Modelling the Relationships among Beliefs about Learning, Knowledge, and Teaching of Pre-Service Teachers in Singapore

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This paper aims to investigate the beliefs about knowledge, learning and teaching of 718 Singaporean pre-service teachers. The results show that three out of eight hypotheses were supported by the data. These hypotheses are 1) Innate ability will significantly influence traditionalist teaching positively, 2) Learning effort/process will significantly influence constructivist teaching positively, and 3) Learning effort/process will significantly influence traditionalist teaching negatively. The results also indicate that the participants may not hold relativistic outlooks and that they may be inclined towards constructivist teaching rather than traditional teaching. In addition, the participants may not be epistemologically ready for constructivist teaching. This paper contributes to the research on teachers' beliefs by applying structural equation modelling to examine the strengths and inter-relationships between different types of beliefs.

Keywords: beliefs; pre-service, structural equation modelling

Teachers' beliefs have been considered by many educational researchers as a key area that needs to be addressed in the context of educational reforms (Woolfolk Hoy, Davis, & Pape, 2006). Earlier studies have documented that teachers' beliefs could act as filters that bias teachers' practice and their own learning (Richardson, 1996). As such, reforms that ignore investigation of teachers' beliefs and subsequent effort in transforming the beliefs are at risk of failing (Ertmer, 2005; Windschitl, 2002).

Teachers hold myriad beliefs such as those about students' acquisition of knowledge, and beliefs about the disciplines. These beliefs could impact the ways teachers conceptualize teaching and learning in the classrooms. In this study, we investigate Singaporean pre-service teachers' beliefs about learning, epistemological beliefs, and their beliefs about pedagogies. This study is timely as recent studies in Singapore and elsewhere have reported that current efforts to reform teaching practices towards constructivist-oriented education have not been very successful (Ertmer, 2005; Lim & Chai, 2008). This paper contributes to the research on teachers' beliefs by applying structural equation modelling to elicit the strengths and inter-relationships between different types of beliefs. This would allow researchers to achieve

holistic understanding of the various roles of the beliefs investigated (Cano & Cardelle-Elawar, 2008; Ertmer, 2005; Woolfolk-Hoy et al., 2006), thereby providing clearer directions for educators in facilitating the necessary changes among pre-service teachers. To date, studies that address the inter-relationships between these beliefs are infrequent among teachers (Chan & Elliott, 2004; Moschner, Anschuetz, Wernke, & Wagener, 2008). Chan (2007) has advocated that more studies of this nature employing structural modeling would deepen educators' understanding about the relations among the beliefs. Chai, Khine and Teo (2006) have also pointed out the need to explore the relations among the beliefs for Singaporean teachers. In this paper, we propose and test a conceptual model on how beliefs about learning and beliefs about knowledge are related to beliefs about teaching (Figure 1). The purpose of this study is to explore and explain the relationships among beliefs about learning, beliefs about knowledge, and beliefs about teaching.

THEORETICAL FOUNDATIONS

In the following paragraphs, we will review the notions related to the three types of beliefs and empirical studies pertaining to these beliefs. We first review beliefs about knowledge as it is arguably the core belief and because it influences how teachers learn and how they teach. This is followed by discussions on beliefs about learning and beliefs about teaching. The interrelationships between beliefs are discussed after each major section to support the formulation of the hypotheses.

Beliefs about Knowledge

Perry (1970) described the epistemological developmental stages among Harvard male graduates as (a) dualism, (b) multiplism, (c) relativism and, (d) commitment with relativism. The underlying dimensions that distinguish the individual's epistemological positions are revealed by their beliefs about the nature of knowledge and the origin of knowledge. An individual with dualistic outlook sees knowledge as either right-or-wrong and that knowledge comes from authority. This outlook would most likely shift toward multiplism during college education as individuals realize that there may be multiple views on subjects. However, a multiplist is still inclined to see most knowledge as certain. When an individual starts to see most knowledge as uncertain and recognizes the self as the primary agent of knowledge, he or she is in the relativistic stage. Finally, individuals may be committed to the stance that knowledge is complex and tentative human construction based on the warrants provided by accumulated evidence. Later researchers such as King and Kitchener (1994) and Belenky, Clinchy, Goldberger, and Tarule (1986) widened Perry's study by interviewing broader samples and they found similar compatible developmental pattern as Perry's work (see Hofer & Pintrich, 1997). More recently, researchers seem to characterize only three developmental stages: objectivist/ realist, relativist/subjectivist, and contextualist/ evaluativist (Gottlieb, 2007; Hearle & Bendixen, 2008; Hofer & Pintrich, 1997).

