J Sci Educ Technol (2009) 18:447–457
DOI 10.1007/s10956-009-9162-6

Ninth Graders' Learning Interests, Life Experiences and Attitudes Towards Science & Technology

Shu-Nu Chang · Yau-Yuen Yeung · May Hung Cheng

Published online: 4 April 2009

Abstract Students' learning interests and attitudes toward science have both been studied for decades. However, the connection between them with students' life experiences about science and technology has not been addressed much. The purpose of this study is to investigate students' learning interests and life experiences about science and technology, and also their attitudes toward technology. A total of 942 urban ninth graders in Taiwan were invited to participate in this study. A Likert scale questionnaire, which was developed from an international project, ROSE, was adapted to collect students' ideas. The results indicated that boys showed higher learning interests in sustainability issues and scientific topics than girls. However, girls recalled more life experiences about science and technology in life than boys. The data also presented high values of Pearson correlation about learning interests and life experiences related to science and technology, and in the perspective on attitudes towards technology. Ways to promote girls' learning interests about science and technology and the implications of teaching and research are discussed as well.

Keywords Learning interest · Life experiences · Attitudes towards technology · Ninth grader

S.-N. Chang (✉)
Swedish National Graduate School in Science and Technology Education Research, Department of Social and Welfare Studies, Linköping University, Linköping, Sweden
e-mail: shunuchang@gmail.com

Y.-Y. Yeung · M. H. Cheng
Department of Mathematics, Science, Social Sciences and Technology, Hong Kong Institute of Education, Hong Kong, China

Introduction

Students' affection dimension about science learning have been studies for decades, and the research results (Gardner 1975, 1996; Schibeci 1984 and references therein) all showed the importance of understanding and cultivating students' learning interests about science and their relationship to learning achievement (Simpson et al. 1994). Apart from examining students' affection dimension, it is significant to convey the relationship of science, technology and society (STS) as we are living in this science and technology dominating century. Accordingly, sustainability becomes a main concern, no matter from the perspective of education or scientific research. This study is situated on the importance of students' affection dimension about science learning and the notion of sustainability, 9th graders' learning interests and life experiences about sustainability related issues and scientific topics are investigated. Moreover, we also want to explore students' attitudes towards technology.

In the following section, the development of the notion of STS, research about students' affection dimension of science learning and students' attitudes towards technology are presented. Following with an important dimension to look into learning interests about science based upon gender issue, a theoretical framework regarding gender issue about science learning is also presented. In the end, we introduce an international project, ROSE, which provides us the main instrument to understand students' learning interests and life experiences about science and technology (S&T), and also their attitudes towards technology.

The Development of the Notion of STS

Following the rise of the global problems about climate change and global warming, it is not hard to notice the significance of addressing the strength and limit of science and technology in school education and society. Similarly, STS is an important notion has been conveyed for more than 50 years. In the Forty-six Yearbook regarding *Science Education in American Schools*, National Society for the Study of Education/NSSE (1947) has pointed out that science instruction in general education should have broad integrative elements and students need to know the relationship of science with problems of human society. The Yearbook Committee also expressed the notice that scientific developments also had the potential to destroy society, and public needed to know the knowledge and skills to make rational judgments about those risks associated with science (DeBoer 2000). However, the concept of STS was still seldom noticed till the 1970s. Scientific literacy was more strongly identified with science in its social context throughout the 1970s and early 1980s (DeBoer 2000). Gallagher (1971) even mentioned that, for future citizens in a democracy, understanding the interrelations of science, technology, and society may be as important as understanding the concepts and processes of science. Then in 1982, the NSTA board of directors adopted a statement entitled *Science-Technology-Society: Science Education for the 1980s* (DeBoer 2000). Till now, the last big promotion of STS is in Project 2061, which shows individuals ought to know science, mathematics, and technology are human enterprises, and people need to understand the implications on their strengths and limitations (AAAS 1989).

Students' Affective Dimension of Science Learning

As neatly defined by Simpson et al. (1994), the *affective dimension of science learning* contains an array of constructs like attitudes (including some essential ingredients such as feeling, cognition and behaviour), values, beliefs, and motivation. They pointed out that attitude should be considered as an essential indicator of the quality of science education. The attitudes in their affective dimension actually referred to student attitudes (specific feelings) towards science, attitudes towards science teachers, and attitudes towards the science curriculum. Noticeably, these attitudes are different from the "scientific attitudes" (e.g. Gardner 1975; Schibeci 1984; Ramsden 1998; Lichtenstein et al. 2008) that are more directly related to the outcomes of science learning. In a comprehensive review article, Gauld and Hukins (1980) defined the conceptual structure of the scientific attitude and stated that scientific attitude comprises the scientific dimension and the affective dimension. The former dimension consists of (1) general attitudes towards ideas and information (e.g. curiosity, open-mindedness and creativity etc.); (2) attitudes related to the evaluation of ideas and information and (3) commitment to particular beliefs or worldview (e.g. loyalty to truth, nature is understandable etc.) while the latter dimension focuses on a person's willingness to use scientific methods or preference (rather than the ability) to do so. In fact, those attitudes are often included as the learning objectives/outcomes in many local/national science curriculum documents/standards. The main reasons are that.

