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Investigating the interrelationships among conceptions of, approaches to, and self-efficacy in learning science

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ABSTRACT

The purpose of this study was to examine the relations between primary school students' conceptions of, approaches to, and self-efficacy in learning science in Mainland China. A total of 1049 primary school students from Mainland China participated in this study. Three instruments were adapted to measure students' conceptions of learning science, approaches to learning science, and self-efficacy. The exploratory factor analysis and confirmatory factor analysis were adopted to validate three instruments. The path analysis was employed to understand the relationships between conceptions of learning science, approaches to learning science, and self-efficacy. The findings indicated that students' lower level conceptions of learning science positively influenced their surface approaches in learning science. Higher level conceptions of learning science had a positive influence on deep approaches and a negative influence on surface approaches to learning science. Furthermore, self-efficacy was also a hierarchical construct and can be divided into the lower level and higher level. Only students' deep approaches to learning science had a positive influence on their lower and higher level of self-efficacy in learning science. The results were discussed in the context of the implications for teachers and future studies.

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Conception of learning; approaches to learning; self-efficacy; science education

Introduction

In recent years, there has been an increase in attention to students' perceptions and interpretations of learning science experiences in the field of science education (Lin & Tsai, 2013a; Lin, Tsai, & Liang, 2012; Shen, Lee, Tsai, & Chang, 2016). Researchers have adopted different perspectives to explore the conceptions of learning science, approaches to learning science, and self-efficacy. Several studies have investigated conceptions of learning science in high school (Lee, Johanson, & Tsai, 2008; Tsai, 2004) and undergraduate students (Chiou, Liang, & Tsai, 2012). For example, Lee et al. (2008) identified lower level conceptions of learning (i.e. memorising, testing, calculating, and practicing) and higher level conceptions of learning (i.e. increase of knowledge,

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applying, and understanding) in high school students. Furthermore, some researchers have started to investigate approaches to learning to examine students' experiences learning science. There were two major approaches to learning science: deep and surface approaches (Kember, Biggs, & Leung, 2004; Li, Liang, & Tsai, 2013). In addition, self-efficacy is considered a crucial aspect of interpreting students' perceptions of learning science (Lin & Tsai, 2013b). Previous studies revealed that self-efficacy was closely related to students' learning processes and outcomes (Liem, Lau, & Nie, 2008; Printrich & Schunk, 2002). Therefore, conceptions of, approaches to, and self-efficacy were considered three primary factors of interpreting students' experiences learning science.

Furthermore, the relationships between conceptions of and approaches to learning science at the high school level (Lee et al., 2008) and at the college level (Liang, Su, & Tsai, 2015) have been previously investigated. In addition, previous studies have investigated the relations between approaches to learning and self-efficacy in learning science (Lin & Tsai, 2013b; Phan, 2011). However, conceptions of learning science, approaches to learning science, and self-efficacy in learning science have not been integrated and investigated within the same model. Whether the construct of self-efficacy is a hierarchical system that can be divided into the lower level and higher level remains a puzzle. In addition, most studies focused on high school or undergraduate students' perceptions of learning science in Taiwan. Few studies have been conducted to examine primary school students' conceptions of learning science, approaches to learning science, and self-efficacy in learning science. Starting in Grade 3, science is a major subject in primary school in mainland China. Moreover, it should be noted that primary school students in mainland China are different from the samples of previous studies. Therefore, it is very interesting and valuable to investigate how primary school students in mainland China perceived and interpreted their experiences of learning science.

Literature review

Cultural impacts on learning science

Learning science means culture acquisition from the perspective of cultural anthropology (Wolcott, 1991). Numerous studies have revealed that learners' cultural backgrounds have impacts on their learning science processes (Li, 2003; Tsai, 2004). Tsai (2000) indicated that different cultural groups had different processes of acquiring scientific knowledge since students' scientific knowledge acquisition occurs in a complex social and cultural context. Li (2003) found that Chinese students' conceptions of learning put emphasis on achievement standards, the unity of knowing, and morality. While Lee et al. (2008) reported that the western students are educated in the western culture that is shaped by constructive philosophy with the notion of high individualised.

Previous studies have been conducted to examine western students' conceptions of learning (Marshall, Summer, & Woolnough, 1999; Sadi, 2017), approaches to learning (Phan, 2011), and self-efficacy (Prat-Sala & Redford, 2010; Uzuntiryaki & Capa Aydin, 2009). However, elementary school students in mainland China are educated in an eastern culture that is influenced by Confucius philosophy. Moreover, the study on elementary school students' conceptions of learning science, approaches to learning science, and self-efficacy in learning science from mainland China remains lacking.

Therefore, this investigation will be very interesting and informative for providing insights into mainland China's students' perceptions of learning science.

Research on conceptions of learning science

Richardson (1999) proposed that conceptions of learning refer to students' views about their personal experiences and learning context. Säljö (1979) conducted pioneering research on conceptions of learning via in-depth interviews and analysis. Säljö (1979) distinguished between five categories of conceptions of learning: increase of knowledge; memorisation; acquisition of facts or principles; abstraction of meaning; and an interpretive process aimed at understanding reality. Building on Säljö's study, many researchers proposed different categories of conceptions of learning (Lee et al., 2008; Marshall et al., 1999; Marton, Dall' Alba, & Beaty, 1993; Tsai, 2004; see Table 1). Lee et al.'s (2008) study indicated that students' conceptions of learning included six factors. Furthermore, numerous studies validated the effectiveness of the six factors (Chiou et al., 2012; Lin, Tsai, et al., 2012). Therefore, the present study adopted Lee et al.'s (2008) questionnaire to investigate primary school students' conceptions of learning.

