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The influence of extracurricular activities on middle school students' science learning in China

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ABSTRACT
Informal science learning has been found to have effects on students' science learning. Through the use of secondary data from a national assessment of 7410 middle school students in China, this study explores the relationship among five types of extracurricular science activities, learning interests, academic self-concept, and science achievement. Structural equation modelling was used to investigate the influence of students' self-chosen and school-organised extracurricular activities on science achievement through mediating interests and the academic self-concept. Chi-square tests were used to determine whether there was an opportunity gap in the student's engagement in extracurricular activities. The students' volunteer and school-organised participation in extracurricular science activities had a positive and indirect influence on their science achievement through the mediating variables of their learning interests and academic self-concept. However, there were opportunity gaps between different groups of students in terms of school location, family background, and especially the mother's education level. Students from urban areas with better-educated mothers or higher socioeconomic status are more likely to access diverse science-related extracurricular activities.

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Science education; extracurricular activities; informal science education; learning outcomes

1. Introduction

The term 'informal learning' is generally used to describe learning activities that occur in 'informal settings' (Rennie, 2014). Given the diversity of learning settings, 'informal science learning' includes all the science-related activities outside of the regular education system (Rennie, 2014). Compared with formal learning at school, in the informal learning environment, students have more autonomy in choosing activities and exploring different possibilities based on their own interests while learning knowledge and skills at their own pace. As some researchers have pointed out, learning from informal sources can be very effective in improving learning and motivating students (Fenichel & Schweingruber, 2010; Osborne & Dillon, 2008; Salmi, 1993). Eshach (2006) suggested that it is critical to make connections between informal and formal learning because they can be complimentary to

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one another. Informal learning in science education has been explored extensively, and many researchers have pointed out that students have more time and opportunities to investigate scientific questions through such learning (Bamberger & Tal, 2007; Suter, 2014). Moreover, the impacts of informal learning in science are regarded as more general, diverse, and long lasting (Bamberger & Tal, 2008; Falk et al., 2012; Miller, 2010; National Research Council, 2009; Wilson et al., 2014; Wu, Zeng, Xie, & Kang, 2009).

Different types of science-related activities, including visiting museums, science and technology centres, zoos, and parks, have been found to have positive influences in improving students' learning outcomes (Salmi, 1993, 2002). A National Research Council report asserted that informal learning in science enhances students' excitement, interest, motivation, understanding of science, acceptance of scientific thinking, and application of science knowledge and skills (National Research Council, 2009). Programme for International Student Assessment (PISA) demonstrated in their 2006 report that students are more likely to not only have better achievement but also improved attitudes and positive beliefs regarding science if they are exposed to more scientific extracurricular activities (OECD, 2012). Some researchers have observed that involvement in extracurricular science activities enhances the interest of college students to pursue Science, Technology, Engineering, and Mathematics (STEM)-related careers (Dabney et al., 2012; Woolnough, 1994).

As increasing evidence indicates that participation in extracurricular activities influences diverse student behaviours and attributes (Bamberger & Tal, 2008; Eastwell, 1998; Hong, Lin, & Veach, 2008; National Research Council, 2009), it is worthy to question the mechanism behind these relationships. Unfortunately, little research has been conducted, providing an insignificant amount of evidence to address the psychological mechanism between attending extracurricular activities and science learning (Suter, 2014). For example, the direct relationship between extracurricular activities and student academic performance has been challenged for a long time (Falk & Dierking, 2000; Suter, 2014). Different psychological attributes have been suggested as mediating variables in this connection (Berger & Karabenick, 2011; Wigfield & Cambria, 2010). A potential mediating variable suggested by researchers is academic self-concept, which has been a consistently good predictor of academic performance. As explained by the social cognitive theory, environmental factors are more likely to influence a person's behaviour through self-beliefs, such as self-efficacy or self-concept, rather than showing a direct effect (Bandura, 1986). Academic self-concept could mediate the relationship between participation in extracurricular activities and academic outcomes (Harper-Tarantolo, 2009). Another possible mediating route is through learning interests, which have been well documented as an influential factor in student achievement. Moreover, it is widely recognised that participation in science activities enhances students' learning interests and enjoyment (Bamberger & Tal, 2007; Eastwell, 1998). Therefore, in the current study, both learning interests and academic self-concept were investigated as the mediating variables connecting the relationship between participation in extracurricular activities and science achievement.

In China, few studies have investigated science-related extracurricular activities (Fan & Fu, 2012; Wu, Li, Zeng, & Ji, 2012). The extent of and how experiences in engaging in science-related extracurricular activities influence Chinese students' science learning have not been explored. Findings based on the Chinese context certainly provide valuable information for educators and researchers to understand the importance of informal learning in science. In addition, it is noteworthy to address the question in terms of what types of contextual factors, such as family-related or school-related factors, influence Chinese students' opportunities to participate in science-related extracurricular activities. Incorporating the 'opportunity gap' perspective will provide a deeper understanding of the problem of education inequity in China caused by the 'disparity of educational resources'. The current study complements previous research by using data collected during a large-scale assessment conducted in China in 2012. The following two general research questions were addressed in the present study:

(1) How does science extracurricular activity participation influence student achievement in physics, biology, and geography?
(2) Is there an opportunity gap in terms of student accessibility and breadth in participating in science-related extracurricular activities given different school locations, gender, family socioeconomic status (SES), and mother's education level?