1. "adoption of scientific attitudes gives the student a better understanding of the nature of the scientific process because, to some extent at least, the student is acting out the role of a scientist as his behaviour is directed by scientific attitudes".
2. "scientific attitudes are important for all students in their everyday lives independently of their supposed importance to scientists… under the influence of these attitudes problems will be approached and information and ideas evaluated in a scientific manner, and consequently, with a greater chance of arriving at a satisfactory solution" (Gauld and Hukins 1980).

The study of student attitudes towards science or science learning has become a key component of science education in the past three to four decades. The research carried out in this field in the 1960s and early 1970s has been critically reviewed by Gardner (1975), who summarized (1) the methodological issues behind the measurement of attitudes, which still remains a key concern 20 years later (Gardner 1996), and (2) the relationships with other variables, such as the other attitudes and cognitive abilities of students and personality, gender, school context, science curriculum, and science pedagogies. More recently, a number of research papers have focused on the design of new research instruments and on the design of classroom instructions or strategies to effect change in student attitudes towards science and science learning. For example, Francis and Greer (1999) developed a new measure of attitudes towards science that has been administered to 2,129 secondary school students in Northern Ireland. It was found that younger pupils demonstrated a more positive attitude towards science than did their older counterparts. Siegel and Ranney (2003) developed a new questionnaire instrument to reflect changes in student attitudes towards science over time and applied it to assess two high school science classes. Tuan et al. (2005) developed a new questionnaire with six scales (self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation) to measure 1,407 junior high school students' motivation towards science learning in Taiwan. Krogh and Thomsen (2005) applied the concept of cultural border crossing for this kind of attitudinal research from the cultural perspective and found that cultural border-crossing factors are key predictors of attitudes towards physics learning in Danish upper secondary schools. Baram-Tsabari et al. (2006) proposed a novel methodology that makes use of US children's self-generated questions to indicate their level of interest in science. In relation to classroom instructions, Scherz and Oren (2006) investigated images of science and technology among middle school students in Israel and the effects of these images using a new instructional innovation to introduce students to science and technology in real-life situations.

Students' Attitudes Towards Technology

Based on a few major review articles of research findings from the late 1960s to early 1980s, Ramsden (1998) drew the miserable conclusion that over the past few decades, young people have generally held unfavourable attitudes towards science and technology. Osborne et al. (2003) confirmed this finding through a comprehensive review of the relevant literature of the past 20 years and its implications. He concluded that to understand and remediate the continuing decline in the numbers of students pursuing further study in science or science-related careers in many Western/developed countries, research on student attitudes towards science was very essential. Francis and Greer's (1999) results reflected that "males record a more positive attitude towards science than female". Based on the ROSE (see "The ROSE Project" section below for details) data collected from 25 participating countries/regions, Sjøberg and Schreiner (2005) found that young people hold a positive view towards science and technology and they consider science and technology *important* for society. However, they found out that "the more developed a country is, the less positive young people are towards the role of science and technology in society". Their studies also revealed that "in poorer countries, young people have a rather heroic image of scientists as persons, while this is not the case in highly developed western societies". In developing countries, both girls and boys favour a career in technology. Although there are some gender differences, yet they are in anyway smaller than that found in the developed countries in which young people are less interested in technology-related jobs and girls are even having much lesser interest.

Gender Issues About Science Learning

Over the last two decades, educational research in science led to some conclusive findings that there are significant gender differences in students' interest, attitudes, academic achievements and experiences of science learning (e.g. Johnson 1987; Kahle and Meece 1994; Weinburgh 1995; Burkham et al. 1997; Jones et al. 2000; Brotman and Moore 2008). For examples, boys show more positive attitudes towards science than girls (Weinburgh 1995) while Japanese girls' attitudes towards science tend to become increasingly negative since reaching junior secondary level (Nakazawa and Takahira 2001). Girls are typically more concerned about the human dimensions of science (or life science field plus topics on environmental issues) than more abstract scientific principles, experiments or instruments while they were much less interested in laboratory based sciences, physical science and engineering subjects because they cannot make affective links between those subjects and what they care about (Miller et al. 2006). Similar results were found that children in UK demonstrated a gender difference in their preference for physical sciences and biological science by the age of nine (Johnson 1987). Regarding the academic achievement in science subjects, girls had a very slight advantage in life science (Lee and Burkham 1996) but this gender gap in life science achievement changed from slight differences to differences favouring boys among high achievers. On the other hand, gender differences in high school physical science achievement changed from a substantially larger male advantage among high achievers to a uniform gap 2 years later for all ability level (Burkham et al. 1997). From students' perceptions of science, Jones et al. (2000) indicated that "significantly more females than males reported that science was difficult to understand, whereas more males reported that science was destructive and dangerous, as well as more 'suitable' for boys". As found by Gilbert and Calvert (2003), most of the female scientists described an experience of a sudden shift from their largely positive experiences of science in junior secondary school years to the negative experiences in their upper secondary years. Even though they were immersed with the subject matter of science from an early age, yet they "all described later feelings of alienation, of being 'cut off' from the possibility of developing a deeper, more 'adult' relationship with science" (likely due to sudden shift in the teaching approach exposed to them).