The above studies suggest that individuals who are inclined to see authority as the source of knowledge are also likely to see knowledge as certain. This developmental pattern also suggests that individuals with a relativistic outlook are more sophisticated than individuals who view knowledge as stable and can be obtained from authoritative sources. The latter are sometimes referred to as holding naïve beliefs about epistemology (Schommer, 1990). However, the distinction between sophisticated and naïve beliefs is now being challenged (Wong, Khine, & Chai, 2008). Published studies on pre-service teachers' epistemological beliefs generally report pre-service teachers as holding a range of epistemological beliefs, with a higher tendency towards a relativistic epistemological outlook (Brownlee, 2004; Chai, Khine, & Teo, 2006; Chan & Elliott, 2004).

Beliefs about Learning

Since 1990, studies on personal epistemology have been linked to studies of beliefs about learning as a result of Schommer's (1990) work. Schommer proposed that personal epistemology is multi-dimensional and extracted four factors from her questionnaire: innate ability, quick learning, simple knowledge, and certain knowledge. Schommer (1990) included these beliefs about learning when she created the Epistemological Questionnaire (EQ). On the other hand, Schommer-Aikins (2004) argued that beliefs that were related to implicit theories of intelligence, control of learning, and speed of learning should not be conceptualized separately from beliefs about knowledge and knowing. According to her, these beliefs are intimately related to each other, and beliefs about knowledge and knowing have been found to be related to several aspects of learning. Since its creation, the EQ and other related instruments such as the Epistemological Beliefs Inventory (Schraw, Bendixen, & Dunkle, 2002) have been employed in studies that investigated how the constructs in the EQ are related to a number of variables such as reading comprehension, problem solving, and learning outcomes (Bendixen & Hartley, 2003; Cano, 2005; DeBacker & Crowson, 2006, Schommer, 1990; Schommer-Aikins & Easter, 2006). For example, Schommer (1990) reported that beliefs in quick learning predicted poor performance in mastery tests and that belief in certainty of knowledge predicted inappropriately absolute conclusions.

In this study, we investigated the constructs of beliefs about innate/ fixed ability and beliefs about learning effort/process, which were derived from Schommer's (1990) conceptualization of beliefs about learning. Based on the differences in cultural context and the studies that they have conducted, Chan and Elliott (2004) argued that Schommer's EQ has to be adapted and redefined the construct of quick learning as a learning effort/process. The dimension of quick learning, which is defined as "learning is quick or not at all" (Schommer, 1990, p. 499), is substituted by the learning effort/ process, "which refers to the hard work and effort spent in drilling at one extreme or understanding at the other" (Chan & Elliott, 2004, p. 821). They reported that the belief about innate/fixed ability is negatively related to the belief in learning effort/ process.

Beliefs about Teaching

Studies on teachers' beliefs about teaching generally classify teachers' views as either seeing teaching as knowledge transmission or teaching as facilitating students' knowledge construction (Lim & Chai, 2008; Samuelowicz & Bain, 2001). The knowledge transmission view is also referred to as the traditional paradigm (Chan & Elliott, 2004). Teachers holding these beliefs are inclined to organise lessons in a teacher-centred and content-oriented manner adopting the didactic teaching practice, while the students' role is confined to being passive recipients. On the other hand, the constructivist view of teaching emphasizes that students should actively make sense of their experiences while teachers create meaningful learning experiences and support students' sense making. These are usually labelled as student-centred and constructivist-oriented teaching. Whether or not the traditional approach or the constructivist approach should be viewed as two opposing ends, or two sets of beliefs that could co-exist in a teacher's teaching repertoire, has been investigated by Driel, Bulte, and Verloop (2005). The results indicated that majority of the teachers who participated in their study seemed to combine elements of both notions of teaching.

The Relationships between the Three Types of Beliefs

The relationships between epistemological beliefs and beliefs about learning have received some attention from researchers. Generally, empirical studies point toward the direction that pre-service teachers who are inclined towards the view that knowledge is simple and stable are also

less likely to believe in learning effort and process (Ravindran, Greene & Debacker, 2005). In the Asian context, Chan and Elliott's (2004) study has also documented that authority/expert and certainty of knowledge is positively related to beliefs in innate ability. This seems to suggest that inclination to believe in innate ability is likely to be negatively associated with constructivist teaching since a relativistic outlook is more likely to be associated with constructivist teaching (see below). As innate ability is negatively associated with beliefs in the learning effort/process (Chan & Elliott, 2004), it would in turn imply that an inclination towards the learning effort/process is positively related to constructivist teaching.