2. Theoretical background

2.1. Theoretical framework of informal learning

Historically, researchers have proposed diverse frameworks to understand the nature of informal learning (Falk & Storksdieck, 2005). According to the literature review (Rennie, 2014), two main theoretical frameworks have been widely employed to explain the complexities of informal learning. From the perspective of a social constructivist theoretical framework, informal learning is regarded as a socially situated learning procedure in which individuals interact with others, thus constructing their knowledge and understanding of the world (Falk et al., 2012). Falk and Dierking (2000) put forth the contextual model of learning with the aim of explaining three different contexts of informal learning, personal context, sociocultural context, and physical context. The personal context indicates that the strong influences of personal motivation, beliefs, interests, and desire on an individual's informal learning should not be ignored. The sociocultural and physical contexts emphasise the importance of cultural value and the physical environment of informal learning.

In the current research, we employed the theoretical framework of both social constructive theory and the contextual model of learning to investigate how the informal learning environment impacts students. Through exploring the inter-relationship among student self-concept, learning interest, and academic achievement that have been separately examined in the past, we would like to gain knowledge about how extracurricular activities influence these personal contextual factors.

2.2. Definition of extracurricular activities

In the current paper, we focus on five different science-related out-of-school learning activities, using the terminology 'extracurricular activities' to represent them. Extracurricular activities refer to a broad range of activities that occur in diverse contexts outside of school, such as visiting science and technology museums (Bohnert, Fredricks, & Randall,

2010) or participating in after-school science programmes (National Research Council, 2009). These activities are categorised into two types (Falk & Dierking, 2000; Suter, 2014). One type of activity is school-organised, regularly scheduled, and supervised by teachers. Students are usually required to participate in them. The other type of activity is supported by students' families or based on their personal willingness without routine. Given the different characteristics of the two types of activities, the measurement in the current survey provided detailed information that distinguished between voluntary and school-organised informal science activities.

2.3. The influence of extracurricular activities on student development

It has been widely recognised that the breadth of engagement in extracurricular activities and participation time were positively linked with youth academic achievement and psychological development (Bohnert et al., 2010; Denault & Poulin, 2009; Fredricks & Eccles, 2006). The existing empirical studies can be categorised into two broad categories. The first category of study primarily addresses the effectiveness or efficiency of extracurricular activities on student academic performance through comparing them with traditional instruction (Bamberger & Tal, 2007; Eastwell, 1998; Hong, Lin, & Lawrenz, 2008; Hong, Lin, & Veach, 2008; Kılıç & Şen, 2014). An experimental research study with both pre-and post-tests was employed to investigate whether out-of-school activities are useful in developing 9th grade students' critical thinking dispositions and attitudes about physics (Kılıç & Şen, 2014). The findings of this study highlighted the importance of implementing physics courses that were supported by out-of-school learning activities rather than either of them individually. Regarding science education specifically, Hong, Lin, and Veach (2008) discovered that a 13-week extracurricular intervention was effective in promoting single-parented students' science knowledge, self-esteem, and social skills. These case studies showed that extracurricular interventions have positive effects on students' science learning to some extent but there is no evidence of its significant influence on science achievement (Hong, Lin, & Lawrenz, 2008; Hong, Lin, & Veach, 2008).

The second category of study is aimed at discovering the relationship between participation in extracurricular activities and students' learning outcomes using cross-sectional data, especially large-scale survey data (Denault & Poulin, 2009; Fredricks, 2011; National Center for Education Statistics, 2012; OECD, 2011). Controlling for demographic variables and previous achievements, it was discovered that the breadth and intensity of participation in extracurricular activities in 10th grade positively influenced students' math performance in 12th grade, indicating the delayed effects of extracurricular activities (Fredricks, 2011). Through the use of the latent growth curves model, it was also found that participation in early to mid-adolescence stages could be beneficial to adolescents in helping them to be more socially connected and allowing them to identify themselves better (Denault & Poulin, 2009). Other exploratory analyses using a Longitudinal Study of American Youth (1987–1993) were conducted with the goal of determining whether visiting science museums results in better science achievement or attitude (George, 2000; Suter, 2014). The findings confirmed their prediction of the positive influences on student academic performance and science attitudes. Consistently, evidence from the PISA (2006) showed that, in most OECD countries, students who attended schools with more science-related extracurricular activities were more likely to achieve better science performance, greater enjoyment of learning science, and a stronger belief in their ability to handle science-related tasks (OECD, 2011).

2.4. Science-related extracurricular activity research in China

Informal science learning has been a widely accepted and important complimentary part of school education since the 1980s or 1990s in many developed countries (Salmi, 1993) but has not gained much attention in China until recently. Therefore, research about extracurricular science activities in China is still limited, showing the importance for further exploration (Chen, Wang, Chen, & Yu, 2014; Wu, Xie, Shang, & Ji, 2009; Wu, Xie, et al., 2009; Xin & Chen, 2014). A few experimental studies have been conducted to investigate the influence of science-related extracurricular activities on student development (Guo, 2014; Ji, 2012; Li, 2012; Sha, 1987; Shang, 2010; Zeng, 2008). For example, in Guo's (2014) study, students in the experimental group had the opportunity to participate in science-related activities, such as feeding animals, observing the weather, planting, conducting experiments, and visiting science exhibitions. The results showed that students in the intervention group had enhanced learning interest and motivation, developed more efficient learning strategies, improved their capabilities in explaining scientific phenomenon and solving real problems in everyday life, and increased their achievements in both Chinese and Math. Given that most museum learning is primarily a voluntary family behaviour (Ji, 2012), the impacts of family involvement in extracurricular science activities have gained the interest of researchers. Students who interacted with their parents in science activities were found to obtain more benefits than those who were controlled by their parents (Li, 2012; Zeng, 2008). Moreover, interactions with peers were also beneficial for students in museums (Wu, Xie, et al., 2009).