To account for the above-mentioned gender difference in science learning, different researchers (e.g. Burkham et al. 1997; Gilbert 2001; Nakazawa and Takahira 2001; Skog 2001; Gilbert and Calvert 2003; Brotman and Moore 2008) put forwards various theories for relating the reasons with the following four main factors:

1. Societal factors—parents and teachers often see science as more important for boys (a male domain) and so they may offer their daughters or female students fewer opportunities for science activities than boys (Burkham et al. 1997). This is coupled with the traditional gender roles and peer influence, leading to gender differences on the level of active participation in the science laboratory activities (Nakazawa and Takahira 2001).
2. Psychological and identity factors—in Gilbert and Calvert's (2003) study, most of the surveyed scientists viewed scientific work as actively *requiring* 'masculine' modes of thinking. Although those female

scientists rightly pointed out that good female 'role models' were important to young women in science education, yet all of them could not produce any convincing stories to make their lives as role models for young female students. Hence, science achievement does not naturally lead to an increase in self-esteem amongst females. In reality, high-achieving females are particularly likely to underestimate their abilities and performance in science subjects (Skog 2001) as they even consider their success and achievements to be undeserved or pure luck (Viefers et al. 2006).

3. Curriculum, pedagogy and school factors—teachers' influence which is embedded with unconscious gender bias in the teachers' expectation and teaching of boys and girls is one of the main causes for the gender differences in the students' experiences and interests in science learning (Nakazawa and Takahira 2001; Skog 2001). Therefore, boys are often allowed to grab most of the science teaching and learning activities in teacher-centred classrooms (Burkham et al. 1997). In the science curriculum itself which is often linked up with the development of masculinity, it tends to stress on changing females to become more similar to males in their behaviour and thinking by rejecting and repressing everything feminine (Gilbert 2001). On conducing a review of the research on the participation of girls in physics as funded by the UK Institute of Physics, Murphy and Whitelegg (2006) pointed out that the contents, contexts and approaches for problem-solving and investigations in physics education more closely relate to boys' (more than girls') out-of-school activities which are associated with masculine (rather than feminine) attributes as defined by the culture. Zohar and Bronshtein's (2005) research study revealed that most physics teachers overlooked the scope and educational significance of the gender gap in their subject and lacked any knowledge about gender-inclusive practices. Furthermore, schools often assigned more qualified teachers to teach advanced mathematics and science courses which were dominated by male students and so those high-ability boys would benefit more from the school science education.
4. Career factors—to become future scientists, females are doubly disadvantaged because they are not only under-represented as a group but also they are even further outperformed by other high-ability males (Burkham et al. 1997). Boys are more able to place a higher value on a dominant goal than that of girls, and to experience less conflict between career goals and future maternal/paternal roles (Crombie et al. 2005). Girls who choose the 'soft' science subjects, aim to prepare for work in female job areas in which they can take care of other people and this is a kind of "rationality of caring" (Skog 2001). The gender difference in the interest of learning different branches of science is mirrored in the children's job aspirations in which there are similar perceptions about sex-appropriateness of many types of jobs as found by Johnson (1987).

The ROSE Project

Apart from the validity and reliability of individual research instruments and methodologies, this vast body of attitudinal research has one major problem in common—the research instruments and methodologies have mainly been adopted by individual teams of researchers in specific contexts (and/or countries or regions; e.g. George 2006; Blalock et al. 2008). There is no easy way to undertake a comparative study directly from student responses as collected by different questionnaires or research instruments. The aforementioned TIMSS and PISA studies mainly focus on the academic performance or achievements of students (or learning outcomes to inform policymakers at the national and international levels), with little data on the affective domain of student science learning. Therefore, in 2002, Prof. Svein Sjøberg, who is a world-renowned professor in science education at the University of Oslo, initiated the ROSE (Relevance Of Science Education) international comparative project to fill this research gap, based on his previous "Science-And-Scientists" study. The ROSE proposal gained the support of educators in several key international associations in science education and received funding from several national education organizations. A number of international collaborators in more than 40 countries also received financial support from their own countries for local data collection. Around ten Ph.D. students in different countries are basing their theses on national and international data from the ROSE project. The term "relevance" in the ROSE project title actually refers to a wide spectrum of factors (particularly including interests and attitudes) that lie in the affective domain of science learning in the broadest sense of the definition. Those factors are related to students' relationship with and emotions towards science and technology such as interests, willingness and motivation to learn science, thinking and feeling about science, likeness, hopes, values, fears, perceptions and attitudes towards science, views, images and experiences (inside and out of schools) of science as well as orientation, plans, and priorities of science-related career etc. Furthermore, science education in the project also embraces S&T education.

