The role of motivation and perceptions about science laboratory environment on lower secondary students' attitude towards science

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Received 26 Aug., 2017
Revised 29 Dec., 2017

Contents

Abstract

Attitude towards learning science is a well-researched domain for more than four decades. Globally, studies on attitude still stay relevant following the decline in enrollment in science-related studies across many levels. Particularly, emergent of new sciences in this century calls for a shift in the content included in school science, to be more contemporary. Hence, there is a need to inculcate an appropriate attitude to learn the new content. Many factors contribute to the development of attitude, in particular, motivation in learning the subject and the environment constitute learning the subject are imperative. In school science, investigating science laboratory environment is essential. Following this claim, in this study, an attempt was made to articulate the relationship between lower secondary school students' perceptions about laboratory environment, attitude, and motivation towards learning. For this purpose, in this quantitative survey, a total of 1003 lower secondary students between 13-15 years old from different schools in the Northern Region of Malaysia have participated. The result shows that motivation and perceptions of the learning environment are two factors that predict attitude towards learning science. These findings suggest that in designing teaching strategies, teachers need to consider how the teaching can affect the motivation and learning environment. Subsequently, the teaching strategies anticipated to influence students' attitude towards learning science.

Keywords: Attitude, Lower Secondary Students, Motivation, Science Laboratory Environment

Introduction

Remarkable advancements in science and technology frequently resulted in people living in this period of time equipped with various challenges. This mainly happens because contemporary scientific discoveries and advancements shape human thinking and influence the decision making either at the individual or communal level (Raved & Assaraf, 2011). The rapid development of science and technology had impacted the school science as well. It is notable that with the integration of some of the emerging new sciences teaching and learning of school science has changed its role in the 21st century. The purpose of science education has shifted from producing next-generation scientists to educate the general population on the issues and challenges impacting the world. These include issues on climate change, genetic modification, energy, diseases, medical advancement and pharmaceutical and cosmetic products derived from scientific innovations and inventions (Stewart, 2010). These contemporary issues constantly harming the world population and therefore there is an instant call to educate the people on the 21st-century science for the people to be able to make wise decisions concerning these challenging issues. For this purpose, the school science and the science classroom teaching and learning practices have to be restructured to make way for the inclusion of most current sciences and also to facilitate the development of 21st-century skills. Communication, problem-solving, and decision making are among the vital

21st-century skills. In addition to the skills the contemporary school science also should be able to inculcate desired behaviors and values among the students (Drake et. al, 2015).

Binkley, Erstad, Herman, et al. (2010) pointed out that for the new generation to success in the modern age, students must be able to communicate, share, and use the information to solve complex problems, adapt to new demands, and should be innovative in manipulating technology to create new knowledge. In order to produce technocrat students capable of handling and fulfilling the 21st-century requirements, teaching and learning in schools have to be aligned with this need. Teachers play an important role in determining the success of 21st-century philosophy through developing a positive attitude towards learning science among the students both inside and outside the school settings. The positive attitude ultimately expected to encourage students to take up science as their major subjects in future. A positive attitude towards learning science has been reported not only able to improve students' academic achievement in science, but also in other subjects (Movahedzadeh, 2011).

Background of the Study

Attitude towards learning science is an affective domain that has been researched for more than four decades (Aiken & Aiken, 1969; Can, 2012; Cheung, 2009, 2011; Otor & Achor, 2013; Xu, Villafane, & Lewis, 2013) and is a well-established construct that predict humans' behaviour (Glasman & Albarracin, 2006; Kelly, 1988; Koballa, 1988). Many studies have been carried out relating attitude to other constructs such as academic achievement, (Osborne & Collins, 2000; Xu et al., 2013), preference and behaviors (Glasman & Albarracin, 2006). In other words, although attitude has been extensively studied, it will be evaluated in this study because various other researchers indicated attitude still stays relevant in today's context. One of the reason for attitude to be still relevant is due to the ability of this construct not only to predict students' achievement in class, but it covers a wider area inclusive of human behaviors (Glasman & Albarracin, 2006).

Students' attitude towards science has been a research topic since 1980's and it is again emphasized in the 21st century with the decline of student's positive attitude towards science learning (Aiken & Aiken, 1969; Can, 2012; Cheung, 2009, 2011; Chua & Karpudewan, 2015; Xu et al., 2013). Studies conducted by Freedman (1997) and Weinburgh (1995) suggested that students with positive attitudes toward science have higher tendency to score better in science. As such apart from school academic achievement, attitude is another important aspect to be investigated in the academia evaluation especially in science education (Bennett, Lubben, & Hogarth, 2007).