Marton et al. (1993) regarded conceptions of learning as a hierarchical system. The following three categories were grouped as the lower level: increase of knowledge, memorising, and an acquisition of facts or principles level (see Table 1); the higher level categories were: understanding, an interpretive process aimed at understanding reality, and changing as a person. Similarly, Lee et al. (2008) regarded memorising, testing, calculating, and practicing as lower level categories; and, the following were higher level categories: increase of knowledge; applying; understanding, and seeing something in a new way. Therefore, lower level conceptions of learning science focused on the memorisation or practice of what was taught by teachers or read in textbooks. However, higher level conceptions of learning science represented the application of what students learned and/or their ability to see information in a new way.

Table 1. Conceptions of learning proposed by different researchers.

Level of conceptions	Säljö (1979)	Marton et al. (1993)	Marshall et al. (1999)	Tsai (2004)	Lee et al. (2008)
Lower level	Increase of knowledge	Increasing knowledge	Memorising	Memorising	Memorising
	Memorising	Memorising and reproducing	Applying equations and procedures	Preparing for test	Testing
	Acquisition of facts or principles	Applying	Making sense of concepts and procedures	Calculating and practicing tutorial problems	Calculating and practicing
Higher level	Abstraction of meaning	Understanding	Seeing in a new way	Increases of knowledge	Increase of knowledge
	An interpretive process aimed at understanding reality	Seeing things in a different way		Applying	Applying
		Changing as a person	A change as a person	Understanding	Understanding and Seeing in a new way
				Seeing in a new way	

Research on approaches to learning science

Approach to learning refers to the methods of academic learning (Biggs, 1994). Previous studies indicate that learners adopt different ways of learning when completing academic tasks (Biggs, 2001; Marton & Säljö, 2005). Typically, there are two main approaches: surface and deep approaches (Liang, Lee, & Tsai, 2010; Lin, Liang, & Tsai, 2012). The surface learning approach is elicited by surface motivations, which lead to surface strategies (Chiou & Liang, 2012). Learners who possess surface learning approaches are afraid of failure and only memorise what they are taught to pass examinations. However, the deep learning approach is stimulated by deep motivation, resulting in deep learning strategies (Chiou & Liang, 2012). Learners who have a deep learning approach are motivated by intrinsic motivation and have a deep understanding of learning content, or integrating prior knowledge with new information. The primary difference between surface and deep approaches is whether learners can produce meaning from learning materials (Chiou et al., 2012).

Research on self-efficacy in learning science

Self-efficacy refers to individuals' perceptions of their academic ability to complete learning tasks (Bandura, 1997). Self-efficacy plays a crucial role in students' academic performance (Printrich & Schunk, 2002) and motivation (Cetin-Dindar, 2016). Previous studies indicate that learners with higher levels of self-efficacy are prone to using deep learning strategies and achieve better learning performance (Liem et al., 2008). In studies examining self-efficacy, researchers used different perspectives. Initially, self-efficacy was regarded as a single scale (Glynn, Taasoobshirazi, & Brickman, 2009; Tuan, Chin, & Shieh, 2005). However, multi-dimensional self-efficacy instruments were developed with high school or undergraduate students in later studies (Capa Aydin & Uzuntiryaki, 2009; Uzuntiryaki & Capa Aydin, 2009). Lin and Tsai (2013b) developed five-factor self-efficacy scale to measure high school students' self-efficacy. The five factors were conceptual understanding, higher order cognitive skills, practical work, everyday application, and science communication. Lin and Tsai (2013b) believed that the conceptual understanding subscale measured students' self-efficacy in understanding definitions, laws, and theories. The higher order cognitive skills subscale assessed students' self-efficacy in utilising complex cognitive skills. The practical work subscale measured students' self-efficacy in completing practical activities. The everyday application subscale evaluated students' self-efficacy in solving real-life problems. The science communication subscale addressed students' self-efficacy in communicating or discussing what they have learned in science. Furthermore, Lin, Liang, and Tsai (2015) adopted four-factor self-efficacy scale to measure university students' self-efficacy in learning biology. These four factors include higher order cognitive skills, everyday application, science communication, and practical works. However, few studies investigated the construct of self-efficacy in learning science for primary school students. Thus, the present study examined the construct of self-efficacy of primary school students in mainland China. Empirical data were collected to validate the new self-efficacy constructs.

Hypothesis development

Researchers are interested in the relations between conceptions of learning science and approaches to learning science. Lee et al. (2008) found that high school students' conceptions of learning science were closely related to their approaches to learning science. Students who had higher level conceptions of learning were more likely to adopt deep approaches. Li et al. (2013) investigated college chemistry major students' conceptions of and approaches to learning chemistry. They found that juniors and seniors had higher level conceptions of learning chemistry and tended to adopt deep approaches to learning chemistry. Chiou et al. (2012) analysed the relationship between conceptions of and approaches to learning in biology. They reported that students who possessed lower level conceptions of learning tended to use a surface approach, and students who expressed higher level conceptions were more likely to adopt a deep approach. Moreover, researchers have explored the relations between self-efficacy and conceptions of learning. Tsai, Ho, Liang, and Lin (2011) reported that high school students' conceptions of learning were associated with their self-efficacy. Lower level conceptions of learning were negatively associated with self-efficacy, while higher level conceptions of learning were positively related to self-efficacy. In addition, Chiou and Liang (2012) found that conceptions of learning had an impact on self-efficacy.

