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The key factors affecting students' individual interest in school science lessons

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ABSTRACT

Individual interest in school science lessons can be defined as a relatively stable and enduring personal emotion comprising affective and behavioural reactions to events in the regular science lessons at school. Little research has compared the importance of different factors affecting students' individual interest in school science lessons. The present study aimed to address this gap, using a mixed methods design. Qualitative interview data were collected from 60 Hong Kong junior secondary school students, who were asked to describe the nature of their interest in science lessons and the factors to which they attribute this. Teacher interviews, parent interviews, and classroom observations were conducted to triangulate student interview data. Five factors affecting students' individual interest in school science lessons were identified: situational influences in science lessons, individual interest in science, science self-concept, grade level, and gender. Quantitative data were then collected from 591 students using a questionnaire. Structural equation modelling was applied to test a hypothesised model, which provided an acceptable fit to the student data. The strongest factor affecting students' individual interest in school science lessons was science self-concept, followed by individual interest in science and situational influences in science lessons. Grade level and gender were found to be nonsignificant factors. These findings suggest that teachers should pay special attention to the association between academic self-concept and interest if they want to motivate students to learn science at school.

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Individual interest; secondary school; modelling; affective domain

Introduction

Interest is often considered to be an important source of intrinsic motivation (Hidi, 2006; Hidi & Renninger, 2006; Silvia, 2006). However, when students move from primary to secondary school, their interest in science drops (Häussler, 1987; Krapp, Hidi, & Renninger, 1992; Osborne, Simon, & Collins, 2003; Van Griethuijsen et al., 2015; Yager & Bonnstetter, 1984). Researchers have recognised two types of interest: individual interest, and situational interest. Individual interest is a relatively stable, enduring personal predisposition to attend to a specific class of tasks, objects, events, or ideas (Hidi, 2006; Silvia, 2006). It develops over time as a result of life experiences, innate preferences, or orientations.

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For example, a student may have a strong individual interest in exploring natural phenomena, while another student may have an individual interest in learning about music. Situational interest is environmentally triggered and occurs when a specific situation stimulates the attention of a person (Hidi, 2006; Silvia, 2006). It is a momentary psychological state of positive emotion and heightened concentration, which may not last for a long time. For example, a surprising science laboratory experiment may induce a student's interest immediately even though she is not normally interested in science lessons.

In Hong Kong, secondary schooling consists of six years (referred to as Secondary 1–6). Science is a compulsory subject for Secondary 1–3 students (Curriculum Development Council, 1998). Most schools allocate four 45-min science lessons per week. Interest is content-specific (Hidi & Renninger, 2006). The topics covered by the Secondary 1–3 science curriculum are shown in Table 1. Secondary 1, 2, and 3 students study topics 1–6, 7–11, and 12–15, respectively. Curriculum Development Council (1998) has recommended the use of inquiry learning activities. Students should be provided with opportunities to participate in scientific investigations to develop science process skills. *Individual interest in school science lessons* can be defined as a relatively stable and enduring personal emotion comprising affective and behavioural reactions to events in the regular science lessons at school. When interested, individual students will have a feeling of liking for science as a school subject, show a tendency to become absorbed in the learning experiences provided in science lessons, and give selective attention to tasks assigned by science teachers. It is important to investigate students' individual interest in school science lessons because individual interest positively influences academic performance (Chang & Cheng, 2008; Hidi, 1990; Schiefele, Krapp, & Winteler, 1992) and

Table 1. Topics covered by the Hong Kong Secondary 1–3 science curriculum.

Topic	Examples of the core content
1. Introducing science	The work of a scientist, lab safety, lab equipment, scientific investigation.
2. Looking at living things	Characteristics of living things, classification of animals and plants, endangered species.
3. Cells and human reproduction	Basic structure of a cell, sex cells, fertilisation, puberty, pregnancy.
4. Energy	Forms of energy, energy conversion, common fuels, generation of electricity, alternative energy sources.
5. The wonderful solvent – water	Water purification, the water cycle, water pollution, water as a solvent.
6. Matter as particles	States of matter, particle theory, gas pressure, density, thermal expansion and contraction.
7. Living things and air	Fire triangle, chemical energy stored in food, photosynthesis, respiration, smoking and health, air pollution.
8. Making use of electricity	Electric current, voltage, resistance, circuit symbols, series and parallel circuit, fuses, household electricity.
9. Space travel	Examples and effects of forces, friction, force of gravity, rocketry, problems faced by astronauts living in space.
10. Common acids and alkalis	Common acids and alkalis used at home, indicators, action of dilute acids on metal, acid rain, neutralisation, safety.
11. Sensing the environment	Structure and functions of human sense organs, sensory and motor functions of the brain, effects of drugs on our senses.
12. A healthy body	Balanced diet, carbohydrates, fats, proteins, vitamins, human digestive system, cholesterol, indicators of fitness.
13. Metals	Discovery of metals, elements, compounds, extraction of metals from ores, properties and uses of metals, alloy.
14. Materials of the modern world	Making plastics from crude oil, problems of disposal of plastics, examples of composite materials.
15. Light, colours and beyond	Luminous objects, law of reflection, dispersion of white light, infra-red and ultra-violet radiation, EM spectrum.

interest in future science-related courses and careers (Hulleman & Harackiewicz, 2009; Taskinen, Schütte, & Prenzel, 2013).

What factors are important to consider when predicting students' individual interest in school science lessons? Most previous empirical studies have focused on students' situational interest (Dohn, 2013; Lin, Hong, & Chen, 2013; Palmer, 2004, 2009) or individual interest in science topics (Alexander, Johnson, & Kelley, 2012; Dawson, 2000; Häussler, 1987; Trumper, 2006), in different science disciplines (Baram-Tsabari & Yarden, 2009; Häussler & Hoffmann, 2000; Osborne & Collins, 2001) and in different teaching methods and learning activities (Dawson, 2000; Häussler, 1987). Although these previous studies are useful, little research has compared multiple factors affecting students' individual interest in school science lessons. Only by comparing them together can researchers determine their relative importance in predicting students' individual interest and then plan intervention strategies accordingly.

Previous research on students' individual interest in school science lessons

In Jordan, Hasan (1975) used a science interest scale to measure eleventh grade students' interest in science topics, school science lessons and activities, and leisure-time science activities. The influence of four types of factors (i.e. instruction, student, home, and social desirability) on interest in science was examined. Both male and female students with a higher level of interest in science were found to possess a better perception of science abilities, have more desire to follow a career in science, and have parents who show more desire to see them follow a career in science, but the relative importance of those factors was not determined.