In a study involving 11th grade (16–17 years old) 576 high school students, Salta and Tzougraki (2004) reported that there is a significantly strong correlation between students' attitude towards chemistry and their achievement in Greece. Besides this, there are various evidence on the existence of a positive relationship between achievement and attitude (Cheung, 2009). Chua and Karpudewan (2015) reported that there was a significant interaction effect between students' grade and gender and positive attitude towards learning chemistry. Meanwhile, Cheng and Yang (1998) found that Taiwanese students showed a positive attitude towards biology and this same study also reported that gender and socioeconomic status were not significantly correlated to students' attitude towards biology lessons. As such it could be surmised that up to this end attitude is an unresolved issue and persistently impacting the science teaching and learning.

Asabe (2013) and Wong et al. (1997) investigated the relationship between science laboratory environment and students' attitude. A review indicates that positive science laboratory environment contributes to a more positive attitude in science learning. In science laboratories, students have the opportunities to learn science by using their five senses. On the contrary, in the conventional classrooms teachers play the dominant role of lecturing the content to students. Ibrahim and Karpudewan (2013) claimed that positive laboratory learning managed to improve students' attitude. Similarly, Piburn and Baker (1993) pointed out that in order to inculcate a positive attitude towards science among students, the interaction between students with their teacher and the interaction among the students in discussing and sharing their ideas during the laboratory is essential. Hofstein and Mamlok-Naaman (2011) suggested that when interaction takes place between students and teaching materials, students and students as well as students and their science teacher this will further lead to effective, meaningful learning and understanding of science concepts. The decline of such interaction in the class eventually leads to the decline of students' attitude towards science. In order words, a teacher who engages the students in science laboratory work provides the students with an opportunity to question, share idea and actively engage in the learning process to have a better attitude.

Hofstein and Lunetta (1982) have pointed out that school science laboratory should provide a conducive learning environment whereby students can collaborate among themselves to investigate the scientific phenomenon. In order to provide a productive laboratory learning environment, Fraser and McRobbie (1995) had listed out some important aspects that should be taken into consideration which include students' cohesiveness, open-endedness of the laboratory, integration of the syllabus and the science laboratory, clarity of the laboratory rules and physical setting and materials in the laboratory. These aspects suggest that to foster a great learning environment in the science laboratory, the dynamic between students' expectation for learning, the interaction between student-student and student-teacher as well as the setting of the laboratory are essential.

Review shows that the failure of school science curriculum and classroom practices to spark the interest among the students in learning science are the factors that contribute to the low enrolment and low achievement in science subject (Osborne & Dillon, 2008; Sjøberg & Schreiner, 2010; Tytler, 2007). Boekaerts and Cascallar (2006) identify that self-regulation among students manages to influence students' engagement in the learning of science as well as school achievement. Similarly, Velayutham, Aldridge and Fraser (2011) had pointed out that students' motivation and self-regulated science learning would be factors that could promote students' interest in learning science and in return to have a better enrolment and achievement in science subjects. Therefore, besides perceptions on science laboratory learning environment, students' level of motivation contributes to the positive attitude among the students in learning science (Boekaerts & Cascallar, 2006; Kaplan et al., 2009; Zimmerman, 2000). It is a big challenge for school science teachers to stimulate students' motivation in learning science (Theobald, 2006) as motivation have been identified as internal circumstances that instigate goal-orientated behaviors (Schunk, 2004). Wu, Huang, and Wu (2006) identified science learning motivation mediated the relationship between learning environment and attitude toward science.

As it is evident that attitude is an important dimension in science teaching and learning and that science laboratory learning environment and motivation in some ways influence students' attitude towards science, this study was undertaken with the aim to investigate the predictive effect of the learning environment and motivation on attitudes towards science. As a laboratory-based instruction is an integral part of teaching and learning science in Malaysia, this study will be able to provide insights for teachers in designing laboratory lessons in a way that could inculcate positive attitude among the students. Poor performance in the TIMSS and PISA assessments and decline in the enrollment in science classes calls for investigating motivation as a predictive factor that affects the attitude.