2.5. Psychological mechanism behind the influence of extracurricular activities

As mentioned above, the current research focuses on the personal context in the framework of the contextual model of learning. Although we know about the relationships between different personal contextual factors, such as motivation, belief, and interests, with student science academic performance (Jansen, Schroeders, & Lüdtke, 2014; Marsh & Yeung, 1997; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Suter, 2014), the mechanism behind these relationships requires extensive investigation. According to different theories, two potential mediating variables suggested by researchers are academic self-concept and learning interests.

2.5.1. Academic self-concept

As explained by Shavelson, Hubner, and Stanton (1976), who pioneered development of the theoretical foundation of contemporary self-concept research, an individual's self-concept is a person's perceptions of oneself. With the aim of understanding this construct better, they proposed a multi-dimensional model with a hierarchical structure. The hierarchical self-concept structure includes general self-concepts covering different dimensions, such as emotional, social, and academic self-concepts. The academic self-concept refers to the overall perceptions or beliefs that a student has of his or her academic performance (Byrne & Gavin, 1996; Marsh, 1990c; Marsh & O'Neill, 1984; Shavelson &

Bolus, 1982; Wigfield & Karpathian, 1991). The academic self-concept is subject-specific, which means that self-concept in one specific subject, such as math, does not necessarily transfer to other subjects, such as reading (Arens, Yeung, Craven, & Hasselhorn, 2011; Jansen et al., 2014; Marsh & Yeung, 1997).

A student's science-related self-concept refers to the perceptions or beliefs of his or her ability to do well in science (Shavelson & Bolus, 1982). Students with higher academic self-concept are confident about learning science, with stronger motivation and persistence, and engage more in learning behaviour. Conversely, students with lower self-concept in science have less confidence and tend to be less engaged in learning activities (Nagengast et al., 2011). Based on their structural equation modelling (SEM) analysis findings, Jansen et al. (2014) illustrated that it is better to separate the self-concept in different science subjects, including chemistry, biology, and physics, than employ a general science self-concept. As suggested, in the current research we considered subject-specific self-concepts in physics, biology, and geography separately.

According to the self-enhancement model, self-concept is a determinant variable of academic achievement; thus, the enhancement of education to improve self-concept could result in better achievement (Calsyn & Kenny, 1977). Increasing empirical evidence has been provided to support the significantly positive and direct effect of academic self-concept on students' academic performance (Calsyn & Kenny, 1977; Hamachek, 1995; Marsh, 1990a; Marsh & Martin, 2011; Salmi, Vainikainen, & Thuneberg, 2015; Sebald, 2010; Shavelson & Bolus, 1982). This relationship trend was also clearly identified in a meta-analysis review conducted by Huang (2011). Moreover, it was found that if the subject of academic self-concept and achievement were matched, the effect of such relationship is much higher than when only a general self-concept was considered (Jansen et al., 2014). Many studies have discovered the positive influence of academic self-concept on academic performance in science, such as in chemistry and physics (Bauer, 2005; Chiu, 2008; Jansen et al., 2014; Möller, Streblow, Pohlmann, & Köller, 2006; Wang, Oliver, & Staver, 2008).

In addition to investigations of the direct relationship between academic self-concept and achievement, research has been focused on its mediating role in the relationship between other factors and learning outcomes (Arens et al., 2011; Jones, Audley-Piotrowski, & Kiefer, 2012). The primary rationale behind this is social cognitive theory, which explicates that the self-concept is formed and can be influenced by environmental factors and thus affects achievement (Bandura, 1986). For example, students' perception of their friends' behaviours could influence their math self-concept, which in turn influences their math performance (Jones et al., 2012).

2.5.2. Learning interest

Interest has been studied in the fields of psychology and education since Herbart's (1965a, 1965b) argument that interest should be fostered because it could, in turn, facilitate learning. An extensive body of studies have focused on the explanation and measurement of interest as an independent construct (Hidi & Renninger, 2006; Potvin & Hasni, 2014; Wigfield & Cambria, 2010), some have explored its effects on other constructs (such as self-efficacy) and learning outcomes (such as strategies, self-regulation, and achievements) (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Hidi, 1990; Köller, Baumert, & Schnabel, 2001; Lee, Lee, & Bong, 2014; Renninger & Hidi, 2002; Schiefele, Krapp, & Winteler, 1992), and others studied what factors influence interest (Harackiewicz & Hulleman, 2010; Hidi & Renninger, 2006; Krapp & Prenzel, 2011; Potvin & Hasni, 2014).

The positive relationship between interest and learning outcomes (Harackiewicz et al., 2008; Hidi, 1990; Köller et al., 2001; Lee et al., 2014; Renninger & Hidi, 2002), especially academic achievement (Köller et al., 2001; Marsh et al., 2005; Marsh & Martin, 2011; Renninger & Hidi, 2002; Schiefele et al., 1992; Tucker-Drob, Cheung, & Briley, 2014) has been supported based on empirical evidences. Schiefele et al. (1992) examined the relationship between interest and performance using a meta-analysis of over 150 studies. It was indicated that, on average, the strength of interest accounts for approximately 10% of the observed achievement variance. Tucker-Drob et al. (2014) used a multi-level structure to examine the relationship between the interest and science achievement of 40,000 students in 57 countries. They observed that, considering the family SES and national GDP, interest has a positive effect on science achievement, especially for students in higher SES families or those from higher GDP countries. Interests were also found to have a significant influence on students' achievement in an analysis of longitudinal data of German students, even controlling for previous achievement (Köller et al., 2001; Marsh et al., 2005). In addition to its direct influence on student learning outcome, learning interest is also considered as an important mediating or moderating variable. Wigfield and Cambria (2010) reviewed theories of interest and proposed that there was a need to study the mediating effects of learning interest on achievement. For example, Marsh et al. (2005) discovered that interest could be used as a mediating variable that positively connects self-concept and achievement.