Yager and Bonnstetter (1984), in a survey of American students' perceptions of science teachers, classes, and course content, found that the percentages of junior high students who reported their science classes to be fun, interesting, and exciting were only 41%, 52%, and 44%, respectively. They did not examine personal and situational factors contributing to such a decline in student interest in science classes.

In Australia, Dawson (2000) reported a survey of Year 7 students' interest in 77 science topics and 17 science learning activities. Both boys and girls most liked to learn more about earthquakes, dissection of dead animals, poisonous animals of Australia, use of science instruments, and crystals. Both sexes also rated a stronger interest in experiential learning activities (e.g. doing project work, making models about science topics) than traditional, passive modes of learning.

Hulleman and Harackiewicz (2009) conducted a randomised field experiment to investigate the effect of relevance of science course material on American students' interest in science classes. The participating students were randomly assigned within each class to either write about the usefulness and utility value of the course material in their own lives (i.e. the experimental condition) or write a summary of the course material they were studying (i.e. the control condition). Those students with low-success expectancies reported more interest in science classes at the end of the semester in the experimental condition than in the control condition. In an international study, Van Griethuijsen et al. (2015) measured primary and secondary students' interest in science lessons. They reported that students in the UK, the Netherlands and Malaysia showed a lower interest in science lessons than did students in India, Turkey, and Lebanon. However, both Hulleman and Harackiewicz (2009) and Van Griethuijsen et al. (2015) did not compare the factors influencing students' interest in science lessons.

Only the study conducted by Häussler and Hoffmann (2000) in Germany quantitatively compared multiple factors affecting students' individual interest, but they focused on physics education rather than junior secondary science education. They emphasised the difference between interest in physics and interest in physics as a school subject. Three questionnaire items were constructed to measure German students' interest in physics as a school subject. Students were asked to rate their interest in physics courses in general, in relation to the physics course they have at present, and in relation to other science and non-science courses. Häussler and Hoffmann (2000) discovered that students' physics self-concept was the best predictor ($\beta = .43$) of interest in physics as a school subject, and the second best predictor was stimulation of interest by the physics teacher. Surprisingly, individual interest in physics was found to be a weak predictor of interest in physics as a school subject. However, these findings may not be applicable to junior science education because physics is taught as a science discipline in school whereas junior secondary science is taught as an integrated subject comprising physics, chemistry, biology, and earth science.

Actually, science self-concept is a popular construct in science education research. Most empirical studies in the past 15 years have been concerned mainly with the relations of science self-concept to academic achievement (e.g. Jansen, Schroeders, & Lüdtke, 2014; Liou, 2014; Wang, Oliver, & Staver, 2008), intentions to study science courses (e.g. Jack, Lin, & Yore, 2014; Quinn & Lyons, 2011), and feelings of competence while participating in specific learning activities (e.g. Glowinski & Bayrhuber, 2011). For example, Quinn and Lyons (2011) investigated Australian 15-year-old students' science self-concept and liking for school science as predictors of their intentions to study university science courses. Jack et al. (2014) analysed the PISA 2006 data from Taiwan and Canada and found that students' science self-concept did not predict their future intended interest in science learning. Glowinski and Bayrhuber (2011) reported that science self-concept positively predicted German students' feelings of competence while conducting molecular biology laboratory experiments in an out-of-school learning programme. Liou and Liu (2015) used four items in the TIMSS 2011 project to measure students' science self-concept. They found that Taiwanese students' science self-concept was a positive predictor of their science achievement, but they did not examine other effects of science self-concept. Similarly, based on the PISA 2006 data, Lau, Ho, and Lam (2015) found that East Asian students had low self-concept in science, but the effect of self-concept on interest in science learning was not examined. Thus, the relationship between science self-concept and individual interest in school science lessons remains unclear.

Theoretical background and research questions

This study was built on Hidi and Renninger's (2006) theoretical model of interest development. If a triggered interest in studying science is sustained, it will evolve into a maintained situational interest. The maintained situational interest is a precursor to the development of an emerging individual interest in school science lessons, which can then lead to the final stage called a well-developed individual interest. This study focuses on individual interest. In addition to situational interest, I wanted to explore other personal and situational factors affecting Hong Kong students' development of an individual interest in school science lessons. The present study aimed to answer two research questions:

(1) What are the key factors that affect junior secondary school students' individual interest in school science lessons?
(2) To what degree does each of the key factors predict junior secondary school students' individual interest in school science lessons?

An exploratory sequential mixed methods design (Creswell, 2012) was used. In the first phase of the study, qualitative data were collected with a small sample of Hong Kong students to explore the key factors affecting their individual interest in school science lessons. In the second phase, quantitative data were collected with a large sample of students to analyse the relationships among the variables identified in the first phase of the study.

Phase 1: Qualitative study

Methodology

Participants and data collection

Research in Phase 1 was designed to answer the first research question. In Hong Kong, secondary schools are classified as Band 1, Band 2, and Band 3 schools by the government based on the ability of their Secondary-1 students. Students of high ability go to Band 1 schools while those of low ability study at Band 3 schools. The academic year begins in September. Three secondary schools of different bands were invited to participate in the qualitative part of this study in January 2014 (i.e. five months into the academic year). Interviews were conducted with 60 Secondary 1–3 students (mean age = 13.5 years, $SD = 1.01$, 34 boys, 26 girls) with different levels of science achievement. They were selected from 18 science classes in the 3 secondary schools, with 2 classes for each grade level per school.

According to the literature review conducted by Potvin and Hasni (2014), very few researchers have used methodology other than questionnaires when investigating students' interest, motivation, or attitude towards science and technology. In this study, multiple sources of data were collected to provide triangulation. A semi-structured interview protocol was used to investigate how students describe the nature of their interest or lack of interest in school science lessons and the factors to which they attribute their interest or lack of interest. The 60 students were interviewed individually by a research assistant or me. Each interview, lasting about 30 minutes, was conducted in Chinese and audio-taped. Below are examples of interview questions:

- To what extent would you say you are interested in science lessons?
- Why are you interested (or not interested) in science lessons?
- What sorts of things does the science teacher do that can instantly catch your attention during a science lesson? Why?
- What sorts of things does the science teacher do that help you hold your attention or interest during a science lesson? Why?