Previous studies have started to focus on the relations between approaches to learning science and self-efficacy in different learning contexts. For example, Phan (2011) found that there was a positive relation between undergraduates' self-efficacy and their approaches to learning. Chiou and Liang (2012) investigated the relations between high school students' approaches to learning science and self-efficacy. They reported that approaches to learning significantly predicted self-efficacy. Therefore, according to previous studies, the following hypotheses were proposed (See Figure 1):

> Hypothesis 1 (H11): Primary school students' lower level conceptions of learning science will have a significant and positive effect on the surface approach to learning science.

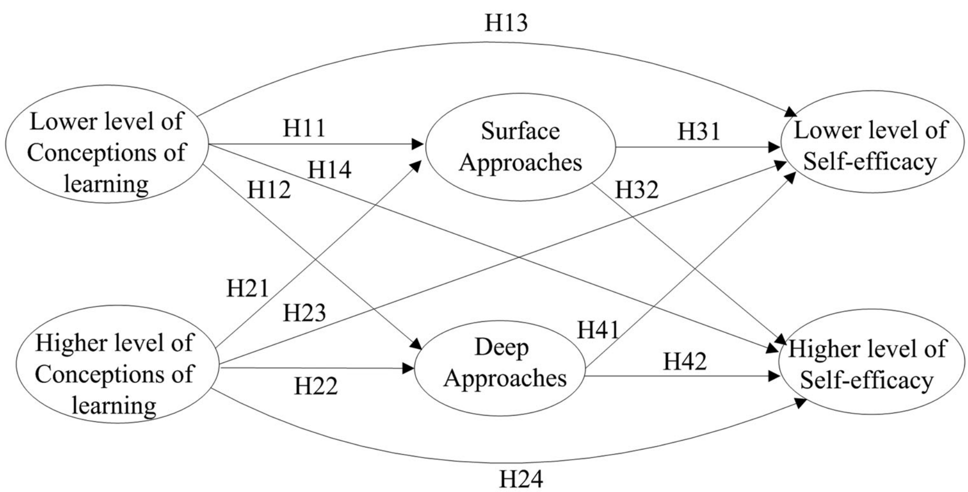

Figure 1. Proposed conceptual model.

Hypothesis 1 (H12): Primary school students' lower level conceptions of learning science will have a significant and negative effect on the deep approach to learning science.

Hypothesis 1 (H13): Primary school students' lower level of conceptions of learning science will have a significant and positive effect on lower level of self-efficacy in learning science.

Hypothesis 1 (H14): Primary school students' lower level conceptions of learning science will have a significant and positive effect on higher level of self-efficacy in learning science.

Hypothesis 2 (H21): Primary school students' higher level conceptions of learning science will have a significant and negative effect on the surface approach to learning science.

Hypothesis 2 (H22): Primary school students' higher level conceptions of learning science will have a significant and positive effect on the deep approach to learning science.

Hypothesis 2 (H23): Primary school students' higher level conceptions of learning science will have a significant and positive effect on lower level of self-efficacy in learning science.

Hypothesis 2 (H24): Primary school students' higher level conceptions of learning science will have a significant and positive effect on higher level of self-efficacy in learning science.

Hypothesis 3 (H31): Primary school students' surface approaches to learning science will have a significant and negative effect on lower level of self-efficacy in learning science.

Hypothesis 3 (H32): Primary school students' surface approaches to learning science will have a significant and negative effect on higher level of self-efficacy in learning science.

Hypothesis 4 (H41): Primary school students' deep approaches to learning science will have a significant and positive effect on lower level of self-efficacy in learning science.

Hypothesis 4 (H42): Primary school students' deep approaches to learning science will have a significant and positive effect on higher level of self-efficacy in learning science.

Method

Participants

A convenience sampling method was used to recruit participants. Participants included 1049 elementary students from Mainland China, who were enrolled in grade 4 or grade 5 elementary school classes; 550 were male and 499 were female. The participants with an average age of 11 were from Beijing, Tianjin, and Guizhou provinces. All participants were recruited from science courses, and volunteered to complete three questionnaires: conceptions of learning science, approaches to learning science, and self-efficacy of learning science. The three questionnaires are described in detail below.

Instruments

Three questionnaires were adopted to measure the conceptions of learning science (CLS), approaches to learning science (ALS), and self-efficacy of learning science (SELS) in the current study. The CLS and ALS questionnaires were adapted from a measure developed by Lee et al. (2008). The CSL scale included six subscales and 31 items (e.g. 'Learning science means memorizing the definitions and formulas in the science textbook'). The six subscales included: a 5-item memorising subscale; a 6-item testing subscale; a 5-item calculating and practicing subscale; a 5-item increasing of knowledge subscale; a 4-item applying subscale; and a 6-item understanding and seeing in a new way subscale.

The 24-item ALS scale included four subscales: an 8-item deep motive subscale; a 6-item deep strategy subscale; a 5-item surface motive subscale; and a 5-item surface strategy subscale (e.g. 'I always look forward to going to science class').