In summary, academic self-concept and learning interest have been found to serve as important predictors of science achievement (Fonseca, Valente, & Conboy, 2011; Huang, 2011; Lavonen & Laaksonen, 2009) and outcome variables influenced by extracurricular activities (Abruzzo, Lenis, Romero, Maser, & Morote, 2016; Blomfield & Barber, 2009; 2011; Harper-Tarantolo, 2009; Hong, Lin, & Veach, 2008; National Research Council, 2009; Salmi et al., 2015). In the current study, we examine the mediating influences of science academic self-concept and learning interest in the relationship between science extracurricular activities and science achievement. It was hypothesised that increased engagement in extracurricular activities is related with higher academic self-concept and interests, in turn positively influencing student academic achievements.

3. Methodology

3.1. Sample

This study used secondary data from a large-scale education assessment collected in 2012 in Guangdong, China. Data on student achievement in physics, biology, and earth and space science and extensive contextual information related to learning and teaching were collected. The target population was 8th grade students from middle schools in the Guangdong province. With the aim of making the sample more representative of the population, a three-stage stratification cluster sampling design with systematic probability proportional to size technique was employed. Counties were selected according to their GDP and educational development levels in the first stage; eight schools were selected from each county based on their location, schooling quality, and school size. Within each school, approximately 30 students were randomly selected. The final sample consisted of 7410 middle school students (with an average age of 14.7 years) from 120 middle schools from 18 counties.

3.2. Measures

3.2.1. Extracurricular activity participation

Extracurricular activity participation was self-reported by the students. Five measurable indicators of extracurricular activities were used: (1) visiting science museums or exhibitions; (2) science investigations out of school; (3) raising small animals or growing plants; (4) attending events that include science knowledge; and (5) completing small creative science projects. For each of the five activities, three choices were designed to indicate the participation level: '1' was 'Yes, I have attended the school-organised activities,' '2' was 'Yes, I have attended by myself (self-chosen),' and '3' was 'No.' Based on those choices, the following two indices capturing the categories of these activities were developed.

School-organised attendance: A measure of the number of students attending school-organised extracurricular activities. The index was created by summing all the '1' responses for all five items for each student, with a range from 0 to 5.

Self-chose attendance: A measure of the number of students attending different types of extracurricular science activities based on the student's free willingness and choice, which is usually supported by their families. The index was created by summing the '2' responses across the five items for each student, with a range from 0 to 5.

The following two additional indices measuring the extent of students' attendance at these activities were developed.

Accessibility: Attending at least one type of extracurricular activity, regardless of if it is school-organised or self-chosen.

Breadth of attendance: Attending at least three types of extracurricular activities, regardless of whether they are school-organised or self-chosen.

3.2.2. Achievement test

Student achievement in biology, geography, and physics were measured using a standardised test that was developed based on the National Curriculum Standards. All the items were extensively reviewed by experts in the science subject and educational measurement specialists. Before the implementation, a pilot field test was conducted with the aim of improving the quality of the test. All the items selected in the final test had good psychometric characteristics.

3.2.3. Learning interest

A key variable that serves as a mediating variable in the hypothesised model is learning interest. Student learning interest for each subject domain (physics, biology, and geography) was measured separately using a short scale of three items. As Haeussler and Hoffmann (2000) suggested, the interest scale used in this study includes 'domain interest,' which is student interest in the domain of particular subjects, and 'subject interest,' which is related to how the school subject is being taught in school. The two 'domain interest' items were from the scale used in PISA 2006 (OECD, 2009) and other interest-related research (Marsh et al., 2005). The 'subject interest' was about the science teacher, which was a critical factor in students' interest in learning. The following items are the same for all three subjects: (1) I like to learn physics (biology, geography); (2) I like my physics (biology, geography) teacher; and (3) I am interested in the content of the physics (biology, geography) textbooks. The students were asked to indicate the level of agreement on a five-point Likert scale from '1' (strongly disagree) to '5' (strongly agree). The internal consistency reliability (Cronbach's alpha) of the scales were .812 (physics), .819 (biology), and .852 (geography).

3.2.4. Academic self-concept

The second key variable that serves as a mediating variable in the hypothesised model is academic self-concept. Similar to the learning interest, the learning self-concept for each subject domain (physics, biology, and geography) was measured using a short scale that focuses on three different subjects. The academic self-concept scale items were chosen from the Self-Description Questionnaire II for adolescents (Marsh, 1990b) in the specific subject. A similar scale was found to be high quality in many studies (Möller, Pohlmann, Köller, & Marsh, 2009; Nagengast et al., 2011; Nagengast & Marsh, 2012) and international large-scale assessments, such as PISA 2006 (OECD, 2009) and the Trends in International Mathematics and Science Study (TIMSS) 2011 (Martin & Mullis, 2012). The items were (1) I learn physics (biology, geography) very well; (2) I believe that physics (biology, geography) is one of my best subjects; (3) I learn physics (biology, geography) knowledge fast; and (4) I feel physics (biology, geography) is hard to study. The fourth item was designed as a negative statement to avoid response bias. It was reversely coded before analysis. The items were on a five-point Likert scale. The internal consistency reliability (Cronbach's alpha) of the scales was .851, .840, and .870 for physics, biology, and geography, respectively.