Research Purpose and Questions

Since the ROSE instrument itself probes for a wide array of aspects on students' affective dimension of science learning, it would be too difficult and too lengthy to present and analyse the findings of all the questionnaire items. Hence, we shall narrowly focus on some coherent aspects which are of special research interest to the authors but there are not much findings (especially on Chinese learners) from past research. Therefore, the purpose of this study is to investigate 9th graders' learning interests and life experiences about S&T in Taiwan, and also their attitudes towards technology. According to the purpose, the research questions include:

1. Whether there is any gender difference about their learning interests and life experiences about S&T, and also their attitudes towards technology?
2. Is there any correlation between learning interests and life experiences about S&T?
3. Is there any correlation between attitudes towards technology, the learning interests and life experiences about S&T?

Methodology

In the methodology section, we will describe the data collection procedure, development of our instruments. The method of analysis will also be presented.

The Participants

We chose urban students from a major city called Taipei as our sample population because we need to eliminate the severe economic differences that would exist if students in rural regions were surveyed. This point is particularly important for our future direct comparison of findings with those from Chinese students living in other metropolitan cities like Hong Kong, Shanghai and Guangzhou as the same Chinese ROSE instrument has been employed to conduct similar surveys in those three cities. Of course, this lack of data on rural students will limit the validity of our overall results, but we had to make a compromise in view of the substantial difficulties and huge effort required to carry out the survey in remote/rural regions.

The basic idea was to invite around 800 students with about 100 students from each school to participate in this study in Taipei. Hence, we invited three classes from each school, since the average number of students in every class is 35 students in Taipei nowadays. To prevent the bias might be generated from the socio-economic status of different locations, there were altogether eight schools from different locations in the north, middle and south of Taipei were invited and they all agreed to participate in this study. A total of 942 ninth graders participated in this study, 505 male students and 437 females. The detailed distribution of the participants is presented in Table 1.

Table 1 Number of student participants and their locations of their schools

Locations	Number of students
North	390
Middle	278
South	274
Total	942

The Instruments

The main instrument adopted in this study is the ROSE questionnaire (Schreiner and Sjøberg 2004). To collect student data on their interests, attitudes, views, and motivation in the affective domain of science education (Gardner 1975; Crawley and Koballa 1994; Simpson et al. 1994; Osborne et al. 2003), Yeung and Cheng (2007, 2008) have already developed a Chinese version of the international ROSE research instrument, of which the theoretical framework of the complete instrument and the proper procedures of administration have been fully documented in the research handbook by Schreiner and Sjøberg (2004). Sjøberg and his collaborators have already carefully considered the validity, reliability, and credibility of their questionnaire instrument, which has undergone one local test survey in Norway and three rounds of international trials in 2002. During the development of the original research instrument, advice was sought from the ROSE Advisory Group, which consists of 13 experienced science educators from different countries. The Chinese version of the English ROSE research instrument, which includes a section for collecting its own set of socio-economic data, has undergone rigorous processes to ensure its validity and reliability. For example, two project team members have independently reviewed and refined the draft translation made by a research assistant and submitted the revised version for external scrutiny by another three independent science educators in Hong Kong, Guangzhou, and Shanghai. Data collection for the pilot study has been completed, and 2,426 valid questionnaires have been returned from 70 classes of students in addition to 251 student interview records. Yeung and Cheng's (2007, 2008) preliminary data analysis of the overall reliability of the ROSE questionnaire instrument found that the Cronbach's alpha = 0.98.

In this study, students were invited to answer the whole ROSE questionnaire, but the data analyzed and presented in this paper were a total of 116 items extracted from five out of ten sections (sections I, III, V, VII and VIII) of ROSE questionnaire, which were categorized into three main dimensions of learning interests (75 items), life experiences (25 items) and attitude towards technology (16 items). In terms of learning interests, there are different attributions of sustainability issues related to two sub-topics of life (16 items) and environment (10 items), earth science (15 items), biology (13 items), human physiology (14 items), chemistry (3 items), and information technology (4 items); and regarding to the dimension of life experiences, which are about sustainability issues related to environment (3 items), earth science (6 items), biology (8 items) and information technology (8 items). Items belonging to the category learning interests are from sections I, III and V. However, items related to life experiences are mainly from section VIII. Table 2 shows the different groups of items and their attributions with regards to the two dimensions of learning interests and life experiences. Items related to the dimension of attitude towards technology, are found in section VII. The reliability of the total of 116 items was 0.97 (Cronbach's alpha). The reliability was 0.98 (Cronbach's alpha) for the 75 items of learning interests, 0.85 (Cronbach's alpha) for the 25 items of life experiences and 0.87 (Cronbach's alpha) for the 16 items of attitude towards technology. The examples of the items are presented in Appendix.

Data Analysis

From ROSE questionnaires, a Likert scale scoring from one (not interested/never/disagree) to four (interested/often/agree) is adopted separately to reflect students' views regarding their learning interests, life experiences and attitude toward technology (Appendix). After grouping the items according to the attributions described above, independent *t*-test (SPSS 12.0) was adopted to analyze the data in order to answer research questions regarding students' learning interests, life experiences and the differences between genders. Furthermore, Pearson correlation (SPSS 12.0) was used to see if there is any correlation among learning interests, life experiences and attitude towards technology.