Because my research focused on students' situational interest experiences in regular science lessons rather than the situational interest elicited by an intervention (e.g. a special inquiry-based science lesson), I asked them to recall their learning experiences and incidents several months back in time. In their longitudinal study, Logan and Skamp (2013) used similar retrospective interview questions (e.g. 'What do you like about science lessons?' 'Why do you like doing these things?') to investigate Australian students' interest in science across four years of secondary schooling.

Semi-structured interviews were subsequently conducted with the science teachers ($n = 12$) teaching the 18 classes. The teachers were interviewed individually by a research assistant or me in schools. Each interview, lasting about 35 minutes, was conducted in Chinese and audio-taped. The following interview questions were used:

- Do you promote students' interest in science in your classroom? If so, how do you promote it?
- What strategies do you use, if any, to catch your students' interest in science during a science lesson?
- What strategies do you use, if any, to hold your students' interest in science during a science lesson?
- Are there any other factors affecting your students' interest in school science?

A total of 48 parents were also interviewed by my research assistant. The original plan aimed to interview one of the parents of each of the participating 60 students. However, 12 parents declined the invitation to be interviewed. The semi-structured interviews were conducted face-to-face in schools or on the phone. Each interview lasted about 20 minutes. Below are the interview questions:

- Is your son/daughter interested in school science? How do you know?
- When did you notice that your son/daughter is interested (or not interested) in school science?
- What does your son/daughter do during free time?
- Did your son/daughter ask science-related questions at home?
- What strategies do you use, if any, to increase your son's/daughter's interest in school science?

Two classroom observations per teacher were conducted to gather data on teachers' pedagogical variations that caught or held students' interest for studying science. When interested, individuals display specific observable behaviours (Ely, Ainley, & Pearce, 2013; Reeve, 1993; Swarat, Ortony, & Revelle, 2012). During each classroom observation, my research assistant recorded when those behaviours (e.g. asking follow-up questions, longer eye contact, facial expression of excitement) occurred.

Data analysis

To answer the first research question, the qualitative interview data were transcribed, coded, and analysed by using the QSR NVivo 10 program (Bazeley & Jackson, 2013). My research assistant and I coded samples of the interview transcripts. After assigning first-level codes to all transcripts, the research assistant and I listened to each interview again while reviewing codes. Efforts were made to reduce the number of first-level codes by combining related categories to form a hierarchical coding scheme (Saldana, 2009). As an example, Table 2 shows part of such a coding scheme for the student interview data. Categories are also called themes, which are similar codes combined together to form a major, unique idea in the database (Creswell, 2012). Thematic development resulted in an in-depth understanding of the interrelationships among the codes. Only major categories were retained. Disagreements were resolved through discussion and refinement of the coding scheme. The intercoder reliability on 20% of each data source was: student interview 86% agreement; teacher interview 83% agreement; parent interview 88% agreement; classroom observation entries 82% agreement.

Although individual interest and situational interest are two different forms of interest, they may not occur in isolation from each other (Logan & Skamp, 2013). As Bergin (1999) pointed out:

> It is important to recognize that personal or individual factors always interact with situational factors to create interest, or lack of interest. It is not useful or accurate to claim that a particular factor is purely personal or purely situational … The rule of thumb that I have used for categorization is that factors that are largely under teacher control (like using hands-on activities) are situation factor, whereas factors that are difficult to change (like background knowledge) or nearly impossible to change (like students' cultural background) are individual factors. (p. 89)

Thus, when my research assistant and I analysed interview data, factors were coded as individual interests if they are difficult to change by science teachers (e.g. individual students' innate preferences), and factors were coded as situational influences if they can be manipulated by science teachers (e.g. instructional strategies). I designed the interview questions to explore both triggers and sources of situational interest while students learn science at school. Triggers of situational interest refer to the curriculum content, teaching methods, learning activities, or environmental conditions in regular science lessons, which can serve as stimuli to elicit fleeting attention or positive feelings instantly from many students (see Table 2). Sources of triggered situational interest are the attributes of the triggers, which cause the elicitation of students' situational interest in regular science lessons. For example, laboratory work is often a powerful trigger of situational interest due to the involvement of hands-on activities. Information technologies such as computer games and videos can spark many students' situational interest because they like to participate in novel and funny learning activities.

Table 2. Part of a hierarchical coding scheme for analysing student interview data.

Category	Subcategory	Code
1. Science self-concept	1.1 External comparison	1.1.1 Comparison with peers
		1.1.2 Good science achievement in class
		1.1.3 Unsatisfactory science achievement in class
	1.2 Internal comparison	1.2.1 Comparison with other academic subjects
		1.2.2 Science work is easy
		1.2.3 Science work is difficult
2. Situational influences	2.1 Triggers of situational interest	2.1.1 Laboratory work
		2.1.2 Use of information technologies
		2.1.3 Group discussion
	2.2 Sources of triggered situational interest	2.2.1 Hands-on
		2.2.2 Novelty
		2.2.3 Pleasant feelings

Results

Analysis of the student interview data revealed that all the 60 students were interested in science lessons, irrespective of gender, grade level, and school banding. Of the 60 students, 5 Secondary-1 boys were particularly interested in science lessons, but such a pattern was not found in Secondary-2 and Secondary-3. When analysing the interview data, three categories of factors affecting individual interest in school science lessons emerged. For confidentiality, the 60 students are referred to in this paper as S1–S60.

Situational influences in science lessons

Throughout the interviews, students, teachers, and parents often identified hands-on laboratory experiments, funny videos, unusual things, and daily life applications of science as effective teaching and learning aids to promote student interest in science lessons. All the 60 students attributed their interest in science lessons to hands-on laboratory work organised by their teachers. It caught their attention and heightened engagement in the learning process. Also, all students reported feelings of happiness or excitement when engaged with hands-on laboratory experiments. The following quotes from students are typical: 'I like science lessons because science experiments are interesting' (S3); 'Science is my favourite subject because experiments are not available in other subjects' (S6); and 'Doing science experiments in the lab is fun' (S17). For example, two students elaborated on the interestingness of science laboratory work as follows:

> I am interested in science lessons because I can do science experiments. Although science was taught in the primary General Studies lessons, science experiments were not available. Experiments can provide me with very special learning experiences … For example, I had an opportunity to observe grasshoppers and oatmeal worms several months ago. I needed to draw their external features. That's the first time I had drawn a grasshopper and a worm … Another example is about the Bunsen burner experiments. In the first two months, English was the medium of instruction in science class. I didn't fully understand my teacher's teaching and was bored. But when my teacher emphasized skills in using the Bunsen burner, it caught my attention. A number of classmates failed to light the burner even making several attempts. I just attempted once and lighted it successfully. (S2)

> I am interested in science lessons because science experiments are exciting. For example, my teacher asked us to design an experiment to compare the temperatures when the air hole of a Bunsen burner is closed and open. I was happy and enjoyed doing the experiments when I was able to find out the difference in hotness. (S5)

Observational data corroborated with student comments about science experiments. All the 12 teachers (coded as T1–T12) included practical work in their science classes. For example, T3 used several laboratory experiments to facilitate his Secondray-2 students to learn about acid–base chemistry. They were allowed to test a variety of liquids by using universal indicator solution. The liquids included dilute hydrochloric acid, dilute sodium hydroxide, lime water, dilute ammonia solution, table salt solution, and sugar solution. Students displayed facial expressions of feelings of excitement and joy when conducting the laboratory experiments. They also gave more attention to listening to the teacher's talk and instructions when conducting the laboratory experiments.