3.2.5. Demographic variables

Researchers have indicated that the effects of attending extracurricular activities on students still hold when confounding variables were controlled for. However, multiple factors that might influence the participation in extracurricular science activities should be considered as controlling variables in the current study, with the aim of avoiding overestimating their effects on students. The core independent variables considered in the current study included gender (male and female), location of the school (city, county, township, and countryside), student social economic status (high, medium, and low), and mother's education level (never attended, primary school, junior school, high school, college, and master's and above).

3.3. Data analysis

The data analysis consisted of two parts: a descriptive analysis with a chi-square test was conducted to identify the opportunity gap between students with different backgrounds. SEM was conducted to examine the psychological mechanism of how students' participation in extracurricular activities based on their own choices influences student learning in science. The data were structured hierarchically with students within schools, which resulted in a two-level hierarchy of measurement. Specifically, all the students in one school would be influenced by the school-organised science activities. Therefore, multilevel SEM was applied to explore how school-organised activities influence the psychological attributes and impact student achievements, given the nested data structure.

SEM was selected as an analysis tool because of its capability to manage the complex relationships among different variables and control for measurement error. The overall model fit was evaluated based on the following index: the root mean square error of approximation (RMSEA) should be below .08 and up to .10, indicating a reasonable fit (Byrne, 2001). The Tucker–Lewis Index (TLI) and comparative fit index should be greater than .90 or .95 (Schermelleh-Engel, Moosbrugger, & Müller, 2003). In addition, the loading values of the items on the latent factors should be over .40. The path coefficient in the model was tested with T statistics to determine whether the hypothesised relationship was significant.

4. Results

Research Question 1: Could students' participation in science-related extracurricular activities based on their own willingness positively influence their interests and self-concept in learning science, in turn influencing their achievement in physics, biology, and geography?

Finding 1**:** In the initial model, the controlling variable of gender was not found to be significant. Taking this into consideration, the model was specified by removing the path between gender and student achievement. Based on the final SEM analysis, the frequency of students' attending science-related extracurricular activities based on their own choices was found to have statistically significant indirect effects on student achievement in three subjects (physics, biology, and geography) through learning interests and academic self-concept, while controlling for student SES (see Figures 1 and 2 and Tables 1 and 2). Students attending these activities frequently tended to have stronger learning interests and higher academic self-concept toward science and thus were more likely to have better academic achievement, when controlling for student SES. As shown in Tables 1 and 2, the learning interest and self-concept items were above .40, indicating reliable measurement of these two latent variables. The overall model fit indices also demonstrated that the hypothesised model matched the observed data.

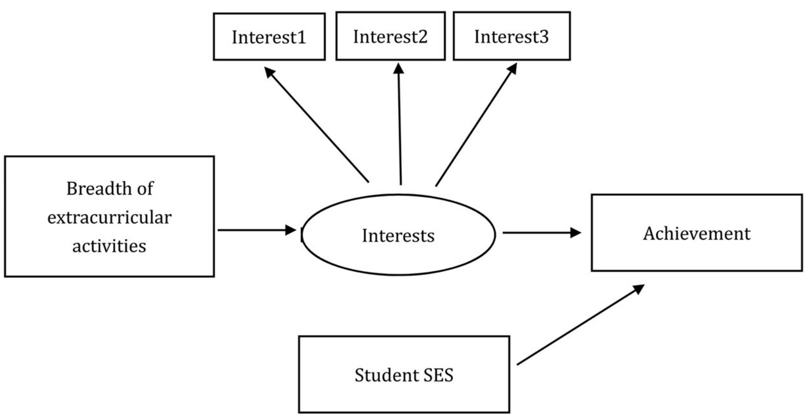

Figure 1. Student-level SEM with mediating effect of learning interests.

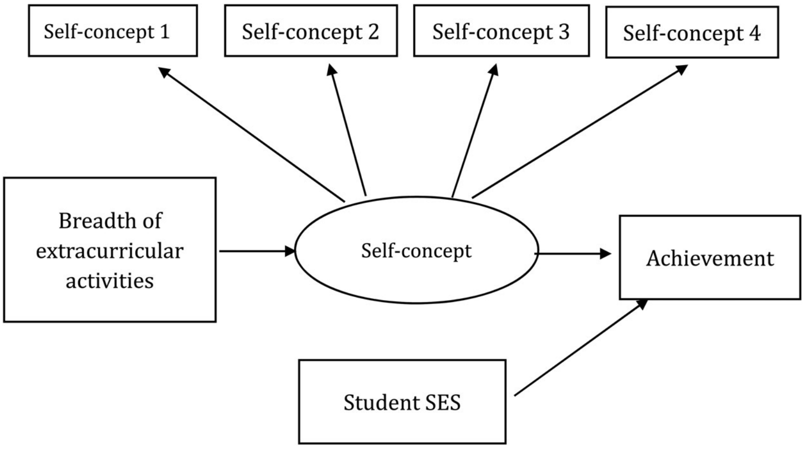

Figure 2. Student-level SEM with mediating effect of academic self-concept.

Research Question 2: Could school-organised science-related extracurricular activities positively influence students' interests and self-concept in learning science and in turn influence their achievement in physics, biology, and geography?

