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Enhancement of School Students' Interest in, and Attitude toward Science by Training Their Teachers on Effective Delivery of Practical Activities

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Abstract: In this paper we report on enhancing students' attitude toward and interest in science by training teachers on Effective Practical Delivery in science. Teachers from 17 schools in Qatar, among them 24 secondary school teachers teaching grade 11, and 11 preparatory school teachers teaching grade 8, were enrolled in two, independent, extended training courses (four hours per week for 16 to 18 weeks) on delivery of practical science lessons. Each course was designed to train teachers on delivering practical activities aligned with science curriculum standards, in a way that allowed teachers to practice each activity during the training before delivery to their students. Teachers would then reflect on their teaching and discuss feedback with their trainers and colleagues in the subsequent training session.Evaluation of the program was based on Trainees' performances, student performance and measurement of students' attitudes toward science before and after training. Results suggest a notable and significant change in the skills, knowledge and confidence of teachers in delivery of practicals in their science classes as reflected by results from tests and observations. This paper will focus on the measurement of secondary school trainees' students' attitude toward science before and after training. Main findings using t-test show:

- Very significant increase in attitude of trainees' students after training ($p < 0.0001$)
- No significant change in control schools' students over the same period (p 0.78 - 0.86)
- Male students show higher attitude & higher self-efficacy than female students toward practical part of science and future science career but no significant difference in attitude toward science in general.

Keywords: Science**,** Practical, Delivery, Curriculum Standards, Training

Introduction

In general, attitudes are defined as a predisposition to respond positively or negatively to things, people, places, or ideas. Attitude contains affective, cognitive, and behavioral components (Simpson & Oliver, 1995) Attitudes toward science refer to whether a person likes or dislikes science, or has "a positive or negative feeling about science" (Koballa & Crawley, 1985, p. 223). Attitudes toward science, by researchers at one time or another, have been used to describe: a) attitudes towards science and scientists; b) attitudes towards school science; c) enjoyment of science learning experiences; d) interests in science and science-related activities; and e) intentions to pursue a career in science or science-related work (Tytler & Osborne, 2012).

Many research studies confirm the positive correlations between students' achievement in science subjects and positive attitudes toward science. Students who have positive attitudes show increased attention to classroom instruction and participate more in science activities (Shrigley et al.1988, Osborne, Simon &Collins 2003).

The focus on student interest and attitudes in the sciences derives from the well-established relationship between these affective variables and pre-college students' learning and achievement (Ainley, Hidi, & Berndorff, 2002;

Hidi, 1990; Tobias, 1994) particularly in science (e.g., Chang & Cheng, 2008; Glynn et al., 2009, Laukenmann et al., 2003; Weinburgh,1995). Additional studies (e.g., Borget & Gilroy, 1994, Calabrese Barton & Basu, 2007; Lavonen, et al., 2008; Mason & Kahle, 1989) have reported a relationship between such affective factors and decisions to pursue scientific studies, as well as choice of future careers.

Positive attitude is developed through personal support (teachers and family), use of a variety of teaching strategies and innovative learning activities, and student-centered instructional design (Csikszentmihalyi, 1997, Jarvis and Pell 2005). Previous studies have reported a decline in students' attitudes toward science as they approach secondary school (Farenga & Joyce, 1998; Kelly, 1986; Pell & Jarvis, 2001; Yager & McCormack 1989, Said et al. 2016). This decrease is especially pronounced for girls (Greenfield, 1997). Lovelace and Brickman (2013) reviewed several research studies on attitudes and students' motivation which show that "*students' perceptions of courses and attitudes toward learning play a significant role in retention and enrollment. Motivation has a strong direct effect on achievement, and, in some courses, students' attitudes may provide a better predictor of success than quantitative ability" (p.606)*

It is well known that students, as other humans, tend to experience the greatest enjoyment when they are involved in activities that require some investment of skill or effort (Harter 2009) According to Shumow and Schmidt (2014) "*If given the choice many students will opt for an activity that presents a moderate challenge over one that is mindless, because the challenging one is actually more enjoyable. Thus if students experience challenge in science, they may be more likely to choose to become involved in science tasks. Challenging activities are not just enjoyable, they also require that students focus their attention and energy in engaging more deeply in the task at hand. Thus practical activities are the best challenging tasks in learning science"* (p.112).