Most of the 48 parents (coded as P1–P48) also mentioned laboratory experiments when explaining why their children are interested in science lessons: 'My son likes to study science at school very much … because he likes to do science experiments' (P4); 'Laboratory work can motivate my daughter to study science … Last month, she told me how she operated a microscope in the school laboratory to observe onion skin cells and the cornea cells of ox eye' (P2); and 'Science experiments … the most important source of intrinsic interest for my son' (P12).

Additionally, 48 students mentioned that unusual teaching aids and funny videos can trigger their interest in science lessons. The following are three examples:

> I was particularly attentive when learning about some unusual things. For example, I didn't know that an oatmeal worm only has legs in its upper part of the body. I thought there are legs throughout the body. (S26)

> I seldom jot down what my science teacher is talking about in class. I thought the topic 'A Healthy Body' is common sense stuff … teach us how to eat smart. We all know that we should not often have hamburger, fries, and soft drink for lunch … because of high fat, sugar and salt content. But I was curious when my teacher showed us an article from the Internet … about wooden chopsticks. Low-quality disposable, wooden chopsticks are produced from wood that needs to be bleached. I didn't know that poisonous sulphur dioxide gas is commonly used to bleach wooden chopsticks. The bleaching process will leave sulphur dioxide on the wood … My teacher reminded us: Don't suck sauces off of chopsticks when having meals and don't put chopsticks into hot liquids such as soups and congees because poisonous sulphur dioxide can dissolve in water easily. (S35)

> Funny videos can catch my attention in class, particularly videos about living things or videos showing some surprising phenomena … I thought light must travel along a straight line. I saw a video about internal reflections in my science class. It's from the Internet … Light can travel along a curved stream of water through repeated total internal reflections. That surprised me. (S38)

Of the 60 students, 35% ($n = 21$) reported that games and competitions are interesting learning activities when studying science at school. Typical responses made by students are: 'I like interactive learning activities such as games and competitions rather than seatwork … ' (S59); 'Chalk-and-talk is boring. I don't fall asleep in class when science games are organized for us' (S41); and 'Sometimes, we (the students) want to compete with each other … Learning science concepts through competitions is exciting' (S22). During the interview, a Secondary-1 boy provided the following specific example:

> When my teacher taught about living things, we were given a pack of cards showing the faces of some extraterrestrial beings. The game was stimulating and made me pay attention to the science lesson. We needed to analyze the features of a variety of faces and then designed a flowchart to identify the extraterrestrial beings. (S44)

Teacher interview data supported the validity of the above student comments. When the 12 science teachers were asked to talk about how they promoted students' interest in science lessons, all reported that students liked hands-on laboratory experiments, funny videos, unusual things, and daily life applications of science. They emphasised that these teaching strategies can effectively catch the attention of both boys and girls. Comments such as the following are typical of the responses the 12 teachers made: 'Both boys and girls are happier if I allow them to do science experiments' (T9); 'Often, the use of ICT can make my science lessons more interesting, such as funny YouTube videos' (T6); 'Students always direct their attention to those things they find unusual, such as a photo taken by a doctor with an endoscope'; and 'Students are eager to participate in some unusual ways to study science, such as group work, games and competitions … they can interact with each other' (T4).

Individual interest in science

Not surprisingly, those students who were interested in exploring natural phenomena were also interested in science taught at school. Of the 60 students, 47% ($n = 28$) reported that they enjoy learning about new scientific discoveries, like to read science fictions, like to watch science-related shows on television, like to visit science museums, or are interested in the applications of science to everyday life. This indicates that individual interest in science is one of the key factors affecting individual interest in school science lessons. In this study, individual interest in science refers to a relatively stable and enduring interest in science that students bring to classroom. It develops slowly over time and tends to have long-lasting effects on a student's science knowledge and values. More boys ($n = 16$) mentioned this factor than girls ($n = 12$). The following are comments from two Secondary-3 boys:

> I enjoy going to the science museum in Tsim Sha Tsui [a district in Hong Kong]. There are a lot of interesting exhibits and the staffs allow us to touch some exhibits. I am particularly eager to visit the science museum when there are new exhibits from overseas. My primary school teacher organized visits to the science museum, but my secondary school science teacher has not planned a visit yet … more fun if I can go with my classmates. (S20)

> I like to learn about new scientific discoveries. Recently, I found some new terms when I read a webpage … genome editing, genome engineering, RNA, genetic code, and gene mutation. But the content was difficult for me. I didn't understand … I hope after I study more science in school, I would be able to understand these new scientific discoveries. I want to know their applications. (S57)

Furthermore, six students thought that they are interested in science lessons due to an innate desire: 'I like science … not for any instrumental reasons' (S54); 'I always want to know more about the universe … stars, planets, galaxies' (S51); and 'Science is great! … A lot of applications. I want to know how doctors use chemotherapy to kill cancer cells' (S10).