The SELS questionnaire was adapted based on measures used by Lin and Tsai (2013b) and Lin, Tan, and Tsai (2013). The SELS scale included five subscales and 32 items: a 5-item conceptual understanding subscale; a 6-item higher order cognitive skill subscale; a 7-item practical work subscale; an 8-item everyday application subscale; and a 6-item science communication subscale (e.g. 'I am certain I can master the skills in science class').

The three questionnaires were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This survey was administered in Mandarin Chinese. A back-translation procedure was employed to ensure the equality of the English and Chinese versions. Three experts in science education were invited to examine the content of three questionnaires to verify the validity of the questionnaires.

Data analysis

The exploratory factor analysis (EFA) was performed to examine the factor structure of three questionnaires. The confirmatory factor analysis (CFA) was further conducted to examine the construct validity of three questionnaires. In addition, 1049 participants were randomly split into two subsets for the EFA ($n = 519$) and the CFA ($n = 530$), respectively. Moreover, structural equation modeling (SEM) was conducted using Amos 18.0 to examine the relations between conceptions of, approaches to, and self-efficacy in learning science as well as to test the proposed hypotheses.

Results

EFA for CLS, ALS, and SELS

Prior to the EFA, the Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests were adopted to examine whether the data were appropriate for factor analysis. KMO was expected to be larger than 0.5 (Field, 2000). It was found that the KMO value was 0.89 for CLS, 0.86 for ALS, and 0.92 for SELS. Furthermore, chi square was 5018.67 ($p < .01$) for CLS, 3550.292 ($p < .01$) for ALS, and 3306.448 ($p < .01$) for SELS. The findings indicated that the data had a normal multi-variable distribution (Sadi, 2017). Therefore, the data were suitable for factor analysis. Furthermore, the principle components analysis method with an oblique rotation was performed on three questionnaires of CLS, ALS, and SELS. This study adopted a factor loading larger than 0.5 for retaining the items, leading to delete 22 items.

Table 2 shows the EFA results for the CLS questionnaire. In the final version of CLS, 27 items were kept and divided into six factors, namely memorising, testing, calculating and practicing, increasing one's knowledge, applying as well as understanding and seeing in a new way. The total variance explained in the CSL was 58.29%. The Cronbach's alpha values of each scale were 0.84, 0.84, 0.66, 0.77, 0.63, and 0.78, respectively, and the

Table 2. CLS questionnaire factor analysis results.

Dimensions	CLS factors	Cronbach's alpha values	Means (SD)
Lower level	Factor 1 Memorising (CLM)	α = 0.84	Mean (SD) = 3.16 (1.02)
	Item 1	0.800	
	Item 2	0.784	
	Item 3	0.799	
	Item 4	0.822	
	Item 5	0.829	
	Factor 2 Testing (CLT)	α = 0.84	Mean (SD) = 2.42 (1.01)
	Item 1	0.816	
	Item 2	0.813	
	Item 3	0.816	
	Item 4	0.803	
	Item 5	0.800	
	Item 6	0.839	
	Factor 3 Calculating and practicing (CLC)	α = 0.66	Mean (SD) = 3.39 (0.83)
	Item 1	0.610	
	Item 2	0.592	
	Item 3	0.566	
	Item 4	0.608	
Higher level	Factor 4 Increasing one's knowledge (CLI)	α = 0.77	Mean (SD) = 3.79 (0.87)
	Item 1	0.706	
	Item 2	0.726	
	Item 3	0.715	
	Item 4	0.711	
	Factor 5 Applying (CLA)	α = 0.63	Mean (SD) = 3.46 (0.79)
	Item 1	0.512	
	Item 2	0.504	
	Item 3	0.634	
	Item 4	0.567	
	Factor 6 Understanding & Seeing something in a New Way (CLU)	α = 0.78	Mean (SD) = 3.81 (0.89)
	Item 1	0.718	
	Item 2	0.723	
	Item 3	0.717	
	Item 4	0.733	

overall reliability coefficient was 0.85. It was indicated that the scale had a good consistency if the reliability coefficient was higher than 0.60 (Nunnally & Bernstein, 1994). Therefore, the CLS had a good internal consistency.

A total of 19 items were remained in the final version of the ALS, which were grouped into four factors, including deep motive, deep strategy, surface motive, and surface strategy (see Table 3). The total variance explained was 54.88%. The Cronbach's alpha values of each scale were 0.80, 0.78, 0.77, and 0.83, respectively. The overall reliability coefficient of ALS achieved 0.81. Thus, the ALS questionnaire also had a good internal consistency.

In the final version of the SELS, there were remaining 19 items, which were divided into four factors (see Table 4). These four factors were conceptual understanding, practical work, everyday application, and science communication. The total variance explained was 54.83%. The Cronbach's alpha values of each scale were 0.78, 0.73, 0.63, and 0.82, respectively. The overall reliability coefficient of SELS achieved 0.89. Thus, the SELS questionnaire also had a good internal consistency. Furthermore, it was notable that only four factors were remained in spite of the original five factors. The main reason was that six items of higher order cognitive skills had the lower reliability coefficient and factor loading value. Thus, the subscale of higher order cognitive skills was eliminated.

Table 3. ALS questionnaire factor analysis results.