Other ways of conceptualizing beliefs about learning include deep/ shallow approaches and qualitative or quantitative views of learning (Biggs, 1994; Dart et al., 2000). Dart et al. (2000) suggest that a deep approach to learning, which is akin to beliefs toward learning effort/ process, is characterized by an intention to seek meaning from the materials. They also believe that this approach to learning is related to constructivist teaching whereas the surface approach emphasizes the transmission model of teaching. However, Chan and Elliott (2004) reported that while belief in innate/fixed ability is positively related to transmission mode of teaching, belief in the learning effort/process is negatively related to a constructivist notion of teaching. Chan and Elliott suggested that one possible explanation for this surprising result may be that the Hong Kong pre-service teachers perceive the learning effort/process as working hard in terms of repetitive drills for knowledge acquisition. Based on the broader literature we have reviewed, we adopt the stance that the learning effort/process should be positively associated with constructivist teaching.

Teachers' relativistic epistemological beliefs have been reportedly associated with constructivist ways of teaching in some studies (e.g. Brownlee, 2004; Chai, & Khine, 2008). Among practicing teachers, Kang and Wallace (2005) reported that

teachers who view Science as a body of factual information are likely to transmit knowledge. Schraw and Olafson (2002) also reported that out of the 24 teachers interviewed on epistemological worldviews, 23 of them can be typified as contextualists or relativists. They further suggested that realists are likely to transmit knowledge, while contextualists and relativists are more likely to engage in constructivist oriented teaching. Sinatra and Kardash's (2004) study also indicates that American pre-service teachers who view knowledge as evolving are reportedly more inclined to see teaching as supporting knowledge construction. However, Chan and Elliott (2004) reported that although Hong Kong teachers hold generally relativistic epistemological outlooks, they do not express an inclination towards constructivist teaching. Some educators suggest that pre-service teachers may be relativistic in outlook but they may also view teaching as an uncomplicated process of knowledge transmission (Richardson, 2003). On the other hand, Entwistle and his colleagues (2000) reported that beginning teachers are unlikely to adopt a behaviourist notion of teaching, which is more akin to the traditional view, but neither are they overly idealistic about child-centred education. These conflicting findings suggest that the relationship between teachers' epistemological outlooks and their beliefs about teaching warrants further research. In summary, it seems theoretically sound to hypothesize that belief towards authority as sources of knowledge and certainty of knowledge should be associated with traditional teaching while relativistic epistemological outlooks are more likely to be related to constructivist teaching.