The fact that science teaching is most commonly associated with a laboratory, which is part of the physical environment, may favor the positive impact of physical environment on students' attitude and achievement. Therefore, researchers mostly report positive correlations between school environment and students' achievement. However, the extent of the impact and its significance is also dependent on other factors and, therefore, results cannot be conclusive.

In previous investigations (Said et. al 2013, 2016), we extensively studied the science teaching practices in Qatar. One finding of these studies was a declining interest in science and declining intentions to pursue or engage with science as they proceed across the grade ladder.

Tytler and Osborne (2012) explained that attitudes towards science is a complex concept that may include one or more of the following concepts embodied:

- the display of favorable attitudes towards science and scientists;
- the display of favorable attitudes towards school science;
- the enjoyment of science learning experiences;
- the development of interests in science and science-related activities;
- the development of an interest in pursuing a career in science or science related work.

In this paper we present results of how practical activities improve interest in, and attitude toward, science of secondary school students whose teachers were trained on effective delivery of these practical activities and how this training has impacted these attributes.

Method and Procedure

Participants

In the first phase (the focus of this paper) the participant teachers and students were as shown below:

- Number of teachers' trainees 24 (12 males and 12 females) – 8 from each science subject: Biology, Chemistry and Physics teaching grade 11.
- Number of control teachers: 27 (14 males and 13 males) selected randomly from various schools
- Number of schools involved – 8 intervention + 2 control
- Number of students impacted: 1800
- Number of training sessions: 19

- Total number of training hours: 80

Characteristics of the Plan

The main features that characterize the plan as implemented were based on the guidelines published by the Council of Chief State School Officers (CCSSO) on successful program development for teachers (Blank and Alas 2009). The authors reviewed extensively, by a meta-analysis study, hundreds of published papers on successful professional development programs for science and math teachers. They selected 74 of those which linked students' learning to their teachers' professional development programs. In another screening process, they selected 16 programs with best learning outcomes. The common features of these 16 programs are:

- content focus,
- active learning by teachers,
- coherence with curriculum/standards,
- collective participation,
- sufficient time (frequency, duration, follow-up).

Recently, Hammond et al. (2017) reviewed 35 methodologically rigorous studies that have demonstrated a positive link between teacher professional development, teaching practices, and student outcomes. Very similar common features were identified. This review indicated, as they stated, "that meaningful professional learning that translates to changes in practice cannot be accomplished in short, one-off workshops (p.15). Our program which started in 2015, has several common features to these characteristics.

The procedure that we implemented is summarized below:

In every training session conducted at the end of the week, teachers were trained on practical activities on a specific topic from the curriculum, selected to be in line with the academic plan provided by MEHE, then they perform the same activities at their schools in the week to follow. In the subsequent training session, teachers reflect and discuss feedback with their trainers and colleagues. Evaluation of the program is based on both teachers' performance and students' attitudes before and after training (Said et al. 2017).

Secondary school teachers' performances were tested by two means: class observation to assess lab delivery skills after the training course compared with a control group. In the last session, the 24 teachers were asked to write a comprehensive test on subject content knowledge, the related activities performed, and on designing lab experiments. Twenty-seven teachers, randomly selected from different schools, served as a control group and were also asked to take the same test.

Students' Attitude toward Science

As mentioned previously, this paper is concerened with the impact of teachers' training in improving students' attitude toward science.

544 students from classes taught by trainee teachers and 224 control students from students taught by teachers from two control schools were surveyed before and after the long training course in order to evaluate any change that could have happened in students' attitude toward, and interest in, science over the period of the training course (October 2015-April 2016).

Results and Discussion

A 5-point Likert score survey that contained 40 items grouped into six subset factors, was administered. The six factors include: Attitude, value of science, self-efficacy, family support, teacher support and attitude toward practical activities.

Figure 1 compares pre and post training interest in and attitude toward science of trainees' students before and after practical.As can be shown from the figure, the mean average of all the six factors increased significantly.

t-test analysis of the six factors using a statistical package for the social sciences, SPSS software, gives the data shown in Table 1. As shown from the table, the two-tailed "p" value is less than 0.0001 for all the six factors.

By conventional criteria, this difference is considered to be extremely statistically significant which is interpreted as a significant positive change reflecting the great impact of teachers' training on students' interests and attitude toward science.