Dimensions	ALS factors	Cronbach's alpha values	Means (SD)
Deep level	Factor 1 Deep motive (DM)	$\alpha = 0.80$	Mean (SD) = 3.58 (0.85)
	Item 1	0.769	
	Item 2	0.763	
	Item 3	0.795	
	Item 4	0.774	
	Item 5	0.780	
	Item 6	0.782	
	Item 7	0.778	
	Factor 2 Deep strategy (DS)	$\alpha = 0.78$	Mean (SD) = 3.44 (0.96)
	Item 1	0.706	
	Item 2	0.721	
	Item 3	0.698	
	Item 4	0.756	
Surface level	Factor 3 Surface motive (SM)	$\alpha = 0.77$	Mean (SD) = 2.68 (1.18)
	Item 1	0.743	
	Item 2	0.638	
	Item 3	0.684	
	Factor 4 Surface strategy (SS)	$\alpha = 0.83$	Mean (SD) = 2.45 (1.08)
	Item 1	0.792	
	Item 2	0.783	
	Item 3	0.792	
	Item 4	0.794	
	Item 5	0.840	

CFA for CLS, ALS, and SELS

CFA was conducted to examine the CLS, ALS, and SELS constructs. Hair, Black, Babin, Anderson, and Tatham (2006) proposed that the relative Chi square (χ^2/df), the root mean square error of approximation (RMSEA), the goodness of fit index (GFI), the comparative fit index (CFI), the parsimony-adjusted normed fit index (PNFI), and the

Table 4. SELS questionnaire factor analysis results.

Dimensions	SELS factors	Cronbach's alpha values	Means(SD)
Lower level	Factor 1 Conceptual understanding (SEC)	$\alpha = 0.78$	Mean (SD) = 3.34 (0.86)
	Item 1	0.726	
	Item 2	0.723	
	Item 3	0.761	
	Item 4	0.735	
	Item 5	0.764	
	Factor 2 Science communication (SES)	$\alpha = 0.82$	Mean (SD) = 3.56 (0.86)
	Item 1	0.809	
	Item 2	0.801	
	Item 3	0.790	
	Item 4	0.790	
	Item 5	0.788	
	Item 6	0.799	
Higher level	Factor 3 Practical work (SEP)	$\alpha = 0.73$	Mean (SD) = 3.53 (0.83)
	Item 1	0.673	
	Item 2	0.660	
	Item 3	0.659	
	Item 4	0.674	
	Item 5	0.722	
	Factor 4 Everyday application (SEA)	$\alpha = 0.63$	Mean (SD) = 3.47 (0.88)
	Item 1	0.566	
	Item 2	0.414	
	Item 3	0.607	

parsimony-adjusted comparative fit index (PCFI) can be adopted to assess the goodness of fit. The measurement model fits the data well if χ^2/df is less than 5; RMSEA is less than .08; GFI is larger than .80; IFI, TLI, and CFI exceed .90; and both PNFI and PCFI exceed .70 (Bentler, 1990; Schumacker & Lomax, 2004). Table 5 demonstrated the results of CFA. The fitness of items for each factor of the CLS, ALS, and SELS revealed a sufficient fit and confirmed three questionnaires' structure.

Convergent and discriminant validity

In order to examine the validity of three scales, the factor loadings, composite reliability (CR), and average variance extracted (AVE) were calculated. Table 6 shows the values of factor loadings, CR, and AVE for three scales. All of the factor loading values were higher than 0.5. The CR values of all factors satisfied the threshold value of 0.60 (Bagozzi & Yi, 1988). The AVE values for some constructs were greater than 0.5, but for some constructs were less than 0.5. However, for discriminant validity, Fornel and Larcker (1981) indicated that the square root of the AVE of each construct should be greater than the correlation between the construct and other constructs and should be at least 0.50. From Tables 7, 8, and 9, it was found that all square roots of the AVE of all constructs are significantly greater than the inter-construct correlations and also were greater than 0.5. Therefore, the convergent and discriminant validities of three scales were acceptable.

Structural equation model

A structural equation model technique was used herein to examine the structural relations between the two dimensions of the CLS, the two dimensions of the ALS, and the two dimensions of the SELS. Table 10 shows the fit indices of the structural model. The results indicated that all of the fit indices exceeded the acceptable values. Therefore, the structural model fits the data well. Figure 2 shows the results of the structural model.

Table 5. The results of confirmatory factor analysis ($n = 530$).

Indices	Absolute fit index			Relative fit index			Parsimonious fit index	
	χ^2/df	RMSEA	GFI	IFI	TLI	CFI	PNFI	PCFI
CLS	1.92	0.04	0.92	0.92	0.91	0.92	0.76	0.83
ALS	2.12	0.05	0.93	0.94	0.93	0.93	0.96	0.80
SELS	1.57	0.03	0.94	0.96	0.96	0.96	0.80	0.85
Acceptance value	1–5	<.08	>.80	>.90	>.90	>.90	>.70	>.70

Table 6. The fit index of the structural model.

Indices	Absolute fit index			Relative fit index			Parsimonious fit index	
	χ^2/df	RMSEA	GFI	IFI	TLI	CFI	PNFI	PCFI
Assumed model	2.13	.03	.90	.91	.91	.91	.79	.86
Acceptance value	1–5	<.08	>.80	>.90	>.90	>.90	>.70	>.70

Table 7. The factor loadings, CR, and AVE of three scales.