All the 48 parents reported never using any strategies directly to promote their children's interest in school science lessons. Only 11 parents mentioned individual interest in science when explaining why their children are interested in science lessons: 'My son started to develop an interest for science when he was just 6 years old. That's why he likes science lessons in school. Science is one of his favourite subjects' (P18); 'My daughter likes to watch science-related shows on television … a kind of intrinsically motivated behaviour. I don't need to push her to review science content taught in school every week' (P26); 'He (my son) often becomes wholly absorbed when watching YouTuble science videos … It is natural for him to be attentive during science lessons' (P36); 'She (my daughter) has acquired the habit of borrowing science fictions from libraries … . She is completely immersed when reading a science fiction' (P6); and 'My son is always curious about things, particularly things related to science or technology. Three weeks ago, he wanted to open a used lithium battery at home to check its internal structure and ingredients. I said no … it's dangerous!' (P11). Three parents also reported that their children are fond of exploring natural phenomena and started to develop an interest for science experiments when studying primary school science For example, a parent said,

> Natural phenomena are interesting to my son. He likes to visit the Space Museum and watches 3D shows such as the American space shuttle programme. He is always curious about the design of spacecraft. He once asked me how the spacecraft can protect astronauts from deadly cosmic radiation … My son has also developed a habit; that's, after some science experiments are done in school, he likes to repeat or modify the experiments at home. Several months ago, his science teacher asked students to design an experiment to investigate whether adding sugar to water would affect the number of days that flowers such as carnation and rose stay fresh. After the experiment was done, my son searched the Internet and was excited to find some extra information about the effects of sugar water on plants … He asked me to buy some seeds for him to do experiments at home … to test whether sugar water will help a seedling grow better. (P15)

Interview data from several teachers corroborated with the above student and parent data. Of the 12 science teachers, 4 touched on students' individual interest in science when describing the factors influencing interest in science lessons: 'I know several students are very amazed by scientific discoveries. They are eager to know more … Perhaps, it's a quality that they have when they are born' (T1); 'Two or three students seem to have well-developed personal interests in natural science. They are top students in my class. Science taught at school is important for these students to further explore natural phenomena' (T10); and 'Some students often show spontaneous attention in class. Perhaps they started to develop a personal interest in natural phenomena many years ago' (T6); and 'She (a student) likes learning new things in science and always wants to learn more about the science topics and do more inquiry tasks on her own initiative' (T8).

Science self-concept

In this study, science self-concept refers to students' beliefs about their general or overall competence to study science in school. Of the 60 students, 32% ($n = 19$) mentioned competence to study science as an important factor affecting their interest in school science lessons. Some students judged how good they were in science learning by comparing their competence to those of their peers. Three typical responses provided by students are shown below:

> I am interested in science lessons because I feel competent to learn science topics. I mean I have the necessary knowledge and skills … .I can learn science concepts quickly. Compared with my classmates, I am fairly good at science. I am one of the best students in the science class. (S8)

> I like science. Work in science lessons is easy for me … . I can finish science classwork and homework quickly … I believe I can do well in the science subject. Compared with other students in my class, I don't have difficulty working on science assignments. (S28)

> Some science ideas are abstract, but I didn't have great difficulties in understanding the material taught by my science teacher … . I like science lessons because I expect I can succeed. I got 90% of the total scores on my last science test. In science, I am better than most of my classmates. (S40)

The importance of students' beliefs about their general competence to study science in school was also emphasised by 33% parents. They explained that their children are more interested in school science lessons if they believe that they are capable of accomplishing the learning tasks during the course. Below is a parent's explanation:

> My daughter likes science. She can solve science problems quickly. For example, there are differences between breathed air and unbreathed air of a person at rest. She can list the differences in temperature, oxygen, carbon dioxide, and water vapour quickly. (P8)

Only 13% parents reported that their children were afraid of science lessons due to unsatisfactory academic achievement. They commented on the difficulties their children have in studying school science. For example, a parent said,

> My son often makes a lot of mistakes when he reviews science content at home … I have to serve as a tutor and provide extra help when my son has trouble working out answers to science homework. But, ultimately, he will have to study science himself … For example, my son studied the topic 'Living Things and Air' several months ago. He failed to identify the common uses of some gases. He thought that oxygen is used to fill food packages such as potato chips to extend their shelf life and nitrogen is used to fill balloons for children. (P39)

In addition to social or external comparison, 25% students also compared their competence in science learning with those in other school subjects (i.e. internal comparison). Below are comments from two students who were interested in learning science at school:

> One of my reasons for liking science is that I did well on most of the science assignments, including classwork, and lab reports … I like science more than any other school subjects. (S46)

> I am better in science than in other school subjects such as English language, mathematics, and music. I got high scores on science tests. (S52)

In contrast, 12% students felt uncertain about their ability to study science at school even though some of them had fairly good academic performance in science. For example, two students said,

> I like physical education more than science because I don't have the ability to do well in science. About two weeks ago, I had a science test. I couldn't finish the test even though I tried very hard. Umm … several questions were very challenging. (S32)

> Compared with other school subjects such as Chinese language and mathematics, I feel less confident to gain high scores … Science is hard for me. I need to memorize a lot of science concepts to get high scores on tests. (S56)

About 60% of the 12 teachers also reported that higher academic achievers tend to be more interested in school science lessons than low achievers, confirming that students' self-concept of ability may be an influential factor. For example, Teacher T34 said: 'Generally, students with better academic achievement feel happier responding to my questions in science class and are more willing to complete written classwork'. When asked how they promoted student interest in science lessons, only three teachers mentioned the use of positive reinforcement or similar techniques such as encouragement, positive feedback, pride, feeling of satisfaction, and admiration for good work. Observational data showed that these three teachers used feedback effectively, which provided important information for developing students' science self-concept. For example, Teacher T20 gave his students a science test with a focus on forces and friction. He returned the marked test papers to his students and said: 'More than half of students in this class received high scores … They were particularly good at describing ways to reduce friction … So, you can be more successful in learning science if you try harder'. One of the questions in the science test asked students to explain why a wet floor is slippery. A wet floor is slippery because water acts as a lubricant between the floor and our shoes. Teacher T20 named a particular student and praised him: 'Tom, you have provided the answer to this question correctly. Good work!'

Discussion

The 60 students attributed their individual interest in school science lessons to three major factors: situational influences in science lessons, individual interest in science, and science self-concept. The validity of this finding was cross-checked with data from teacher interviews, parent interviews, and classroom observations through triangulation. To the best of my knowledge, no previous science education researchers have identified these three factors in a single study. Although situational influences in science lessons was the most easily recognised factor when I analysed the observational data and interview data, the qualitative data could not ascertain the relative effects of the three factors on individual interest in school science lessons.