Results

Learning Interests and Life Experiences from the Perspective of Gender

Findings suggest that there are gender differences among 9th graders' learning interests regarding S&T and also their attitudes towards technology. Boys all showed higher learning interests about S&T in this study, but only two attributions revealed significant differences ($P < 0.05$) between boys and girls (Fig. 1). One was the sustainable issues related to environment (boy = 2.41 ± 0.82 and girl = 2.22 ± 0.75), and another one is about their learning interests in chemistry (boy = 2.38 ± 0.84 and girl = 1.79 ± 0.78).

In terms of life experiences about S&T, findings revealed that girls showed more life experiences about S&T than boys from all four attributions (Fig. 2), and three out of four attributions demonstrated significant differences ($P < 0.05$). One was their experience related to the sustainability issues related to environment (boy = 2.55 ± 0.88 and girl = 2.73 ± 0.62), and the second attribution

Table 2 The items analyzed in this study and their attributions

Attributions	Learning interests				Life experiences	
	Section	Items	Total number of items		Items from section VIII	Total number of items
Sustainability issues						
Life	I	18, 26, 32	16	26	NA	0
	V	7, 8, 9, 10, 11, 12, 13, 14, 15, 22, 31, 32, 35				
Environment	V	3, 4, 5, 6, 16, 17, 19, 20, 21, 33	10		18, 24, 25	3
Earth science	I	1, 3, 4, 5, 19, 22, 23, 24, 25, 34, 35, 44	15		1, 3, 4, 5, 12, 13	6
	III	16, 17				
	V	2				
Biology	I	6, 12, 13, 14, 15, 16, 20, 27, 28	13		6, 7, 8, 10, 14, 15, 16, 17	8
	V	1, 18, 24, 25				
Human physiology	I	7, 8, 9, 10, 11, 29, 33, 36, 37, 38, 40, 42, 43	14		NA	0
	V	23				
Chemistry	I	2, 17, 31	3		NA	0
Information technology	I	45	4		44, 45, 46,47, 48, 49, 50, 51	8
	III	5, 6, 7				

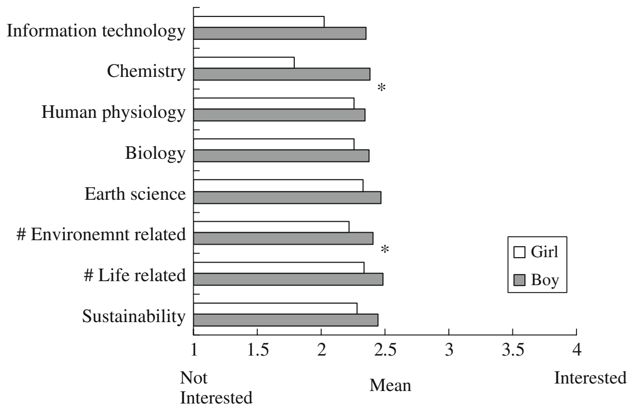

Fig. 1 Ninth graders' learning interests regarding S&T (*$P < 0.05$)

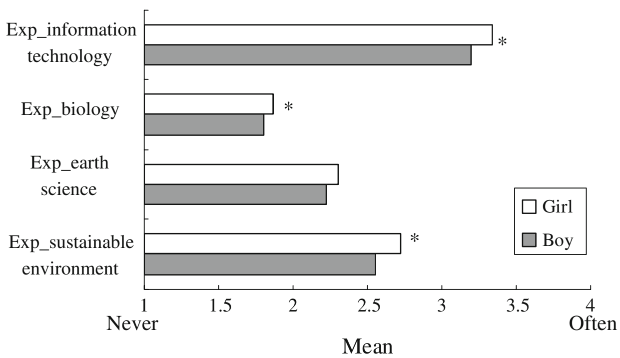

Fig. 2 Ninth graders' life experiences about S&T (*$P < 0.05$)

was about their experiences related to biology (boy = 1.81 ± 0.51 and girl = 1.87 ± 0.45). The third one was about experiences with information technology (boy = 3.20 ± 0.63 and girl = 3.34 ± 0.57).

With regard to the attitudes towards technology, findings also reveal significant difference between boys and girls ($P < 0.01$), in which boys showed more positive attitudes than girls (boy = 2.70 ± 0.54; girl = 2.57 ± 0.45).

The Correlation Between Learning Interests and Life Experiences

Table 3 summarizes the results related to the learning interest and life experiences which show significant correlation levels, ranging from 0.117 to 0.535 ($P < 0.000$), except learning interest about chemistry and life experience of information technology (0.024, $P < 0.000$). The values of Pearson correlation about students' life experiences from earth science are showed to be strongly correlated to the attributions of learning interests about sustainability (0.499, $P < 0.000$) and its related issues of life (0.430, $P < 0.000$) and environment (0.511, $P < 0.000$), also earth science (0.535, $P < 0.000$) and biology (0.496, $P < 0.000$). Comparing with items having high correlation values, the values of Pearson correlation about life experiences of information technology are relatively lower with all the attributions of learning interests, ranging from 0.024 to 0.169.