Finding 2: Two-level hierarchical SEM analysis was used to examine the same psychological mechanism, but for school-organised activities. The same trend was also observed for school-based extracurricular science activities. School-organised extracurricular activities showed strong indirect and positive influences on student achievement in both physics

Table 1. Student-level SEM with mediating effect of learning interests in three subjects.

	SES	Activities to interest	Interest to achievement	Items of interest	Model fit	Total effects
Physics	.224***	.170***	.316***	.925 .607 .806	CFI:.993 TLI: .988 RMSEA: .035	.054***
Biology	.221***	.175***	.260***	.911 .614 .838	CFI:.996 TLI: .993 RMSEA: .028	.046***
Geography	.215***	.135***	.280***	.927 .645 .884	CFI:.995 TLI: .992 RMSEA: .032	.038***

Table 2. Student-level SEM with mediating effect of academic self-concept in three subjects.

	SES	Activities to self-concept	Self-concept to achievement	Item loading of self-concept	Model fit	Total effects
Physics	.205***	.168***	.318***	.871 .881 .815 .533	CFI: .981 TLI: .970 RMSEA: .053	.053***
Biology	.209***	.183***	.284***	.870 .869 .828 .481	CFI: .985 TLI: .977 RMSEA: .049	.052***
Geography	.192***	.137***	.298***	.914 .906 .868 .500	CFI: .984 TLI: .976 RMSEA: .058	.041***

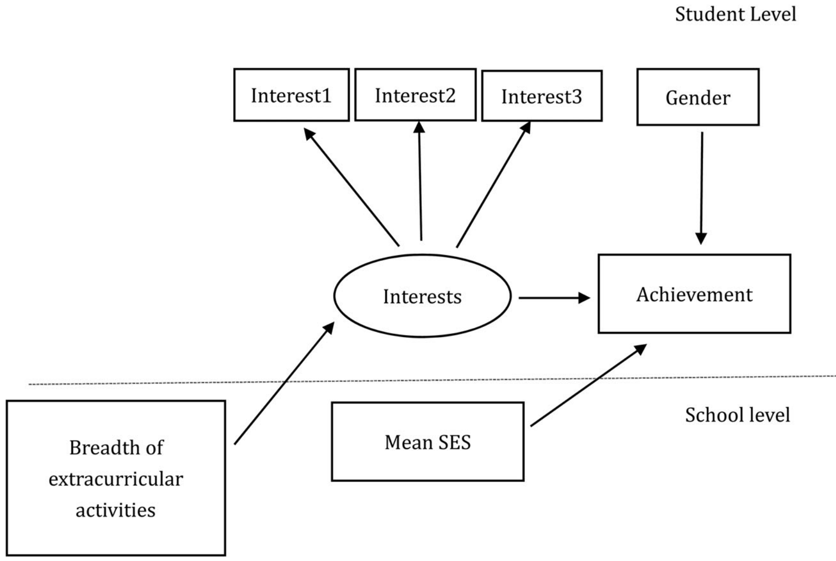

Figure 3. Student- and school-level SEM with mediating effect of learning interests.

and biology through learning interests and self-concept (see Figures 3 and 4 and Tables 3 and 4). In addition, both school-level average SES and student gender were revealed to significantly positively influence student achievement. The overall model fit also met the minimum requirement, with item loadings from .60 to .90. However, these results were not observed for the subject of geography.

Research Question 3: Whether there was an opportunity gap in students' accessibility to and breadth of participation in science-related extracurricular activities, given different school locations, gender, student family SES levels, and mother's education levels?

Finding 3: Regarding the accessibility of science-related extracurricular activities, all four demographic variables were found to be significant influential factors. Students

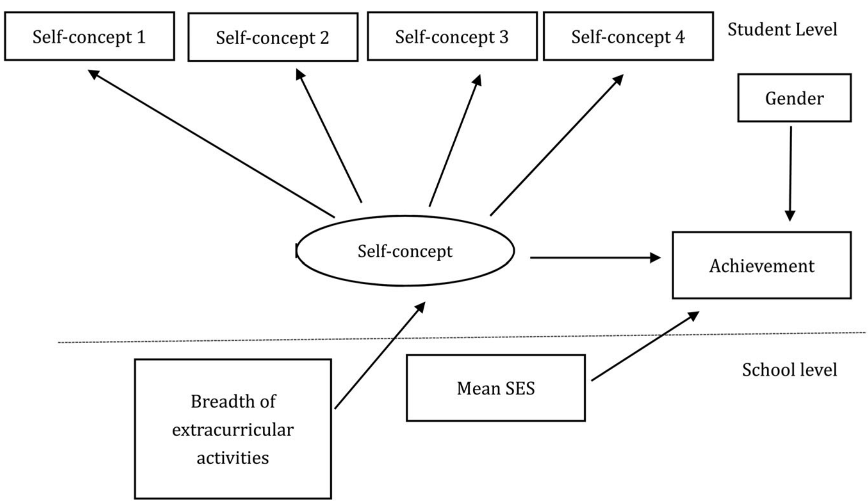

Figure 4. Student- and school-level SEM with mediating effect of academic self-concept.

Table 3. Student- and school-level SEM with mediating effect of interests in three subjects.

	Mean SES	Gender	Activities to interest	Interest to achievement	Items of interest	Model fit	Total effects
Physics	.836***	.062***	.634***	.296***	.896 .609 .768	CFI: .944 TLI: .897 RMSEA: .053	.205***
Biology	.789***	.029***	.336***	.194***	.895 .642 .782	CFI: .991 TLI: .983 RMSEA: .025	.065***

Table 4. Student- and school-level SEM with mediating effect of academic self-concept in different subjects.