Methodology

The Science Laboratory Environment Inventory (SLEI), Students' Adaptive Learning Engagement Science Questionnaire (SALES) and Test of Science Related Attitudes Questionnaire (TOSRA) were employed for the purpose of this research to measure the students' perceptions about learning environment, attitude and motivation to learn science (Fraser, 1981; Fraser & McRobbie, 1995; Velayutham & Aldridge, 2013; Velayutham, Aldridge, & Fraser, 2011). The SLEI consists of five constructs namely Student Cohesiveness, Open Endedness, Integration, Rule Clarity, and Material Environment. Each construct in SLEI consists of seven items with a total of 35 items aimed to measure the psychosocial aspects of the science laboratory learning environment. Meanwhile, SALES which aimed to measure students' motivation in learning science consisted of 32 items. The 32 items were further categorized into 4 different constructs which include Learning Goal Orientation, Task Value, Self-Efficacy, and Self -Regulation. Lastly, TOSRA consists of seven constructs with a total of 58 items. These constructs are Social Implications of Science, Normality of Science, Attitude to Scientific Inquiry, Adoption of Science Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. This study was performed in two stages. In the first stage, a pilot study was conducted to ensure the reliability and validity of SLEI, SALES and TOSRA questionnaires. Once the internal consistencies of the instruments were determined in the second stage the instruments were administered to a larger sample. In Table 1 examples of items for all the constructs in three questionnaires used in this study is illustrated.

Table 1. *The Example of Items for the Constructs in the Questionnaires*

Questionnaires	Constructs	Example of Items
Science Laboratory Environment Inventory (SLEI)	Student Cohesiveness	I get on well with students in this laboratory class.
	Open Endedness	In this laboratory class, I am required to design my own experiments to solve a given problem.
	Integration	What I do in our regular science class is unrelated to my laboratory work
	Rule Clarity	My laboratory class has clear rules to guide my activities

	Material Environment	I find that the laboratory is crowded when I am doing experiments
Students' Adaptive Learning Engagement Science Questionnaire (SALES)	Learning Goal Orientation	One of my goals is to learn as much as I can
	Task Value	What I learn can be used in my daily life
	Self-Efficacy	I can master the skills that are taught
	Self-Regulation	Even when tasks are uninteresting, I keep working
Test of Science Related Attitudes Questionnaire (TOSRA)	Social Implications of Science	Science can help to make the world a better place in the future
	Normality of Scientists	Scientists are about as fit and healthy as other people
	Attitude to Scientific Inquiry	I would prefer to find out why something happens by doing an experiment than by being told
	Adoption of Science Attitudes	I enjoy reading about things which disagree with my previous ideas
	Enjoyment of Science Lessons	Science lessons are fun
	Leisure Interest in Science	I would like to belong to a science club
	Career Interest in Science	When I leave school, I would like to work with people who make discoveries in science

The questionnaires were adopted due to its high internal consistency and validity. The SLEI, SALES and TOSRA have been validated and used by several researchers such as Wong and Fraser (1994, 1997); McRobbie, Fraser, & Giddings (1991), Henderson, Fisher, & Fraser (2000), Karpudewan & Chua (2016), Welch (2010), and Yetiser & Ceylan (2015) in their studies involving large number of students. This provided a strong foundation for researchers to adopt these questionnaires in future research related to laboratory learning environment, motivation in learning science and science attitude.

Pilot study

In order to ensure that the original questionnaire developed was suitable to be used in the Malaysian context, a pilot study was conducted with 60 (30 Form 2 and 30 Form 3) students from one of the non-participating secondary school. The original version of SLEI was provided with five options for students to choose from 1 (almost never) to 5 (almost always). Similarly, for SALES and TOSRA it ranges from strongly disagree to strongly agree with five points Likert scale. However, in the modified version of SLEI, SALES, and TOSRA the neutral scale has been eliminated. The main reason for not providing the neutral middle choice is to force the respondents to decide whether they agree or disagree with the items. Many survey respondents chose the neutral option on the Likert scale as they felt reluctant to express their own opinions, and this can have a significant impact on the results.

The Cronbach's alpha reliability values obtained from the pilot study ranges from 0.89 to 0.95. Meanwhile, the alpha value for all the constructs in each questionnaire was more than 0.70. According to Nunnally (1978), value above 0.7 was considered reliable and suitable to be used in the real study. Since the reliability index for items in the modified SLEI, SALES, and TOSRA were reported high, the modified version of SLEI, SALES, and TOSRA was used in the real data collection. Table 2 illustrates the Alpha Cronbach values for the instruments used in the study. A total of three secondary science teachers with more than five years of teaching experiences volunteered to validate the instruments. These three teachers checked for the content validity of the instruments and agreed that the content is suitable to the Malaysian context.

Table 2. *The Alpha Cronbach Values for the Instruments Used in the Study.*

Instruments	**Alpha Cronbach Values**
Science Laboratory Environment Inventory	0.89
Students' Adaptive Learning Engagement in Science	0.92
Test of Science-Related Attitudes	0.94

In the real study, a total of 1003 lower secondary students between 13-15 years old from different schools in Northern Region of Malaysia (Kedah and Penang) participated. The participating schools were randomly selected from these two states. The schools are government funded schools well equipped with basic amenities such as well-equipped science laboratories, textbooks, and computer laboratory.