The Correlation Among Attitudes Towards Technology, Learning Interests and Life Experiences

The correlations between attitudes towards technology and learning interests were all at significant level (Table 4), ranging from 0.216 to 0.306 ($P < 0.000$). Especially, the values of Pearson correlation were higher about sustainability (0.305, $P < 0.000$) and its related issue of life (0.306, $P < 0.000$). In terms of the correlations between attitude towards technology and life experiences, the values were all at significant level (Table 5) as well from 0.155 to 0.229 ($P < 0.000$). However, the value of Pearson correlation was lower with sustainability attribution related to environment (0.155, $P < 0.000$).

Conclusions and Discussions

Studying about students' attitudes towards science or science learning has become a key component of science education in the past three to four decades. From those research results (Lichtenstein et al. 2008; Simpson et al. 1994), they all pointed out that attitude should be considered as an essential indicator of the quality of science education. Noticeably, the attitudes described in the affective dimension of the previous studies are actually different from the notion of "scientific attitudes" (e.g. Lichtenstein et al. 2008) which is defined to be directly related to the outcomes of science learning. In this study, we focus on affective dimension, which was neatly defined by Simpson et al. (1994), the *affective dimension of science learning* contains an array of constructs like attitudes (including some essential ingredients such as feeling, cognition and behaviour), values, beliefs, and motivation. The present findings will provide some useful information to fill the knowledge gap in the ROSE Project in which there was no previous study on the Chinese learners in Taiwan, Mainland China and Hong Kong (under strikingly different educational systems) before 2007 (Yeung and Cheng 2007, 2008).

From the results of this study, we found boys showed higher learning interests regarding science subjects of earth science, biology, chemistry and so on, and also more positive attitudes towards technology, which are all similar to the results of previous studies (Francis and Greer 1999; Sjøberg and Schreiner 2005; Weinburgh 1995). Moreover, our research results revealed that boys were also more interested in sustainability issues with regards to life and environment. However, only two

Table 3 The correlation between learning interests and life experiences about S&T

Learning interests	Life experiences			
	Sustainability_ environment	Earth science	Biology	Information technology
Sustainability	0.289**	0.499**	0.346**	0.152**
Sustainability_life	0.271**	0.430**	0.300**	0.169**
Sustainability_environment	0.278**	0.511**	0.354**	0.118**
Earth science	0.232**	0.535**	0.314**	0.151**
Biology	0.264**	0.496**	0.407**	0.123**
Human physiology	0.264**	0.347**	0.301**	0.126**
Chemistry	0.117**	0.366**	0.194**	0.024
Information technology	0.181**	0.379**	0.234**	0.119**

** Correlation is significant at the 0.000 level (2-tailed)

Table 4 The correlation between attitudes towards technology and learning interests about S&T

Sustainability	Sustainability_life	Sustainability_ environment	Earth sciences	Biology	Human physiology	Chemistry	Information technology
0.305**	0.306**	0.272**	0.216**	0.234**	0.238**	0.234**	0.268**

** Correlation is significant at the 0.000 level (2-tailed)

Table 5 The correlation between attitudes towards technology and life experiences about S&T

Sustainability environment	Earth sciences	Biology	Information technology
0.155**	0.217**	0.229**	0.223**

** Correlation is significant at the 0.000 level (2-tailed)

attributions of chemistry and sustainability issues with regards to environment showed significant differences.

Although boys showed higher learning interests from the other past research (Johnson 1987; Nakazawa and Takahira 2001; Weinburgh 1995), one surprising finding was revealed in this study, that is girls' life experiences about S&T were higher than boys, like the sustainability issues of environment, earth science, biology and information technology, and only earth science was no significant difference. From this result, as science educators, we need to ask ourselves "How can we explain that girls have more experience related to S&T than boys, but not feel interested in learning S&T?" Jones et al. (2000) researched on students' perceptions of science and their findings indicated that "significantly more females than males reported that science was difficult to understand as well as more 'suitable' for boys". Also Miller et al. (2006) mentioned about girls feel that they cannot make affective links between those subjects and what they care about. But how to bridge the life experiences and learning interests about S&T for girls? In the literature review of this paper, we provide four main factors (societal factors, psychological and identity factors, curriculum, pedagogy and school factors, career factors) serving as the reasons influencing girls learning interests about science (e.g. Burkham et al. 1997; Gilbert 2001; Nakazawa and Takahira 2001; Skog 2001; Gilbert and Calvert 2003; Murphy and Whitelegg 2006; Brotman and Moore 2008). These factors can serve as a foundation for further research which aims to improve girls' learning interests about S&T.