	Mean SES	Gender	Activities to self-concept	self-concept to achievement	Items of self-concept	Model fit	Total effects
Physics	.837***	.077***	.728***	.288***	.857 .825 .742 .520	CFI: .924 TLI: .899 RMSEA: .051	.210***
Biology	.787***	.039***	.281***	.255***	.859 .864 .785 .485	CFI: .986 TLI: .977 RMSEA: .026	.072***

from city schools had higher possibilities in engaging in activities than their peers in counties, towns, and particularly in rural areas (χ^2 (3) = 99.165, $p < .001$) but the effect is small ($V = .116$). The same results were obtained from chi-square tests of the mother's education level and student SES level. The students whose mothers possess higher education levels or from high SES families had more opportunities to access the activities (χ^2 (5) = 94.631, $p < .001$, $V = .122$; χ^2 (2) = 94.060, $p < .001$, $V = .113$, respectively). Compared with the males, girls had more chances to access extracurricular activities (χ^2 (5) = 36.785, $p < .001$, $V = .072$).

Regarding the diversity of activity participation, students in schools located in cities had more opportunities to participate in diverse activities than their cohorts in schools located in counties, towns, and rural areas. This disparity was also significant (χ^2 (3) = 350.477, $p < .001$) and the effect was large ($V = .218$). This disparity was also present for the mother's education and SES levels (χ^2 (5) = 440.61, $p < .001$, $V = .264$; χ^2 (2) = 509.290, $p < .001$, $V = .263$, respectively). However, such a gap was not observed for gender (χ^2 (5) = .340, $p = .560$), which indicated that female and male students had similar breadth of engagement in activities.

5. Limitations

One of the limitations of this study is the secondary analysis of existing large-scale assessment data. Although we believe that such an assessment provides helpful information, it also constrains the usage of the data. First, it only allows use of the existing instrument. Given that all the variables were collected by self-reported survey, further analysis using other methods, such as interviews or observations, are required to yield more refined and supplementary findings. As some researchers have articulated (Phipps, 2010), different research methods might be chosen. Second, only learning interests and academic self-concept were addressed in the current study. Exploration of other possible factors that might show potential mediating influences on the linkage between extracurricular participation and science achievement is also worthwhile. Third, it is easier to obtain significant results using large datasets, thus, the effect size of each result is provided.

The current effort examined the possible linkage of the different variables. Although it provides insight on the effects of participation in extracurricular science activities, caution should be taken in attempts to draw causal inferences. Based on the current finding, it is dangerous to conclude that providing more opportunities for attending extracurricular activities would definitely result in higher self-concept and learning interesting. However, evidence based on such large-scale survey data, combined with findings from the experimental studies certainly provides understanding of the role of science-related extracurricular activities in influencing middle school students' science learning in China.

6. Discussion

The positive influence of extracurricular activities on academic performance has been identified in many studies (Guèvremont, Findlay, & Kohen, 2014; Salmi, 2002; Suter, 2014). However, the mechanism underlying this positive relationship has received less attention. This paper attempted to contribute to the literature by identifying factors that could be used to explain the mechanism behind the association between attending extracurricular science activities and academic performance. Instrumental to this analysis are the roles of student academic self-concept and learning interests as both serve as influential factors of student learning outcomes.

6.1. The mediating role of academic self-concept and learning interest in the relationship between extracurricular learning and science academic performance

As Rennie (2007) explained, the most salient attribute of informal learning is that an individual's characteristics and experiences could be fully situated in the contexts during the learning procedure. Based on the literature review, a theoretical and conceptual model summarising the relationship between different key variables was proposed. Student extracurricular participation was hypothesised to have an indirect influence on student achievement via learning interest and student learning self-concept, controlling for two important demographic variables of gender and SES. Through exploring the secondary data, the influences of five types of activities were examined: (1) visiting science museums or exhibitions; (2) conducting science investigations out of school; (3) raising small animals or growing plants; (4) attending an event that includes science knowledge; and (5) completing small creative science projects. Given that student extracurricular activity participation could be divided into two levels, the student level (students participate based on their own willingness) and school level (school-organised activities) were considered in separate models in the current study.

The results suggest that middle school students would benefit from attending science-related extracurricular activities from both academic and psychological perspectives. Moreover, the empirical evidence in this research also supports the assertion that students' interests and academic self-concept in learning science serve as mediating variables. Similar patterns were found for both types of extracurricular activities, ones based on students' choice and those organised by the school. Social cognitive theory could provide rationales for the findings in the current study. As explained in social cognitive theory (Bandura, 1986), an individual's self-concept and interest could be intermediaries between the environment (extracurricular activities) and the individual's behaviour (science performance). If students engage in more extracurricular activities, regardless of whether they are voluntary or required, they will be involved in an interactive learning environment. The most potential direct change that students experience from such learning environments is that they might enhance their academic self-concept and learning interests in science, in turn achieving more in the long term. These findings also provide evidence supporting Rennie's statement that informal learning is 'cumulative' (2007).