Aim of the present study

The aim of this study is to explore and explain the relationships among beliefs about learning, beliefs about knowledge, and beliefs about teaching. Using structural equation modelling, the proposed model will be tested against the data for model fit.
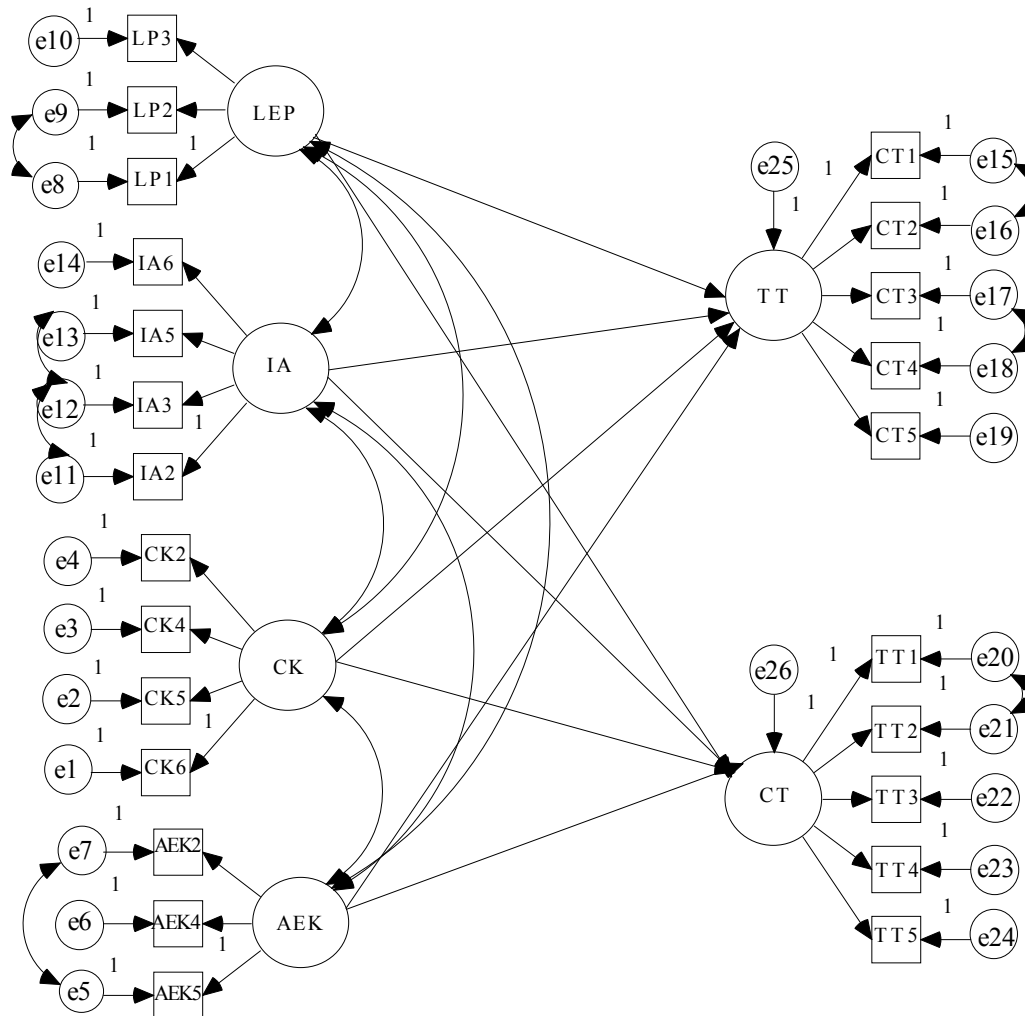
Figure 1. *Proposed research model*

Hypotheses

From the above literature review, the following hypotheses were formulated:

H1: Innate ability will significantly influence constructivist teaching negatively.

H2: Innate ability will significantly influence traditionalist teaching positively.

H3: Learning effort/process will significantly influence constructivist teaching positively.

H4: Learning effort/process will significantly influence traditionalist teaching negatively.

H5: Authority/expert knowledge will significantly influence constructivist teaching negatively.

H6: Authority/expert knowledge will significantly influence traditionalist teaching positively

H7: Certainty of knowledge will significantly influence constructivist teaching negatively.

H8: Certainty of knowledge will significantly influence traditionalist teaching positively

Figure 1 illustrates the hypothesized relationships among the variables. In this figure, beliefs about learning (LEP) and beliefs about knowledge (CK and AEK) correlate with each other to influence beliefs about teaching (CT and TT).

METHOD

Participants

Participants were pre-service teachers (trainee teachers) enrolled at the National Institute of Education (Singapore). A total of 718 pre-service teachers participated in this study and this sample formed 46% of the population of pre-service teachers (N= 1532) at the institute. Participants were enrolled in the Diploma in Education and Postgraduate Diploma in Education program. There were 409 (57%) females and the overall mean age was 25.4 years (SD= 3.8 years). Majority of the participants were from the Chinese ethnic group, consistent with the national demographics in Singapore.

Procedures and Measures

This study used the survey method. Data were collected using an online form specially created for this study and the website address was made available to all participants who volunteered. As this study is a national survey of all pre-service teachers, no particular sampling techniques were employed. Currently, all pre-service teachers in Singapore are trained at the National Institute of Education.

The instrument comprised four parts. Participants indicated their demographic information in part one and responded to the other three parts that comprised various Likert-type scales from instruments that were adapted from the literature. All items were measured on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree).

Beliefs about Learning (BL)

The BL was measured by two scales: Learning Effort/Process (LEP), and Innate Ability (IA). LEP was adopted from Chan and Elliott (2004) who adapted items from similarly-worded constructs from Schommer's (1990) *Epistemological*

Beliefs Questionnaire. The reliability alphas for LEP and IA as reported by Chan and Elliott (2004) were .66 and .69 respectively. Using a sample similar to this study, Chai et al. (2006) used these scales in a study with pre-service teachers in Singapore and obtained alphas of .73 (LEP) and .70 (IA).