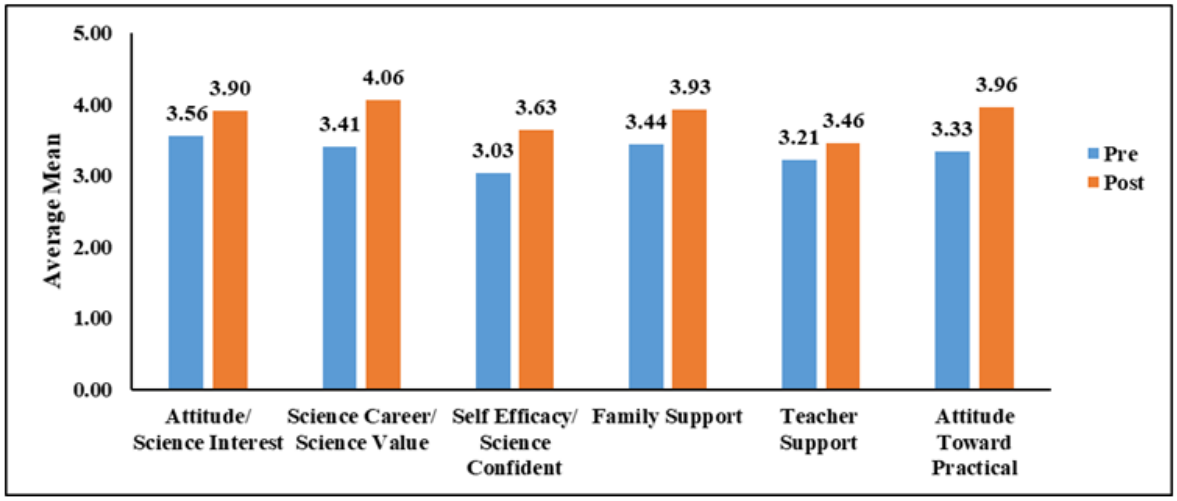

Figure 1. Change in interest and attitude toward science of students after training of their teachers on effective delivery of practical activities in science

Table 1. T-test analysis comparing students' attitude and interest in science before and after their teachers' training

#	Full Description	Short Description	Training	Mean	STD	Test	p	SED
1	Students' Interest in Science (or Students' Science Attitudes)	Attitude	Pre-Training	3.5571	0.67431	8.3893	<0.0001	0.041
			Post-Training	3.9049	0.65008			
2	Students' Beliefs About the Value of Science (Why Science Is Valuable to Me)	Value Of Science	Pre	3.4072	0.52008	17.8050	<0.0001	0.037
			Post	4.0593	0.65044			
3	Students' Beliefs About Their Science Proficiency	Self-Efficacy	Pre	3.0304	0.68776	13.4583	<0.0001	0.045
			Post	3.633	0.74339			
4	Students' Beliefs About Support from Their Families	Family Support	Pre	3.4434	1.13044	7.4024	<0.0001	0.066
			Post	3.9290	0.9556			
5	Students' Beliefs About Support from Their Teachers and School	Teacher Support	Pre	3.214	0.63387	6.3932	<0.0001	0.038
			Post	3.459	0.58931			
6	Items Difficult to Group (and difficult to add scores to each other or other items in a scale)	Attitude Toward Practical	Pre	3.3342	0.76147	13. 1848	<0.0001	0.048

Figure 2 compares change in one specific factor (students' attitude) with two different control schools: one school is classified by the Ministry of Education and High Education among below average performing school in science (control-1) and the other is one among the best schools (control-2). Teachers from control school (2)

are among the teachers who participated in the skill test. Four of them performed relatively well in the knowledge content test with the trainee teachers.