6.2. The opportunity gap in extracurricular activity attendance

According to the review conducted by Falk et al. (2012), very few studies deal with informal science learning in minority, female, or low-income groups. In the current paper, with the aim of detecting whether disparities exist, we examined the students' opportunities to access extracurricular activities and their breadth of participation in terms of their family SES, gender, mother's education level, and school location. The consideration of access to and breadth of in participation in extracurricular activities not only provides a better understanding of the extent to which the youth get involved but can also help capture the critical features of such experiences. Opportunity gaps were found with respect to students' breadth of attendance and accessibility. We believe that such a result reflects the current reality in China, which can partially be attributed to a limited supply of educational resources. First, as expected, students' SES plays an important role in their engagement in extracurricular activities. In terms of the students' participation in voluntary extracurricular activities, it is highly likely that parents play a very important role in supporting them financially. Most museums and science and technology centres are not free to middle school students. Thus, students from families with high social economic status are more likely to be able to afford the tickets. Second, parents (especially the mothers) with higher education levels have a better understanding of the cumulative effects of such learning activities and thus tend to encourage and accompany students in attending more extracurricular activities. Finally, the opportunity gap was also detected between different school locations. Specifically, students from urban schools have more opportunities than their peers in rural schools. The main reason for this is the current urbanisation in China. There are more learning resources, such as science museums, zoos, or technology centres, in urban areas. Consequently, it is much easier for students to approach these activities in their spare time. Moreover, it is convenient for schools to organise such activities as complements to their regular courses (Table 5).

6.3. Practical implications for the development of extracurricular activities

The findings of this research are especially meaningful and inspiring within the Chinese context. As the most important component of learning experiences, informal learning has been paid extensive attention and developed rapidly in Western society (Salmi, 1993). In the early 1980s, the National Board of Education urged schools to provide

Table 5. Student access to and the breadth of science-related extracurricular activity attendance.

		Accessibility	χ^2	Breadth	χ^2
School Location	City	90.2%	$\chi^2(3) = 99.165$,	47.3%	$\chi^2(3) = 350.477$,
	County	84.3%	$p < .001$, $V = .116$	28.5%	$p < .001$, $V = .218$
	Town	85.8%		31.4%	
	Rural	77.9%		17.9%	
SES	High	91.3%	$\chi^2(2) = 94.060$,	53.6%	$\chi^2(2) = 509.290$,
	Medium	86.2%	$p < .001$, $V = .113$	32.5%	$p < .001$, $V = .263$
	Low	80.5%		19.8%	
Mother's education level	Master's and above	96.9%	$\chi^2(5) = 94.631$,	71.9%	$\chi^2(5) = 440.61$,
	College	94.7%	$p < .001$, $V = .122$	64.2%	$p < .001$, $V = .264$
	High school	91.1%		55.3%	
	Junior	88.2%		38.1%	
	Primary	85.6%		27.3%	
	Never attended	75.6%		16.7%	
Gender	Male	83.9%	$\chi^2(5) = 36.785$,	36.3%	$\chi^2(5) = .340$,
	Female	88.9%	$p < .001$, $V = .072$	35.7%	$p = .560$

more out-of-school learning activities for students, with the aim of sealing the gap between school education and real working life. In the U.S., a variety of out-of-school informal plans have been launched and conducted with the aim of providing more opportunities for students in science competition, social learning, community service, and practice. These plans have become part of the public service system (Huang, 2006). In 2009, the government of Great Britain produced a white paper called 'The Learning Revolution' to provide more learning opportunities for people and support the flourishing landscape of informal learning through engaging in a variety of learning resources (DIUS, 2009). Such national investments have benefited many students. Across OECD countries, 89% of students attend schools where science-related field trips are commonly offered; for example, in Australia, this number is 96% (OECD, 2012). In England, according to the Wellcome Trust Monitor Wave 2 report (Clemence, Gilby, Shah, Swiecicka, & Warren, 2013), 57% of young people reported that they have been to science-related attractions, including zoos, museums, or science centres.

However, it has not been very long since the Chinese educational administration recognised the importance of informal learning. Not until 2000 did the Central Committee of the Communist Party of China and the State Council formally issue regulations about infrastructure development for improving the extracurricular learning environment. Along with the new wave of education reform in 2002, 'doing and engaging' has also been the new emphasis in science education (Zhang & Campbell, 2012). The National Education Development Plan 2010–2020 stated that students should be encouraged to participate in more extracurricular activities (Chen et al., 2014). A research study investigating elementary and middle school student engagement in out-of-school activities was conducted in 60 schools from 8 provinces in China (Chen et al., 2014). It was revealed that approximately 45% of students engaged in out-of-school activities. However, the critical issue raised by some researchers is the rigid formalism of extracurricular science activities. Specifically, all the activities were designed or presented to the students without allowing them to engage in the learning procedure (Shang, 2010; Zeng, 2008). Such activities are even worse because they impede students' understanding of scientific inquiry and enjoyment in exploring the mysteries of science.

In the digital revolution era, studies have been conducted to investigate how advanced technologies could be integrated with traditional activities. Students will have more opportunities to learn by accessing a diverse number of digital connectivity tools, such as the Internet, smart learning applications on mobile phones, digital museums, and online exhibitions of art. These learning resources allow the students to choose what, how, when, and where they want to learn (Rennie, 2014). Another remedy for the opportunity gap caused by family-related factors, such as the mother's education level, is to provide more school-organised activities for students. These activities are often free or very low cost and are usually compulsory as part of the course credit. For example, in Germany, besides traditional science centres, museums, or field trips, extracurricular science laboratories for school students have been established where students usually participate in one-day science projects (Uhlmann & Priemer, 2012). A third effective way is to establish collaborations between schools and the local community, such as with local colleges or scientific research associations that have the capability to provide informal learning opportunities for students, such as free tours of different labs. For example, the Australian and British National Science Week works with local scientific research centres to inspire young people through introducing scientific research, challenging the traditional perception of scientists, and demonstrating how science is applied in our lives (Christie, 2016; Cormick, 2014).

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