Instrument	Factors	Factor loading	CR	AVE
CLS	CLM	0.60–0.74	0.81	0.46
	CLT	0.51–0.78	0.79	0.38
	CLC	0.51–0.63	0.66	0.33
	CLI	0.56–0.67	0.73	0.41
	CLA	0.50–0.64	0.60	0.31
	CLU	0.63–0.69	0.76	0.44
ALS	DM	0.52–0.69	0.78	0.34
	DS	0.62–0.70	0.76	0.52
	SM	0.62–0.78	0.76	0.51
	SS	0.72–0.80	0.83	0.57
SELS	SEC	0.56–0.61	0.73	0.35
	SES	0.60–0.70	0.81	0.41
	SEP	0.51–0.63	0.70	0.32
	SEA	0.52–0.68	0.63	0.36

Table 8. Correlations among constructs of CLS (square root of AVE in diagonal).

	CLM	CLT	CLC	CLI	CLA	CLU
CLM	**0.676**					
CLT	0.323	**0.622**				
CLC	0.391	0.163	**0.569**			
CLI	0.260	0.154	0.393	**0.639**		
CLA	0.291	0.018	0.377	0.522	**0.550**	
CLU	0.262	0.158	0.366	0.589	0.523	**0.660**

Note. Diagonal numbers (in bold) indicate the square root of the AVE.

Table 9. Correlations among constructs of ALS (square root of AVE in diagonal).

	DM	DS	SM	SS
DM	**0.579**			
DS	0.519	**0.721**		
SM	0.026	0.015	**0.716**	
SS	−0.202	−0.082	0.325	0**.756**

Note. Diagonal numbers (in bold) indicate the square root of the AVE.

Table 10. Correlations among constructs of SELS (square root of AVE in diagonal).

	SEC	SES	SEP	SEA
SEC	**0.592**			
SES	0.562	**0.643**		
SEP	0.536	0.521	**0.564**	
SEA	0.502	0.524	0.502	**0.603**

Note. Diagonal numbers (in bold) indicate the square root of the AVE.

Table 11 demonstrates the results of the path analysis. It was found that lower level conceptions of learning science had a significant effect on surface approaches to learning science ($\beta = .76$, $p < .001$). Therefore, H11 was supported. However, lower level conceptions of learning did not have a significant influence on deep approaches to learning ($\beta = .15$, $p > .05$), the lower level of self-efficacy ($\beta = -.15$, $p > .05$), and the higher level

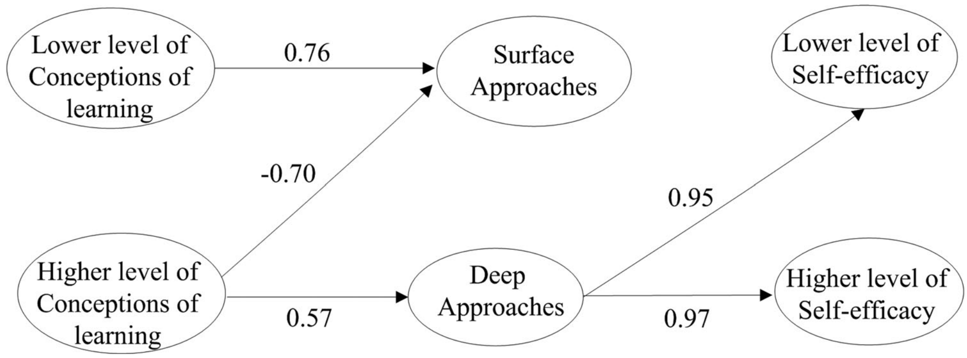

Figure 2. Structural equation model.

Table 11. The results of the path analysis.

Hypothesis	Paths	Path coefficient	Results
H11	The lower level of conceptions of learning→Surface approach to learning	.76	Support
H12	The lower level of conceptions of learning→Deep approach to learning	.15	Against
H13	The lower level of conceptions of learning→The lower level of self-efficacy	−.15	Against
H14	The lower level of conceptions of learning→The higher level of self-efficacy	−.23	Against
H21	The higher level of conceptions of learning→Surface approach to learning	−.70	Support
H22	The higher level of conceptions of learning→Deep approach to learning	.57	Support
H23	The higher level of conceptions of learning→The lower level of self-efficacy	−.24	Against
H24	The higher level of conceptions of learning→The higher level of self-efficacy	−.13	Against
H31	Surface approach to learning→The lower level of self-efficacy	.03	Against
H32	Surface approach to learning→The higher level of self-efficacy	.14	Against
H41	Deep approach to learning→The lower level of self-efficacy	.95	Support
H42	Deep approach to learning→The higher level of self-efficacy	.97	Support

of self-efficacy ($\beta = -.23$, $p > .05$). Thus, H12, H13, and H14 were not supported. Furthermore, higher level conceptions of learning science had a positive effect on deep approaches ($\beta = .57$, $p < .001$) and a negative effect on surface approaches to learning ($\beta = -.70$, $p < .001$). Hence, both H21 and H22 were supported. However, higher level conceptions of learning did not have a significant and direct influence on the lower level of self-efficacy ($\beta = -.24$, $p > .05$) and the higher level of self-efficacy ($\beta = -.13$, $p > .05$). Hence, both H23 and H24 were not supported. In addition, the surface approaches to learning did not have a significant influence on the lower level of self-efficacy ($\beta = .03$, $p > .05$) and the higher level of self-efficacy ($\beta = .14$, $p > .05$). Therefore, H31 and H32 were not supported. However, the deep approaches to learning had a significant effect on the lower level of self-efficacy ($\beta = .95$, $p < .001$) and the higher level of self-efficacy ($\beta = .97$, $p < .001$). Therefore, H41 and H42 were supported.