Additionally, in government-funded schools, science is taught by well-trained qualified science teachers who obtained their bachelor's degree in science education from local public universities.

At the time of this study, the samples were in Form 2 (Grade 8) and Form 3 (Grade 9). Students from government-funded schools have equal opportunity to access to all the facilities provided in the school. For these group of students, science is a compulsory subject. Weekly science lessons were taught for three times for a total of 200 minutes. At lower secondary level science curriculum encompasses basic elements of physic, chemistry and biology. The curriculum provides a foundation for the students to study physic, chemistry and biology as separate curriculum at upper secondary level. The lower secondary examination result determines whether they will be in science or arts stream at their higher secondary level. As such it is appropriate to investigate these students attitude towards learning science, motivation in science learning and science learning environment so that the findings of this study will be a guide for the teachers to formulate better science learning.

Findings

A statistical test was performed to identify the relationship between students' attitude, motivation towards learning science and their perception of the science laboratory learning environment. A statistical data shows that attitude towards learning science was positively correlated with science laboratory learning environment ($r = 0.53$) and motivation towards learning science ($r = 0.51$). The overall model shows that learning environment and students' motivation are strongly correlated with the attitude towards learning science, with the R-value of 0.60. The high R-value indicates that the students perceived laboratory learning environment and motivation towards learning science more positively and tend to have a better attitude towards learning science. Following the correlation analysis, a multiple linear regression was performed to determine whether science laboratory learning environment and students' motivation are the significant predictors of attitude towards learning science. The multiple linear regression indicates that both factors (learning environment and motivation) are significant predictors of the attitude ($F(2, 1000) = 64.52$, $p < 0.05$, adjusted $R^2 = 0.36$). This indicates that 36.0% of the total variance in the attitude is explained by motivation and science laboratory learning environment. This appears to be a relatively large effect as Cohen (1988) suggested that values from 0.5 to 0.8 are considered to be medium to large effect. From the result, it can be concluded that the science laboratory learning environment and students' motivation were significant predictors of attitude towards learning science. Table 3 shows the Beta-value and the t value for the motivation and science laboratory learning environment.

Table 3. *Values for SLEI and SALES in the Regression Model*

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
SLEI	0.33	0.04	0.35	5.80	0.01
SALES	0.29	0.03	0.31	6.41	0.00

The researcher further investigated which construct in the SLEI and SALES significantly correlates with students' attitude towards science. Results indicated that Integration, Material Environment and Students Cohesiveness from SLEI significantly correlated with students' attitude towards learning science with R = 0.52. This reflects that secondary school students who perceived science laboratory environment to be well-equipped, promoting the integration of knowledge with scientific experiments and conducive for interactions among students tend to have a more positive attitude towards learning school science. From the five constructs in the SLEI, only three constructs (Integration, Material Environment and Students Cohesiveness) were significantly predicted the students' science attitude ($F(3, 999) = 37.56$, $p < 0.05$, adjusted $R^2 = 0.264$). The result signified that 26.4 % of the total variance explains by these three constructs and this shows the effects to be medium (Cohen, 1988). Table 4 shows the Beta-value and the t value for the constructs in SLEI.

Table 4. *Values for the Constructs in SLEI in the Regression Model*

Construct	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Integration	0.18	0.05	0.26	3.61	0.00
Material Environment	0.15	0.05	0.21	3.19	0.00

Students Cohesiveness	0.13	0.06	0.16	2.83	0.01

Meanwhile, for SALES, the result indicated that Task Value, Self-Efficacy and Self-Regulation have a significant correlation with students' attitude towards learning science with the R-value of 0.51. This reflects that students with high self-efficacy towards learning, high self-regulation in class and practicing high task value have a more positive attitude towards learning science. Out of four constructs, three constructs from SALES significantly predict the students' attitude in learning science ($F(3, 999) = 12.52$, $p < 0.05$, adjusted $R^2 = 0.256$). The result signified that 25.6 % of the total variance explains by these three constructs and the effect appears to be relatively small (Cohen, 1988). Table 5 shows the Beta-value and the t value for the constructs in motivation towards learning science.