In terms of the correlations about learning interests and life experiences about S&T, the results indicated that the correlations were all at significant levels, but only life experience of information technology and learning interest about chemistry showed no significant correlation. Moreover, students' attitudes towards technology showed significant correlation with their learning interests and life experiences about S&T. Although the data told us that there were significant correlations among learning interests, life experiences and attitudes towards technology, we could not indicate whether there is any causal relationship in-between these dimensions. However, this finding provides us some research directions for the future, like investigating the causal relationship about students' learning interests, life experiences and attitudes towards S&T, to see whether providing more life experiences to students could induce their learning interests and positive attitudes towards S&T. In this case, in school education, hands-on activity should be more addressed and/or providing more informal learning environment to let learners experience S&T more. The present findings provide concrete research-based information to the school science teachers and science curriculum planners for them to revise/refine their teaching and learning activities as well as the curriculum design/content so that students' interests of science learning and engagement in science-related activities will be increased (Osborne et al. 1998).

Appendix

The examples of items

Attributions		Items	Scale
Sustainability issues	Learning interests	**Life** I.18 how radioactivity affects the human body	Not interested ☐ ☐ ☐ ☐ Very interested
		Environment V.5 what can be done to ensure clean air and safe drinking water	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	**Life** N/A	
		Environment VIII. 18 made compost of grass, leaves or garbage	Never ☐ ☐ ☐ ☐ Often
Earth science	Learning interests	I. 1 stars, planets and the universe	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	VIII. 1 tried to find the star constellations in the sky	Never ☐ ☐ ☐ ☐ Often
Biology	Learning interests	I. 6 the origin and evolution of life on earth	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	VIII. 6 watched (not on TV) an animal being born	Never ☐ ☐ ☐ ☐ Often
Human physiology	Learning interests	I. 10 birth control and contraception	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	N/A	
Chemistry	Learning interests	I. 2 chemicals, their properties and how they react	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	N/A	
Information technology	Learning interests	I. 45 the use of satellites for communication and other purposes	Not interested ☐ ☐ ☐ ☐ Very interested
	Life experiences	VIII. 44 used a mobile phone	Never ☐ ☐ ☐ ☐ Often
Attitude towards technology		VII. 1 Science and technology are important for society	Disagree ☐ ☐ ☐ ☐ Agree

References

American Association for the Advancement of Science (AAAS) (1989) Science for all Americans. Oxford University Press, New York

Baram-Tsabari A, Sethi RJ, Bry L, Yarden A (2006) Using questions sent to an Ask-A-Scientist site to identify children's interests in science. Sci Educ 90(6):1050–1072. doi:10.1002/sce.20163

Blalock C, Lichtenstein M, Owen S, Pruski L, Marshall C, Toepperwein M (2008) In pursuit of validity: a comprehensive review of science attitude instruments 1935–2005. Int J Sci Educ 30(7):961–977. doi:10.1080/09500690701344578

Brotman JS, Moore FM (2008) Girls and science: a review of four themes in the science education literature. J Res Sci Teach 45(9):971–1002

Burkham DT, Lee VE, Smerdon BA (1997) Gender and science learning early in high school: subject matter and laboratory experiences. Am Educ Res J 34(2):297–331

Crawley FE, Koballa TR (1994) Attitude research in science education: contemporary models and methods. Sci Educ 78:35–55. doi:10.1002/sce.3730780103

Crombie G, Sinclair NL, Silverthorn N, Byrne BM, DuBois DL, Trinneer A (2005) Predictors of young adolescents' math grades and course enrollment intentions: gender similarities and differences. Sex Roles 52:351–367. doi:10.1007/s11199-005-2678-1

DeBoer GE (2000) Scientific literacy: another look at its historical and contemporary meanings and its relationship to science education reform. J Res Sci Teach 37(6):582–601. doi:10.1002/1098-2736(200008)37:6<582::AID-TEA5>3.0.CO;2-L

Francis LJ, Greer JE (1999) Measuring attitude towards science among secondary school students: the affective domain. Res Sci Technol Educ 17(2):219–226. doi:10.1080/0263514990170207

Gallagher JJ (1971) A broader base for science teaching. Sci Educ 55(4):329–338

Gardner PL (1975) Attitudes to science: a review. Stud Sci Educ 2:1–41. doi:10.1080/03057267508559818

Gardner PL (1996) The dimensionality of attitude scales: a widely misunderstood idea. Int J Sci Educ 18(8):913–919. doi:10.1080/0950069960180804

Gauld C, Hukins A (1980) Scientific attitudes: a review. Stud Sci Educ 7:129–161. doi:10.1080/03057268008559877

George R (2006) A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. Int J Sci Educ 28(6):571–589. doi:10.1080/09500690500338755

Gilbert J (2001) Science and it's 'Other': looking underneath 'woman' and 'science' for new directions in research on gender and science education. Gend Educ 13(3):291–305. doi:10.1080/09540250120063571

Gilbert J, Calvert S (2003) Challenging accepted wisdom: looking at the gender and science education question through a different lens. Int J Sci Educ 25(7):861–878. doi:10.1080/09500690305030

Johnson S (1987) Gender differences in science: parallels in interest, experience and performance. Int J Sci Educ 9(4):467–481. doi:10.1080/0950069870090405