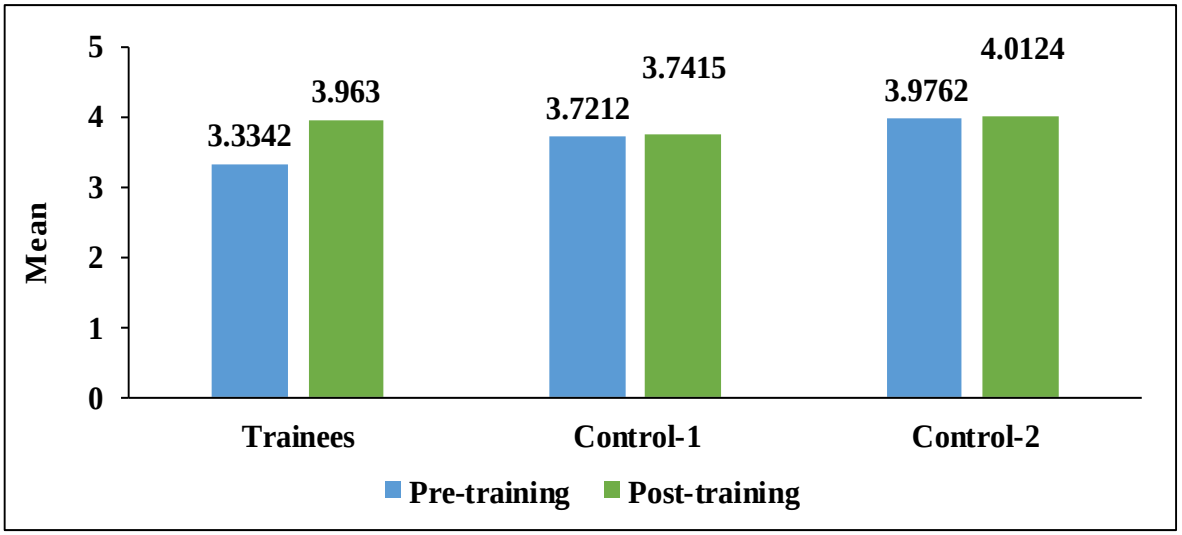

Figure 2**.** Change in students' attitude toward science-comparison with students' from two control schools

Table 2 summarizes t-test data results comparing change in attitude of students from the 8 trainees' schools and the two control schools. As shown from the table, the two-tailed P values of the control groups 0.8630 and 0.743, by conventional criteria, these differences are considered to be not statistically significant. On the contrary, students' attitudes at the 8 experimental schools have significantly positively changed over the same period of the long training course (P<0.0001). Another equally important factor, also, is the attitude toward practical activities which has been significantly improved which also contributed to the enhanced self-efficacy of students (factor -2 in Table 1). These results reflect the importance of effective delivery of practical training of teachers that help students to improve both understanding of theoretical principles and practical skills when communicating science to their students.

Table 2**.** T-test analysis of data on impact of training teachers on students' attitude toward science, comparison with students from two control schools

		N	**Mean**	**STD**	**Test**	**Sig.(P)**	**SED**
Trainees	Pre-Training	521	3.5571	0.67431	8.4330	<0.0001	0.041
	Post-Training	511	3.9049	0.65008			
Control-1	Pre-training	124	3.7212	0.9878	0.1727	0.8630	0.118
	Post-training	111	3.7415	0.7892			
Control-2	Pre-training	127	3.9762	0.8890	0.3274	0.7436	0.111
	Post-training	110	4.0124	0.7998			

Gender Difference

T-test analysis, to find out the extent of these variations for each gender before and after training, shows that improvement is more favored in the case of male students in two constructs of attitudes indicated by the higher test values and lower p-values (table-3). This gender–related difference in attitude toward practical science is a common phenomenon associated with a feeling of less confidence of girls than boys about pursuing science and dealing with technological instruments (Brotman & Moore 2008).

Table 3**.** Pre-and post-training impact of teachers' training on students' attitude toward practical and self-efficacy before and after training – Two Sample t-test

	Male				**Female**			
	Self-efficacy		Attitude toward practical		Self-efficacy		Attitude toward practical	
	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
N	255	266	260	256	261	255	264	262
M	3.83	4.14	3.93	4.23	3.60	3.70	3.87	3.98
SD	1.33	1.19	1.25	1.15	1.39	1.28	1.12	1.05
T	2.80		2.66		1.020		1.311	
P	0.0051		0.0080		0.0309		0.01810	

Conclusion

Students' interest in, and attitude toward science, was greatly enhanced by enrollment of their teachers on effective delivery of practical activities through a long training course which is content focused with "hands-on, mind-on" activities in alignment with their curriculum delivery. Statistical analysis indicates significant improvement in students' belief in the value of science, their self-efficacy, their teacher support and their attitude toward practical activities. Male students expressed better attitude toward practical activities and showed more self-efficacy.

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