Table 5. *Values for the Constructs in SALES in the Regression Model*

Construct	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Self-Efficacy	0.16	0.05	0.23	3.25	0.00
Self-Regulation	0.14	0.07	0.21	3.18	0.02
Task Value	0.12	0.04	0.20	3.02	0.00

Discussion

Donovan, Green, and Mason (2014) has pointed out that learning in the 21st century requires students to be able to design scientific investigation, analyze and interpret data, organize and present arguments from the evidence obtained. This requires the 21st-century science skills to be an integral part of science teaching and learning. Hilton (2008) proposed five competencies that the 21st-century students must acquire. These include the ability to adapt to the changes (adaptability), complex communications/social skills, non-routine problem solving, self-management/self-development, and systems thinking. With advancement in science and technology that has changed the global trend, it is necessary for the teachers and the curriculum to equip the students with all these skills. Profoundly, these skills are also known as higher order thinking skills that are essential for the students to endure the challenges of the 21st century including securing a good job. Efforts to inculcate these skills among the students are already in place in many countries including Malaysia.

The present study intended to investigate the relationship between lower secondary students' attitude, motivation towards learning science and their perception of the science laboratory learning environment. Results yielded from this study indicate that there is a significant relationship between attitude, motivation and science laboratory learning environment. A positive science laboratory learning environment has proven to be a predictive factor in increasing students' attitude to learning science. The results of the study are similar to the studies reported by Asabe (2013) and Wong et al. (1997) in which both studies suggested that a positive science laboratory environment will lead to a more positive attitude in learning science. Piburn and Baker (1993) also pointed out that in order to inculcate a positive attitude towards science among students, the interaction between students during the laboratory session is essential. The findings of this study correspond well with the assertion that interaction between/among the classroom communities and available materials predict the quality of learning (Hofstein & Mamlok-Naaman, 2011). Similarly, in this study students were in the opinion cohesiveness and material environment predict their attitude. Chua and Karpudewan (2015) asserted that integration of practical and theory lessons permits a better understanding of the concepts. Likewise, in this study, students were in the opinion integration is one of the subscales of SLEI that predicts attitude.

The second important finding of this study is that students' motivation significantly contributes to the attitude in learning science. Motivation is evident as a predictive factor in developing a positive attitude towards learning science. Particularly, students' feel motivated if the lessons develop self-efficacy, able to regulate their learning and the task have some values. A similar result also obtained in the study performed by Boekaerts and Cascallar (2006), Kaplan et al. (2009) and Zimmerman (2000). In these studies, it was stated that highly motivated students in science have a better attitude to learn science. The findings of this study suggest that school teachers have to motivate their students to learn science since highly motivated students have a better attitude and this lead to a better achievement in science. As such it could be proclaimed that motivation is one of the predictive factors that determine the attitude. Therefore, a motivated student expected to express a more positive attitude in learning science and this, in turn, increases the possibility of the student to engage in developing higher order thinking skills during science lessons. Science laboratory is a place where scientific processes and transfer of knowledge happens. In the context when students are highly motivated with a positive attitude the learning of scientific processes and transfer of knowledge in the laboratory setting will be more explicit. Additionally, the 21st-century scientific skills will be better comprehended by the students if the curriculum and the teacher could provide a favorable science learning environment for the students to develop and practice these skills.

Conclusion

The findings of this study suggest that students' motivation level and their perception about science laboratory learning environment predicts their attitude towards learning science. The findings of this study, in turn, calls for the teachers to design their teaching considering motivational factors particularly the value of the task; self-efficacy and regulation. Laboratory learning is an integral part of science teaching in Malaysia. In ensuring the laboratory lessons are meaningful, the findings of current suggest that the approach used by the teacher should create a positive learning environment that encourages students' cohesiveness; the environment allows integration of theory and practical lessons, and the environment is conducive for students to perform the laboratory activity.

This study corresponds well to the Ministry of Education's initiatives in improving science teaching and learning. The underperformance of Malaysian students in the global assessment, TIMSS and PISA have again alarmed the educators as well as the Malaysian government. To address the issue of students' underperformance in science and mathematics in the global arena, necessary steps have been taken by the government. This includes initiatives such as reforming of the primary and secondary school curriculum from exam-oriented system to more school-based assessment beginning from 2011. This study partly contributes to the Ministry's initiative in reforming science education in Malaysia.

In terms of research design, a survey was performed administrating the questionnaires to the students from the Northern region of Malaysia. The participants were from government-funded schools. Generally, government-funded schools throughout the country share many similarities. However, to further improve the generalization of the findings, it is recommended replicating the study involving students from different part of Malaysia near future. Additionally, qualitative findings would be able to provide further insights of the quantitative data. As such it is recommended for the students to be interviewed to better understand students' motivation and attitude and their perceptions of the learning environment.

Acknowledgements

Fundamental Research Grant numbered 203/PGURU/6711343 from the Ministry of Education, Malaysia, has supported this research.

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