Discussion

The present study examined the relations between primary school students' conceptions of learning science, approaches to learning science, and self-efficacy. The EFA and CFA methods were adopted to examine the reliability and validity, and path analysis was conducted to test the structural model. The results indicated that the questionnaires about conceptions of learning science, approaches to learning science, and self-efficacy in learning science achieved a good reliability and validity. The fit indices also revealed that the structural model fits with the empirical data well. The findings indicated that primary students' conceptions of learning had a significant influence on approaches to learning, which further exerted an effect on self-efficacy in learning science.

The role of conceptions of learning

The present study revealed that primary students' conceptions of learning played a crucial role in learning science. It was found that lower level conceptions of learning science had a significant and positive effect on the surface approach to learning science. Higher level conceptions of learning had a positive effect on the deep approaches to learning science. Thus, learners with lower level conceptions of learning tended to use surface learning approaches and students with higher level conceptions of learning were inclined to adopt deep learning approaches. Better put, learners were more likely to learn science by reciting if they consider learning science as memorising what is taught in class; preparing for a test; or calculating and practicing. However, when students view learning science as increasing knowledge; applying knowledge; or understanding and seeing knowledge in a new way, they employ deep motives and meaningful learning strategies to learn science. This result was consistent with previous studies reported by Chiou, Lee, and Tsai (2013) and Li et al. (2013), who also found that conceptions of learning science were positively related to approaches to learning science. Moreover, higher level conceptions of learning science had a negative impact on surface approaches to learning science. In other words, students with higher level conceptions of learning were not likely to adopt the surface motives and strategies for learning science. Moreover, lower level conceptions of learning science did not have a significant effect on deep approaches to learning science. The possible explanation for this finding may associate with the examination-centered school culture in mainland China. Passing an examination and getting higher scores were a central theme of education in Mainland China, which was instilled in every student since primary school.

In addition, both lower and higher level conceptions of learning science did not have significant and direct effects on the lower and higher level of self-efficacy in learning science. This finding was consistent with Chiou and Liang (2012), who reported that conceptions of learning science were indirectly related to self-efficacy in learning science.

The role of approaches to learning

When the role of approaches to learning was examined, it was found that students' approaches to learning further influenced their self-efficacy. Specifically, only the deep approach to learning science had significant and positive effects on both the lower and higher level of self-efficacy in learning science. However, the surface approach to learning did not have significant effects on the lower and higher level of self-efficacy in learning science. This finding indicated that students with deep learning approaches had a sense of self-efficacy in learning science. This means that when students learned science for pursuing their inner interests, they had a higher sense of self-efficacy in learning science. Similarly, if students wanted to apply what they had learned to solve real-life problems, they tended to have a strong sense of self-efficacy in learning science. However, if students only memorised what they had learned, they did not obtain self-efficacy in learning science. In previous studies, students' deep approaches to learning were positively associated with their self-efficacy (Lin & Tsai, 2013b; Prat-Sala & Redford, 2010). A similar conclusion was also drawn from the findings in the present study.

Implications

This study had several implications for teachers and practitioners. First, conceptions of learning science had a significant, direct influence on approaches to learning and an indirect influence on self-efficacy; therefore, it was important to help students develop higher level conceptions of learning. Sophisticated conceptions of learning can encourage students to adopt deep motives and deep learning strategies. Teachers and practitioners can adopt inquiry-based learning, problem-based learning, and outdoor investigation to help students realise the purpose of learning science. The purpose of learning science was not to remember what teachers taught in class or prepare for a test; rather, it was to increase knowledge, apply knowledge, and understand knowledge in a new way. We posited that applying what students learn in class to solve real-life problems was the best way to help students obtain a better understanding of conceptions of learning science. Second, teachers and practitioners should encourage students to adopt deep motives and learning strategies for learning science; for example, when teachers guide students in obtaining a thorough understanding of what they learn in class. Students need to link prior knowledge to new information to promote meaningful learning. In addition, it was also important to motivate students to learn science via their own curiosity and interests. Third, students' self-efficacy was closely associated with their science learning performance (Capa Aydin & Uzuntiryaki, 2009); thus, it is necessary to adopt some strategies to promote self-efficacy in science, such as developing higher level of conceptions of learning, solving real-life problems, and adopting deep learning strategies.

Conclusion

In the current study, three instruments were validated to measure primary school students': conceptions of learning science, approaches to learning science, and self-efficacy in learning science. The results indicated that these three instruments had satisfactory validity and reliability. Moreover, the relations between the conceptions of, approaches to, and self-efficacy in learning science were investigated herein. The findings revealed that lower level conceptions of learning science had a positive and significant influence on surface approaches to learning science. Higher level conceptions of learning science had a positive influence on deep approaches to learning science, and had a negative influence on the surface approaches to learning science. Furthermore, the deep approach had significant and positive effects on both the lower and higher level of self-efficacy in learning science.

The present study found that primary students' conceptions of learning science and approaches to learning science were the two major components for their self-efficacy in learning science. These two components represented how students viewed the nature of and approaches to learning science. The main contribution of this study was obtaining a deeper understanding of primary school students' perceptions of learning science, which provides insights into improving pedagogical practices. In addition, the construct of self-efficacy was divided into the lower and higher level of self-efficacy in learning science.