All the 60 students spoke positively about their science lessons and highlighted the interestingness of hands-on laboratory work and novel learning materials. Thus, hands-on laboratory work and novel materials are powerful triggers of situational interest. Students also mentioned the importance of personal relevance or the meaningfulness of science course content and the use of information technology. These findings are consistent with previous research on situational interest (Dohn, 2013; Jack & Lin, 2014; Logan & Skamp, 2013; Mitchell, 1993; Palmer, 2004, 2009; Swarat et al., 2012). For example, Swarat et al. (2012) investigated the effects of content topics, activities, and learning goals on sixth and seventh grade students' situational interest in school science. They found that hands-on activities and the use of scientific instruments or technology elicited higher interest than did other forms of activity. Logan and Skamp (2013) identified a number of teaching strategies for promoting situational interest, including class discussions, topics related to everyday life, and the use of experiments, information technology and humour. Jack and Lin (2014) conducted a literature review and concluded that novelty, involvement, and meaningfulness are the three stimuli that can effect a change in students' negative interest in learning science.

All the 12 teachers used hands-on activities to make their science lessons interesting. This finding is consistent with previous research on instructional strategies for enhancing situational interest in other school subjects. For example, Zahorik (1996) found that American elementary and secondary teachers' the most preferred technique for attracting students' interest was hands-on activities such as the use of manipulatives in mathematics, participation in simulations, and making television commercials in Spanish.

Individual interest in science is the second most easily recognised factor when I analysed the interview data. Nearly half of the 60 students reported that they enjoy learning about new scientific discoveries, like to read science fictions, like to watch science-related shows on television, like to visit science museums, or are interested in the applications of science to everyday life. Thus, regular science lessons in secondary school are excellent opportunities for these students to learn more science and re-engage with science concepts. However, only four teachers pointed out the influence of students' individual interest in science on science learning in secondary school. Perhaps most of the teachers sampled in the present study tended to focus on situational influences in science lessons because they can hardly change their students' individual interests. Furthermore, a total of 11 parents noted that their children developed an individual interest in science when studying in primary schools. Similar findings have also been found by previous research. For example, Maltese and Tai (2010) interviewed 116 chemists and physicists in the USA to identify their initial sources of interest in science. They reported that 65% of these scientists mentioned that the root of their interest in science took place before their middle school years.

The third factor concerns science self-concept. About 32% of the students mentioned their general or overall competence to study science topics and ideas as an important factor affecting their individual interest in school science lessons. This finding suggests that students are more likely to be interested in school subjects where they believe that they can achieve well. About 60% of the teachers and 33% of the parents also recognised the importance of students' beliefs in their own overall competences to study science at school. In Jordan, Hasan (1975) found that secondary school students with high level of interest in science possessed a better perception of science abilities. Häussler and Hoffmann (2000) found that physics self-concept was the best predictor of interest in physics as a school subject. However, only 3 of the 12 teachers reported that they had used instructional strategies to strengthen their students' general competence to study science in school. One plausible reason is that Hong Kong science teachers generally perceive that the main purpose of their science lessons is not to promote students' academic self-concept. Through the past decade, the Hong Kong Government has strongly encouraged science teachers to implement inquiry-based teaching. However, many Hong Kong teachers find inquiry-based laboratory work very difficult to manage in secondary schools (Cheung, 2008). Their major concern is the lack of class time. They are under great pressure to finish the topics and laboratory work recommended by the science curriculum (Curriculum Development Council, 1998). Recently, the Hong Kong Government has promoted the inclusion of STEM education in the junior secondary science. Therefore, the top priority of many Hong Kong science teachers is likely to implement inquiry teaching and STEM education in the science classrooms rather than instructional strategies for fostering students' science self-concept.

Additionally, the interview data revealed that five Secondary-1 boys were particularly interested in learning science at school, but such a pattern was not found among Secondary-2 and Secondary-3 boys. One possible explanation is that, in comparison with Secondary-2 and Secondary-3 topics in the Hong Kong science curriculum (see Table 1), the Secondary-1 science topics are less difficult. A larger student sample is needed to examine the possible effects of gender and grade level on students' individual interest in school science lessons. This issue was addressed in phase 2 of the present study.

Phase 2: Quantitative study

The hypothesised model

Research in Phase 2 was designed to answer the second research question. Structural equational modelling was applied to test a hypothesised model, positing that students' situational influences in science lessons, individual interest in science, science self-concept, grade level, and gender affect their individual interest in school science lessons. The predictive powers of these five factors were quantitatively compared.

Methodology

Participants and procedure

A questionnaire was administered to Hong Kong junior secondary students ($n = 591$; 313 boys, 278 girls) in 2015. They were selected from 12 schools by a stratified random sampling scheme. The numbers of Secondary 1, Secondary 2, and Secondary 3 students were 198, 203, and 190, respectively. The mean age of the students was 13.3 years ($SD = 1.06$). The questionnaire survey was administered by their science teachers or my research assistant during regular class periods and required about 5 min to respond to all the items. Names of students and schools were not collected to ensure anonymity.

Measures

A total of 21 items were constructed to form four measurement scales: situational influences while learning science at school, science self-concept, individual interest in science, and individual interest in school science lessons. These items were written in Chinese and have been translated into English for reader information in Table 3. Students were asked to rate each item on a 6-point Likert-type scale (from 1 = strongly disagree to 6 = strongly agree). I constructed six items to measure situational influences based on the qualitative research findings in phase 1 and my previous research (Cheung & Lo, 2014). These items measured the extent to which teacher use of some specific triggers (e.g. science experiments, group discussions) can stimulate students' situational interest. The six science self-concept items were adapted from the self-concept items used in the PISA 2006 project (Cheung, 2013) and the items used in Bong and Skaalvik's (2003) study. Five items were constructed to measure individual interest in science and adapted from the enjoyment of science items used in the PISA project. Four items measured individual interest in school science lessons and were adapted from the PISA's enjoyment of science items and the items used in my previous study (Cheung, 2009). These items did not focus on the short-term use of specific triggers of situational interest in science lessons; rather, they measured individual students' relatively stable and enduring personal preferences towards learning science at school (e.g. 'I like science more than any other school subject', 'I am happy doing science problems').

Data analysis

I coded student gender as 1 = male and 2 = female, and grade level as 1 = Secondary-1, 2 = Secondary-2, and 3 = Secondary-3. Student responses to other items were coded on a scale of 1 to 6. The reliabilities of student responses to the individual items and to the four measurement scales were examined using the IBM SPSS 21 on the basis of item-total correlations and values for Cronbach's α, respectively. The Pearson correlations between the

Table 3. Reliability estimates and item-total correlations.