Jones MG, Howe A, Rua MJ (2000) Gender differences in students' experiences, interests, and attitudes toward science and scientists. Sci Educ 84(2):180–192. doi:10.1002/(SICI)1098-237X(200003)84:2<180::AID-SCE3>3.0.CO;2-X

Kahle JB, Meece J (1994) Research on gender issues in the classroom. In: Gable D (ed) Handbook of research on science teaching and learning. Macmillan, New York, pp 542–557

Krogh L, Thomsen P (2005) Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom. Int J Sci Educ 27(3):281–302

Lee VE, Burkham DT (1996) Gender differences in middle-grade science achievement: subject domain, ability level, and course emphasis. Sci Educ 80(6):613–650. doi:10.1002/(SICI)1098-237X(199611)80:6<613::AID-SCE1>3.0.CO;2-M

Lichtenstein MJ, Owen SV, Blalock CL, Liu Y, Ramirez KA, Pruski LA, Marshall CE, Toepperwein MA (2008) Psychometric reevaluation of the scientific attitude inventory-revised (SAI-II). J Res Sci Teach 45(5):600–616

Miller PH, Blessing JS, Schwartz S (2006) Gender differences in high-school students' views about science. Int J Sci Educ 28(4):363–381. doi:10.1080/09500690500277664

Murphy P, Whitelegg E (2006) Girls and physics: continuing barriers to 'belonging'. Curric J 17(3):281–305. doi:10.1080/09585170600909753

Nakazawa C, Takahira S (2001) Gender differences in science learning of japanese junior high school students: a two year study. Paper presented at the Annual Meeting of the American Educational Research Association, Seattle

National Society for the Study of Education (1947) Science education in american schools: forty-sixth yearbook of the NSSE. University of Chicago Press, Chicago

Osborne J, Driver R, Simon S (1998) Attitudes to science: issues and concerns. Sch Sci Rev 79(288):27–33

Osborne J, Simon S, Collins S (2003) Attitudes towards science: a review of the literature and its implications. Int J Sci Educ 25(9):1049–1079. doi:10.1080/0950069032000032199

Ramsden JM (1998) Mission impossible? Can anything be done about attitudes to science? Int J Sci Educ 20(2):125–137. doi:10.1080/0950069980200201

Scherz Z, Oren M (2006) How to change students' images of science and technology. Sci Educ 90(6):965–985. doi:10.1002/sce.20159

Schibeci R (1984) Attitudes to Science: an update. Stud Sci Educ 11(1):26–59. doi:10.1080/03057268408559913

Schreiner C, Sjøberg S (2004) Sowing the seeds of ROSE. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) - a comparative study of students' views of science and science education. Oslo: Dept. of Teacher Education and School Development, University of Oslo

Siegel MA, Ranney MA (2003) Developing the changes in attitude about the relevance of science (CARS) questionnaire and assessing two high school science classes. J Res Sci Teach 40(8):757–775. doi:10.1002/tea.10110

Simpson RD, Koballa TR, Oliver JS, Crawley FE (1994) Research on the affective dimension of science learning. In: Gabel D (ed) Handbook of research on science teaching and learning. Macmillan, New York, pp 211–234

Sjøberg S (2000) Science and scientists: The SAS study. Retrieved 1 September 2005 from http://folk.uio.no/sveinsj/SASweb.htm

Sjøberg S, Schreiner C (2005) How do learners in different cultures relate to science and technology? Results and perspectives from ROSE. *Asia-Pacific Forum on Learning and Teaching, l6*(2), Foreword. [Online] http://www.ied.edu.hk/apfslt/v6_issue2/foreword/

Skog B (2001) Girls' avoidance of 'hard' science subjects-protest or a rational choice? Scand J Educ Res 35(3):201–211. doi:10.1080/0031383910350304

Tuan HL, Chin CC, Shieh SH (2005) The development of a questionnaire to measure students' motivation towards science learning. Int J Sci Educ 27(6):639–654. doi:10.1080/0950069042000323737

Viefers S, Christie M, Ferdos F (2006) Gender equity in higher education: why and how? A case study of gender issues in a science faculty. Eur J Eng Educ 31(1):15–22. doi:10.1080/03043790500429948

Weinburgh M (1995) Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970–1991. J Res Sci Teach 32:387–398. doi:10.1002/tea.3660320407

Yeung YY, Cheng MH (2007) Hong Kong junior secondary school students' affective domain of science learning: Preliminary findings from the international "ROSE" study. Paper presented at the conference on integrated learning, 14–15 Dec, 2007, Hong Kong

Yeung YY, Cheng MH (2008) Secondary school students' affective domain of science learning: Comparison of preliminary ROSE findings in Hong Kong, Guangzhou and Shanghai. Paper presented at the Conference of Asian Science Education, Feb 20–23, 2008, Kaohsiung

Zohar A, Bronshtein B (2005) Physics teachers' knowledge and beliefs regarding girls' low participation rates in advanced physics classes. Int J Sci Educ 27(1):61–77. doi:10.1080/0950069032000138798