This study was constrained by several limitations. First, all the participants in the present study were in mainland China. Since conceptions of and approaches to learning are influenced by culture, it would be interesting to examine and compare how different cultures influence students' conceptions of learning as well as approaches to learning. Second, the present study only examined primary school students' conceptions of, approaches to, and self-efficacy in learning science. It is suggested that future studies compare and investigate these three constructs in other contexts. The final limitation, likewise, deserves further investigation as students' conceptions of, approaches to, and self-efficacy in learning science were all related to their learning performance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendices

Appendix A: The Questionnaire Items on the COLS (Final Version)

Memorizing

(1) Learning science means memorizing the definitions, formulae, and laws found in a science textbook.
(2) Learning science means memorizing the important concepts found in a science textbook.
(3) Learning science means memorizing the proper nouns found in a science textbook that can help solve the teacher's questions.
(4) Learning science means remembering what the teacher lectures about in science class.
(5) Learning science means memorizing scientific symbols, scientific concepts, and facts.

Testing

(1) Learning science means getting high scores on examinations.
(2) If there are no tests, I will not learn science.
(3) There are no benefits to learning science other than getting high scores on examinations. In fact, I can get along well without knowing many scientific facts.
(4) The major purpose of learning science is to get more familiar with test materials.

(5) I learn science so that I can do well on science-related tests.
(6) There is a close relationship between learning science and taking tests.

Calculating and practicing

(1) Learning science involves a series of calculations and problem-solving.
(2) I think that learning calculation or problem-solving will help me improve my performance in science courses.
(3) Learning science means knowing how to use the correct formulae when solving problems.
(4) The way to learn science well is to practice constantly calculations and problem solving.

Increasing one's knowledge

(1) Learning science means acquiring knowledge that I did not know before.
(2) I am learning science when the teacher tells me scientific facts that I did not know before.
(3) Learning science means acquiring more knowledge about natural phenomena and topics related to nature.
(4) Learning science helps me acquire more facts about nature.

Applying

(1) The purpose of learning science is learning how to apply methods I already know to unknown problems.
(2) Learning science means learning how to apply knowledge and skills I already know to unknown problems.
(3) We learn science to improve the quality of our lives.
(4) Learning science means solving or explaining unknown questions and phenomena.

Understanding & seeing science in a new way

(1) Learning science helps me view natural phenomena and topics related to nature in new ways.
(2) Learning science means changing my way of viewing natural phenomena and topics related to nature.
(3) Learning science means finding a better way to view natural phenomena or topics related to nature.
(4) I can learn more ways about thinking about natural phenomena or topics related to nature by learning science.

Appendix B: The Questionnaire Items on the ALS (Final version)

Deep approach

Deep motive.

(1) I find that at times studying science makes me feel really happy and satisfied.
(2) I feel that science topics can be highly interesting once I get into them.
(3) I work hard at studying science because I find the material interesting.
(4) I always greatly look forward to going to science class.
(5) I come to science class with questions in my mind that I want to be answered.
(6) I find that I continually go over my science class work in my mind even whenever I am not in science class.

(7) I like to work on science topics by myself so that I can form my own conclusions and feel satisfied.

Deep strategy.

(1) I try to relate what I have learned in science subjects to what I learn in other subjects.
(2) I like constructing theories to fit odd things together when I am learning science topics.
(3) I try to find the relationship between the contents of what I have learned in science subjects.
(4) I try to relate new material to what I already know about the topic when I'm studying science.

Surface approach

Surface motive.

(1) I am discouraged by a poor mark on science tests and worry about how I will do on the next text.
(2) Even when I have studied hard for a science text, I worry that I may not be able to do well on it.
(3) I worry that my performance in science class may not satisfy my teacher's expectations.

Surface strategy.

(1) I see no point in learning science materials that are not likely to be on the examinations.
(2) As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying science subjects. There are many more interesting things to do with my time.
(3) I generally will restrict my study to what is specially set as I think it is unnecessary to do anything extra in learning science topic.
(4) I find that studying each topic in depth is not helpful or necessary when I am learning science. There are too many examinations to pass and too many subjects to be learned.
(5) I find the best way to pass science examinations is to try to remember the answers to likely question.

Appendix C: The Science Learning Self-Efficacy (SLSE) Questionnaire (Final version)

Conceptual understanding

(1) I can explain scientific laws and theories to others.
(2) I can choose an appropriate formula to solve a science problem.
(3) I can link the contents among different science subjects (for example, biology, chemistry and physics) and establish the relationships between them.
(4) I know the definitions of basic scientific concepts (for example, gravity, photosynthesis, etc.) very well.
(5) I feel confident when I interpret graphs/charts related to science.

Science communication

(1) I am able to comment on presentations made by my classmates in science class.
(2) I am able to use what I have learned in science classes to discuss with others.
(3) I am able to explain clearly what I have learned to others.
(4) I feel comfortable discussing science content with my classmates.
(5) In science classes, I can clearly express my own opinions.
(6) In science classes, I can express my ideas properly.

Practical work

(1) I know how to carry out experimental procedures in the biology laboratory.
(2) I know how to use equipment (for example measuring cylinders, measuring scales, etc.) in the biology laboratory.
(3) I am able to recognize the data in the biology experiments.
(4) I know how to set up equipment for laboratory experiments.
(5) I am able to understand the relationships among variables according to research data.

Everyday application

(1) I am able to explain everyday life using scientific theories.
(2) I am able to propose solutions to everyday problems using science.
(3) I can understand the news/documentaries I watch on television related to science.