the ready forms.

Effects of gender, scientific degree (including the educational qualification for teaching) and experience on strategies used for experiments

Lee (2004) noticed a positive change of six American science teachers' practices, after involving in an educational program and applying appropriate educational methods. She stresses the teachers' need to learn new appropriate methods in order to guide scientific understanding and investigation. Another study of Bryan & Atwater (2002) criticizes the educational programs that teachers are involved in, stating that the teachers' practices are a result of educational methods. Additionally, Pérez & Furman (2016).highlights the development of science teachers from 35 high schools in Peru after being involved in a 10 months course designed by Peruvian Ministry of Education. One of its most important results is that engaging teachers in long and different forms of inquiry educational programs leads to a change in their science teaching practices.

On the other hand, Friedrichsen & Dana's (2005) study adapted on high school biology teachers shows that educational qualification programs did not affect the teachers' way of teaching or practices. Luft (2001) studied the effect of inquiry applying program for 18 months on 14 high school science teachers with different

experience betweenn 0 and 17 years. Luft found that practices differ between teachers after the training course; those with teaching experience between 3 to 17 years practices changed more than those between 0 to 2 years of experience. Alqraraa (1995) about applying experiments in chemistry for 9th grade class in Jordan shows that there is no effect of the teacher's gender on the used strategies. In general, independent variables affect the strategies used in some studies and has no effect in others, as it had been shown in the researches.

Materials and Methods

This study is quantitative-qualitative one. First, a questionnaire content and construct validity was checked. Following the feedback, Factor Analysis and VARIMAX Rotation with Kaiser Normalization were used. The final questionnaire consists of three parts, the first part about personal information. The second part consists of 29 questions to measure aims that teachers try to satisfy form using experiments. The third part consists of 17 questions to measure strategies that teachers use in doing experiments. Both second and third parts answers are 4-point on Likert Scale; (1) Nothing, < 1%, (2) little (1-35) %, (3) medium (36-70) %, (4) a lot > 70%.

The questionnaire was distributed to 196 teachers, 109 females and 87 males. They all were high school science teachers who teach the Palestinian curriculum in Jerusalem area with different scientific degrees (including the educational qualification for teaching) and experiences. The qquestionnaire was analysed statistically using SPSS. Means and standard deviations were found for factors of both aims that teachers try to satisfy from using experiments and strategies used by them. On the other side, effects of the independent variables of, gender, scientific degree (including the educational qualification for teaching) and experience, on experiments strategies were found. T-test was used to check if the experiments strategies are affected by gender, and ANOVA were used.to examine if the experiments strategies are affected by scientific degree and experience This was reinforced by interviews, using open questions, carry on with four high school science teachers from different schools, specialities and experience. Their percentage use of experiments are 60%, 70%, 80% and 90%.

Results

Main aims from practicing experiments by high school science teachers in Jerusalem area

Teachers' aims from using experiments were summed up in three factors. Table 1 summarises the mean and standard deviation of each factor.

Table 1. Means and standard deviations for science teachers' aims from doing experiments

Factor No.	Name of factor	Sample size	mean	Standard deviation
1	Achieving gaols deals with cooperative work and scientific research	196	3.28	0.58
2	Developing trends and evaluate students	196	3.11	0.60
3	Achieving scientific knowledge learning	196	3.28	0.62

* 4-point Likert Scale questions (1) Nothing <1%, (2) little(1-35) %, (3) medium (36-70) %, (4) a lot > 70%.

It is clear from Table 1 that teachers use experiments basically for satisfying scientific knowledge learning and developing scientific research and cooperative work, followed by developing trends and evaluating students. Still, Means are high for all factors; so to be more specific, items for the most and less important aims, (specific questions in the questionnaire) and not the general factors are considered in table (2).

The most important aim for applying experiments are those connected to learning, applying, teaching and explaing scientific concepts, in addition to create a collaboration between students and the teacher. On the other side, teachers do not think that experiments are so important for developing trends like humanize science or appreciating scientist, nor for taking the differences between students into account. They do not think that it is the same importancece for encouraging students to design experiments by themselves or for discovering new scientific concepts. This may affect the strategies that teachers used in applying experiments.

Table 2.. Most and less important aims that science teachers try to satisfy

Item format for more important aims	Mean	Standard Deviation	Item format for less important aims	Mean	Standard Deviation
Supporting the theoretical part	3.52	0.71	Caring about differences between students	2.85	0.87
Explaining scientific concepts	3.52	0.72	Humanize science	2.85	0.91
Differentiating teaching methods	3.48	0.75	Appreciating scientists	2.89	0.87
Creating collaborating environment between students and teacher	3.45	0.72	Encouraging students to design experiments by themselves	2.95	0.89
Applying what students learn theoretically	3.40	0.79	Discovering new scientific concepts	2.98	0.84

* 4-point Likert Scale questions were used. (1) Nothing <1%, (2) little (1-35) %, (3) medium (36-70) %, (4) a lot > 70%.

Interviews about aims from practicing experiments by high school science teachers in Jerusalem area

Throughout the interviews with four teachers, they insist on the role of experiments in discovering scientific concepts and learning scientific knowledge. Two teachers use experiment often to discover new scientific knowledge; the others apply it for both discovering and insisting on scientific knowledge. In addition to that, they all emphasized the role of the experiments in developing trends like increasing cooperation between students, teaching them how to be responsible and developing scientific thinking. This go parallel with building the scientific knowledge. It is obvious that teachers' aims from using experiments are merged in both quantitative and qualitative parts. They are also in concert with Bennet (2001), Hikmat & Khalaf (2016) and Lavonen, Jauhiainen, Kopnen, & Kurki-Suonio, (2004)

Main strategies used in practicing experiments of high school science teachers' in Jerusalem area

It is obvious from Table 3 that teachers-dependent strategy is the dominant one, rather than those depend on student. It is the least when teacher has no role, mean = 2.32. To be more precise, items (specific questions in the questionnaire and not the general factors) for most and less strategies used will be shown in Table 4.