Scale and item	Item-total correlation
Situational influences while learning science at school (estimated $\alpha = .85$)	
1. I like to attend science class more when I myself do science experiments.	.61
2. I am more attentive in class when my teacher illustrates science concepts with daily life examples.	.67
3. It is an exciting way to learn science when my teacher explains science contents using Internet information or videos.	.60
4. Participation in science games or competitions can increase my interest in studying science.	.67
5. Group discussions can make our science class more interesting.	.61
6. I am more attentive in class when my teacher explains science concepts with models.	.69
Science self-concept (estimated $\alpha = .91$)	
7. I can fully understand the contents taught by my teacher in science lessons.	.66
8. I can usually give good answers to test questions on science topics.	.70
9. Learning the contents in science lessons is easy for me.	.78
10. I learn science concepts quickly.	.81
11. I can easily acquire the new knowledge taught in science lessons.	.83
12. Completing the classwork in science lessons is easy for me.	.75
Individual interest in science (estimated $\alpha = .85$)	
13. I am interested in thinking about science-related problems shown on television or in newspapers.	.67
14. I am interested in reading information about science.	.72
15. I am interested in learning more about the applications of science to everyday life.	.70
16. I am interested in watching science-related shows on television.	.71
17. I am interested in visiting science museums.	.51
Individual interest in school science lessons (estimated $\alpha = .85$)	
18. Science lessons in school are interesting.	.62
19. I like science more than any other school subjects.	.71
20. I generally have fun when I am reviewing science contents.	.73
21. I am happy doing science problems.	.69

four latent variables were also computed. To test the construct validity of data, the four measures were subjected to confirmatory factor analysis. The confirmatory factor analysis was performed using the IBM AMOS 21 (Arbuckle, 2012). The ability of the one-factor model to fit data was evaluated using the chi-square (χ^2), the Tucker–Lewis index (TLI), the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). Because the χ^2 statistic is sensitive to sample size, I based evaluation of model fit on considerations of multiple indexes and beyond the statistical significance of the χ^2. According to conventional criteria, an acceptable fit is indicated by TLI > .90, CFI > .90, and RMSEA < .08 (Schumacker & Lomax, 2010). Finally, I used the IBM AMOS 21 to estimate all the parameters in my hypothesised model via maximum likelihood estimation.

Results

The student data on situational influences were of high reliability; Cronbach's α was equal to .85, and the item-total correlations ranged from .60 to .69 (see Table 3). A confirmatory factor analysis indicated acceptable fit for a one-factor model ($\chi^2 = 41.164$, $df = 9$, $p < .001$, TLI = .941, CFI = .975, RMSEA = .078).

The scale to measure science self-concept was able to generate highly reliable data; Cronbach's α was equal to .91, and the item-total correlations ranged from .66 to .83. A confirmatory factor analysis indicated good fit for a one-factor model ($\chi^2 = 36.481$, $df = 9$, $p < .001$, TLI = .972, CFI = .988, RMSEA = .072).

Table 4. Means, standard deviations, and Pearson correlations between the latent variables in the study.

	Variable	1	2	3	*M*	*SD*
1.	Science self-concept	–			3.79	1.03
2.	Individual interest in science	.72*	–		4.06	1.01
3.	Situational influences	.69*	.76*	–	4.10	.93
4.	Individual interest in school science lessons	.81*	.77*	.76*	3.74	1.12

Note: $N = 591$.
*Correlation is significant at the .01 level (two-tailed).

The student data on individual interest in science were of high reliability; Cronbach's α was equal to .85, and the item-total correlations ranged from .51 to .72. A confirmatory factor analysis indicated good fit for a one-factor model ($\chi^2 = 21.763$, $df = 5$, $p = .001$, TLI = .958, CFI = .986, RMSEA = .075).

The scale to measure individual interest in school science lessons was also able to generate reliable data; Cronbach's α was equal to .85, and the item-total correlations ranged from .62 to .73. A confirmatory factor analysis indicated perfect fit for a one-factor model ($\chi^2 = .893$, $df = 2$, $p = .640$, TLI = 1.000, CFI = 1.000, RMSEA = .000).

Pearson correlations, means, and standard deviations are presented in Table 4. All the correlations are significant and range from .72 to .81, indicating that the four latent variables are closely related. The correlation (.81) between science self-concept and individual interest in school science lessons was the largest. On a 6-point rating scale from 'strongly disagree' to 'strongly agree', the mean score of individual interest in school science lessons was 3.74 ($SD = 1.12$), indicating that on average Hong Kong Secondary 1–3 students were just slightly positive about their study of science at school.

The fit for the hypothesised model was acceptable ($\chi^2 = 780.852$, $df = 224$, $p < .001$, TLI = .914, CFI = .931, RMSEA = .065). The path between grade level and individual interest in school science lessons was not significant ($\beta = -.04$, $t = -1.8$, $p = .070$). The path between gender and individual interest in school science lessons was also not significant ($\beta = .03$, $t = 1.3$, $p = .189$). The remaining paths were significant (see Figure 1) and

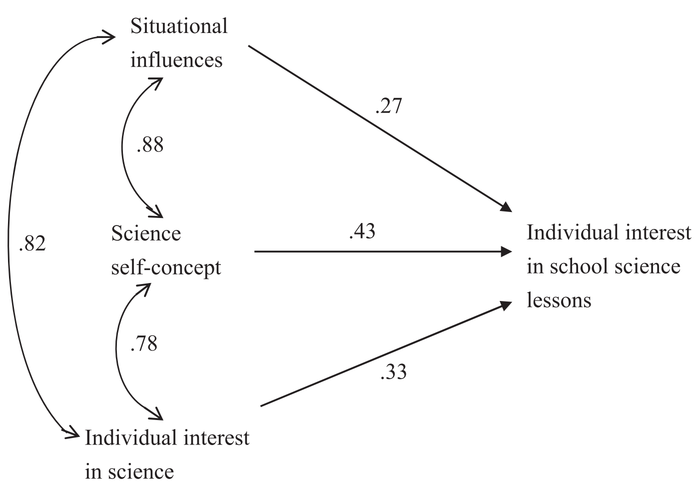

Figure 1. Standardised solution for the model representing the key factors affecting students' individual interest in school science lessons.

confirmed the positive relationships previously found in the qualitative study. Thus, the strongest factor affecting students' individual interest in school science lessons was their science self-concept ($\beta = .43$, $t = 8.3$, $p < .001$), followed by individual interest in science ($\beta = .33$, $t = 4.1$, $p < .001$) and situational influences in science lessons ($\beta = .27$, $t = 3.8$, $p < .001$). The model explained 93% of the variance in students' individual interest in school science lessons.