Beliefs about Knowledge (BK)

The BK was measured by Certainty of Knowledge (CK) and Authority of Expert Knowledge (AEK). These were adopted from Chan and Elliott (2004) who obtained reliability alphas of .60 and .58 for CK and AEK respectively. In a more recent study, Chai et al. (2006) found the increase in the reliability alpha to be .61 (CK) and .67 (AEK) when the scale was used with pre-service teachers in Singapore.

Beliefs about Teaching (BT)

The PB was measured by the Traditional Teaching (TT) and Constructivist Teaching (CT) scales developed by Chan and Elliott (2004) and tested on pre-service teachers in Hong Kong. For both scales, high reliabilities (.84) were reported. The TT and CT scales were pilot tested on a Singapore sample (N=957) between six to nine months before this present study and the Cronbach alphas for TT and CT were .76 and .88 respectively. In a separate study, the TT and CT scale were administered to 877 pre-service teachers and were found to possess appropriate internal consistency as well (TT: .84; CT: .88) (Teo & Chai, 2008).

RESULTS

The mean, standard deviation, and Cronbach's alpha coefficient for each scale are shown in Table 2. The standard deviations suggest a narrow spread of the item scores around the mean. All scales are above the mid-point of 3.0 except for Innate Ability and Traditionalist Teaching.

Table 1
Summary of the scales used in the study

Construct	Factors	No. of Items	Studies in which this construct appeared	Sample Item
Belief about Learning	IA	4	Chan & Elliott, 2004; Chai et al., 2006.	"There isn't much you can do to make yourself smarter as your ability is fixed at birth."
	LEP	3	Chan & Elliott, 2004; Chai et al., 2006.	"If one tries hard enough, then one will understand the course material."
Belief about Knowledge	CK	4	Chan & Elliott, 2004; Chai et al., 2006.	"I feel uncomfortable in dealing with ambiguous situations"
	AEK	3	Chan & Elliott, 2004; Chai et al., 2006.	I have no doubts in whatever the experts say."
Beliefs about Teaching	CT	5	Chan & Elliott, 2004.	"Students should be given many opportunities to express their ideas."
	TT	5	Chan & Elliott, 2004.	"Teaching is simply telling, presenting or explaining the subject matter."
	Total	24		

Index of Reliability

Cronbach's alpha is one of the most widely used measures for evaluating reliability and these are shown in Table 1. The reliability coefficients for the scales range from 0.50 to 0.77. Nevertheless, Cronbach's alpha has several disadvantages, including the fact that it becomes inflated when a scale has a large number of items, and it assumes that all of the measured items have equal reliabilities (Anderson & Gerbing, 1988). In addition, Cronbach's alpha cannot be used to infer unidimensionality (Anderson & Gerbing, 1988). For this reason, the convergent and discriminate validities are examined.

Convergent validity

The convergent validity of a set of measurement items in relation to their corresponding constructs was assessed by examining the item reliability of each measure and the average variance extracted

Table 2
Means, standard deviations and Cronbach's alphas for the measures used in the study

Scale	Mean	SD	No. of items	α
Learning Effort and Process	4.18	.51	3	.50
Innate Ability	2.33	.69	4	.77
Certainty of Knowledge	3.12	.72	4	.76
Authority/Expert Knowledge	3.46	.61	3	.67
Constructivist Teaching	4.31	.45	5	.75
Traditionalist Teaching	2.13	.55	5	.68