Table 3. Means and standard deviations for science teachers' strategies in doing experiments

Factor No.	Name of factor	Sample Size	Mean	Standard Deviation
1	Strategy depends on teacher	195	3.28	0.60
2	Strategy depends on student with teacher's support	195	2.74	0.60
3	Strategy depends on student	195	2.32	0.63

* 4-point Likert Scale questions were used. (1) Nothing <1%, (2) little (1-35) %, (3) medium (36-70) %, (4) a lot > 70%.

It is noticeable that used strategies depend basically on the teacher, since means of the items are between high and moderate, more than 70%, while those depend on students are not common, they range between medium and little, less than 35%.

Interviews about science teachers' strategies in doing experiments

Teachers in interviews declared that they usually prepare and arrange experiments, of which the results are known before. One teacher noted that students help in preparing some experiments if they are safe enough. All teachers divide students into groups, giving them manuals for each steps. Sometimes, students share experiments and obtained results except for dangerous ones, students make reports which are checked and marked by the teacher for evaluation process. This is agrees with Wahyuni & Analita (2017) when they insist on giving scaffolds to students and using feedback through the reports.

Table 4. Most and less strategies that science teachers use in applying experiments

Item format for more important strategies	Mean	Standard Deviation	Item format for less important strategies	Mean	Standard Deviation
Teacher knows experiment's result before applying it	3.66	0.67	Students work separately under teacher control	2.17	0.92
Experiment's procedure designed previously by teacher or curriculum	3.48	0.73	Students know experiment's result previously	2.17	0.75
Teacher does practical exhibition in front of students	3.22	0.80	Steps of experiment determined by student	2.22	0.99
Determine the problem of study by the teacher	3.19	0.87	Practical exhibition by one or few students	2.36	0.76
Determine experiment hypothesis by teacher	3.11	0.81	Determine experiment hypothesis by student	2.41	0.87

* 4-point Likert Scale questions was used.(1) Nothing <1%, (2) little (1-35) %, (3) medium (36-70) %, (4) a lot > 70%.

It is obvious that teacher-dependent strategy is used mostly, followed by teacher-centered approach with students help, while student-depend experiments is not used usually. This result supported those found in the quantitative analysis. (Angel, Guttersrud, & Henriksen, 2004; Brown& Melear, 2006; Hofstein & Lunetta, 2003; Lee, 2004) agree on the result that students' engagement in experiment is very limited. Student self-guided experiments are rarely used all over the globe.

Multi- variables effects correlation

Teachers with different gender, different scientific degrees (including the educational qualification for teaching), and different experiences, use similar strategies. ANOVA and T-Test was applied and showed no statistical significant differences in the teachers' strategies according to any of the independent variables. This result harmonize with Alqraraa, (1995) and Friedrichsen & Dana (2005), while it contradict with Bryan & Atwater (2002); Lee (2004); Pérez & Furman (2016) and Luft, (2001)

Conclusions and Discussion

Science teachers use experiments mainly to teach scientific knowledge for explaining scientific conception and applying the theoretical parts. Developing cooperative work and scientific research come in a second position. They do not use experiments to develop trends which deal with humanity or appreciation of science or scientific researchers. On the other hand, the dominant strategy used by science teachers is the teacher-dependent one and the least is student-dependent one. Experiments aim from doing experiments and strategies used in applying them are merged. Teachers' main aim is to support the theoretical part in science and explaining scientific concepts. This concert with the teacher's dependent strategy as his knowledge of experiment's result.and the teacher's designing an experiment and controlling all its steps,

I think dominant strategies and aims by science teachers is challenged by barriers that they face when applying experiments. Some of these are crowded curriculum, lack of class time, large students' numbers, lack of equipment and the danger of some experiments (Ali-Rweide, 2019). A teacher's dependent strategy will limit student's thinking and treat him/her as a receiver. It will not create good thinkers or scientific researchers, especially when experiment directions are given to student like a cookbook (Duit & Tesch, 2010). On the other hand, this strategy will minimize the time for applying experiments, make students safe, for dangerous experiments, and make it easier for teacher to follow up with a larger students' number. There are no effects for gender, scientific degree with educational qualification for teaching, neither for the experience on the strategies used. I think this is because all teachers have similar conditions at schools by teaching the same curriculum.

In conclusion, considering the barriers, student dependent strategy is difficult to be applied completely because students need direct assistant. There are a lot of variables which determine the strategy used by teachers, like students' numbers, time, curriculum and danger. In my opinion, the most appropriate strategy is the student's dependent one conducted under teacher's guidance. Teachers should give students the opportunity to think and

try many times, if the experiment is safe enough. They must direct them, ask them storming cognitive questions and control the experiments. If the experiment is dangerous, teachers must not allow students to apply it. Hopefully this research will be a trigger to find more sufficient ways to enlarge student's engagement in using experiments.

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Author Information

Tahani Husien Ali-Rweide
Charles University
P.O. Box 66172 East Jerusalem Israel
Contact e-mail: tahaniali01@yahoo.com