Discussion

Structural equation modelling allowed quantitative comparisons of the five factors identified in Phase 1 of my study. As can be seen in Figure 1, individual interest in school science lessons is most heavily affected by one's science self-concept. For every unit increase in science self-concept, individual interest in school science lessons was greater by 0.43 units. In other words, students are more likely to be interested in studying science at school if they believe themselves to have higher levels of competence to learn science successfully. This finding is consistent with the results obtained in my qualitative study. A total 19 students talked about this kind of self-belief during interview. Most of them judged their own competence to study science based on their achievement in class: 'I am one of the best students in the science class. Getting high marks is easy for me' (S8); I have done well in science tests and exams' (S28); and 'I always got very good marks in science' (S40). In Germany, a regression analysis by Häussler and Hoffmann (2000) discovered that students' physics self-concept was the best predictor ($\beta = .43$) of interest in physics as a school subject. Interestingly, their β value is identical with that in my study even though the research contexts are different. Science self-concept is a very important affective variable, but it was not included in the last round of the PISA study (OECD, 2016).

In other fields, some researchers have also recognised the importance of the self-concept construct. For example, Cury et al. (1996), in a study of French girls' interest in school physical education, found that girls' perceived competence was the most important factor positively affecting interest. Marsh, Trautwein, Lüdtke, Köller, and Baumert (2005) tested reciprocal effects models of longitudinal data collected from German students. They reported that prior mathematics self-concept significantly affected subsequent interest in mathematics, whereas prior interest in mathematics had only a small effect on subsequent mathematics self-concept. Viljaranta, Tolvanen, Aunola, and Nurmi (2014) investigated the cross-lagged relationships between interest, self-concept of ability, and academic performance in mathematics and reading by using longitudinal data collected from Finnish students. They found that, in both reading and mathematics, students' self-concept of ability in Grade 2 was able to predict their interest in Grade 4. Also, students' self-concept of ability in Grade 4 predicted interest in Grade 7. However, in both reading and mathematics, students' interest did not predict self-concept of ability. These findings suggest that a causal link may exist from students' prior science self-concept to their later individual interest in school science lessons.

Häussler and Hoffmann (2000) found that German students' interest in physics was a weak predictor of their interest in physics as a school subject. In contrast, the present study found that individual interest in science is the second strongest predictor of individual interest in school science lessons. This finding is in support of the qualitative results. During interview, 47% of the 60 students mentioned the effects of their individual interest in science. Many students started to have an interest for natural science when they were in primary schools. For example, a student said: 'I was curious about natural phenomena even when I was a primary school student. I wanted to learn about why dinosaurs became extinct, how astronauts landed on the moon, how plastic bags can be made biodegradable … ' (S20). For school teachers, however, situational influences in regular science lessons is more important than individual interest in science because they can hardly influence students' incoming individual interests. Thus, the key to promoting students' individual interest in school science lessons is to use instructional strategies that can enhance their science self-concept and provide situational interest experiences in science lessons. Some strategies for triggering and maintaining situational interest in science lessons have already been reported in the qualitative part of my study. Below I discuss some possible strategies for enhancing students' science self-concept.

Many interventions have been tested to bolster students' academic self-concept. In their meta-analysis, O'Mara, Marsh, Craven, and Debus (2006) classified self-concept interventions into 12 broad categories, such as group counselling or discussion, practice or training, praise and/or feedback, social support or environmental restructure, and peer tutoring, cooperative learning or modified curriculum. They found that self-concept enhancement interventions that primarily used praise and/or feedback produced the most positive effects on self-concept. Furthermore, interventions using attributional feedback yielded the highest mean effect sizes, followed by contingent praise upon performance and goal-relevant feedback. Effort for study and ability are the most dominant causes that students use to explain their academic successes and failures (Weiner, 1985). Mueller and Dweck (1998) conducted six empirical studies and found that praise for effort had more positive consequences for students' motivation than praise for intelligence. Students praised for effort showed more task persistence and task enjoyment than students praised for intelligence. When school teachers want to use praise to enhance students' science self-concept, they should pay attention to Brophy's (1981) 12 guidelines for praising effectively. In particular, they should furnish effort attributional feedback for a student's success or failure when studying school science. Furthermore, students in a science class will have a higher level of science self-concept if the teacher focuses on more real-life applications and the school offers a more diverse range of extra-curricular science activities (Taskinen et al., 2013).

Häussler and Hoffmann (2002) reported how they had trained six German teachers to identify suitable and unsuitable teaching techniques to promote a positive physics self-concept in their students. The suitable techniques included the use of hints when students have difficulties to do an easy task and development of plans with low achievers to improve their future achievement. Lewis, Shaw, Heitz, and Webster (2009) found that guided-inquiry activities in a semester-long general chemistry course can improve American students' self-concept regarding chemistry. Although these two studies were not conducted in the junior secondary science classrooms, the findings suggest that differentiated instruction and inquiry teaching have potential for promoting students' science self-concept.

Conclusion and limitations

Little research has quantitatively compared the relative importance of different factors affecting students' individual interest in school science lessons. My study aimed to fill this gap in science education literature by pinpointing the key factors, thus paving the way for pedagogical intervention strategies. Results showed that the strongest factor affecting students' individual interest in school science lessons is their science self-concept, followed by individual interest in science and situational influences in science lessons. Gender and grade level were nonsignificant factors.

As with any research, certain limitations were present in my study. First, the student interviews in the first phase of the study were semi-structured and student responses were likely affected by the Hong Kong education system and the Chinese culture. As a result, one or two key factors may need to be added to my model before it can be applied to other education systems and cultures. One additional factor that may be missing is the type of achievement goals that students adopt in a science course. Harackiewicz, Barron, Tauer, Carter, and Elliot (2000) and Harackiewicz, Barron, Tauer, and Elliot (2002) found that mastery goals positively predicted students' interest in an undergraduate psychology course whereas performance goals and work avoidance goals did not. Future research on the factors affecting students' individual interest in school science lessons could include specific interview questions to explore whether mastery goals are equally relevant to science education in the secondary school.

Second, contrary to many previous studies, grade level was found to be a nonsignificant factor in my model. One possible reason is that only Secondary 1–3 students were invited to participate in the questionnaire survey in phase 2 of this study. They were all junior secondary students. Yager and Bonnstetter (1984) noted that 41% American junior high students found science classes to be fun, but the percentage dropped to 28% for senior high students. Further research is needed to survey both Hong Kong junior and senior secondary students to examine the effect of grade level on individual interest in school science lessons.

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