Table 3
Principal axis factor analysis

	LEP	IA	CK	AEK	CT	TT
LEP1	**.621**	-.088	-.059	-.053	.306	.107
LEP2	**.799**	-.119	-.016	-.153	.211	-.009
LEP3	**.451**	-.036	-.119	-.108	.256	-.006
IA1	-.057	**.591**	-.236	-.172	-.026	-.310
IA2	-.063	**.556**	-.257	-.164	-.025	-.241
IA3	-.113	**.840**	-.219	-.241	-.255	-.420
IA4	-.109	**.812**	-.224	-.218	-.243	-.389
CK1	-.035	-.266	**.560**	.303	.145	.317
CK2	-.077	-.268	**.657**	.349	.064	.361
CK3	-.100	-.209	**.709**	.346	.031	.227
CK4	-.028	-.234	**.674**	.405	.112	.292
AEK1	-.131	-.215	.284	**.522**	.089	.401
AEK2	-.101	-.194	.360	**.778**	.048	.304
AEK3	-.132	-.231	.452	**.643**	.019	.313
CT1	.258	-.126	.018	.080	**.646**	.227
CT2	.326	-.137	-.007	.002	**.674**	.153
CT3	.294	-.164	.090	.063	**.765**	.287
CT4	.217	-.059	.143	.075	**.663**	.200
CT5	.286	-.232	.161	.052	**.621**	.336
TT1	-.046	.333	-.272	-.275	-.214	**-.653**
TT2	-.020	.335	-.207	-.288	-.194	**-.622**
TT3	-.008	.247	-.293	-.278	-.174	**-.610**
TT4	.013	.296	-.274	-.325	-.166	**-.643**
TT5	-.085	.358	-.257	-.291	-.329	**-.746**
Eigenvalue	1.719	3.044	2.753	2.432	2.910	3.679
% Variance	3.249	5.485	4.179	2.364	10.327	20.405

extraction method: principal axis factoring; rotation method: oblimin with kaiser normalization.

Table 4

Measures of internal consistency and average variance extracted

Factor	Alpha	AVE
Learning Effort and Process (LEP)	.64	.56
Innate Ability (IA)	.79	.57
Certainty of Knowledge (CK)	.72	.57
Authority Expert Knowledge (AEK)	.68	.53
Constructivist Conception of Teaching (CT)	.78	.57
Traditional Conception of Teaching (TT)	.76	.52

AVE: Average Variance Extracted. This is computed by squaring the sum of factor loading divided by number of factors of the underlying construct.

(Fornell & Larcker, 1981). The item reliability of an item was assessed by its factor loading onto the underlying construct. Hair et al. (2006) suggested that an item is significant if its factor loading is greater than 0.50. As shown in Table 3, the eigenvalues of all constructs exceed 1.00 and the percentage of cumulative variance explained of these six constructs was 61.6%. The factor loadings of all the items in the measure ranged from 0.644 to 0.819 (in bold). These factor loadings exceeded the threshold set by Hair et al. (2006) and demonstrated convergent validity at the item level.

The resulting exploratory solution with an oblique rotation indicates a six-factor solution (see Table 3). Table 3 shows that the factor loadings range from .451 to .840. Hair et al. (2006) recommends that for sample sizes of 350 or greater, factors loadings of .30 or higher are significant at .05 level and at a power level of 80%. However, for practical significance, factor loadings are considered acceptable if they are .50 and above. In Table 2, although LE3 falls below a factor loading of .50, it is not removed from further analysis because this item is an important measure of the construct. In addition, a minimum of three items (indicators) for a factor is recommended for model identification purposes in structural equation modelling (Kline, 2005). From Table 3, it can be seen that the items loaded strongly on their intended factors.

These six factors accounted for 46.0% of the variance.

The final indicator of convergent validity, average variance extracted, is a more conservative test of convergent validity (Fornell & Larcker, 1981). It measures the amount of variance captured by the construct in relation to the amount of variance attributable to measurement error. Convergent validity is judged to be adequate when average variance extracted equals or exceeds 0.50 (i.e. when the variance captured by the construct exceeds the variance due to measurement error). As shown in Table 4, the convergent validity for the proposed constructs is adequate.

Discriminant validity

Discriminant validity is assessed to measure the extent to which constructs differ. At the item level, Barclay, Higgins, and Thompson (1995) suggested that discriminant validity is present when an item correlates more highly with items in the construct that it intends to measure than with items belonging to other constructs. In this study, an acceptable level of discriminant validity at the item level was found.

At the construct level, discriminant validity is considered adequate when the variance shared between a construct and any other construct in the model is less than the variance that construct shares

Table 5
Inter-factor zero-order correlations

	1	2	3	4	5	6
1. Learning Effort/ Process	(.75)					
2. Innate Ability	-.09(**)	(.75)				
3. Certainty of Knowledge	-.07(*)	-.28(**)	(.75)			
4. Authority/Expert Knowledge	-.13(**)	-.27(**)	.45(**)	(.73)		
5. Constructivist Teaching	.31(**)	-.15(**)	.08(**)	.07(**)	(.75)	
6. Traditionalist Teaching	-.05	.41(**)	-.32(**)	-.39(**)	-.26(**)	(.72)

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).
Diagonal (in brackets): square root of average variance extracted from observed variables (items);
Off-diagonal: correlations between constructs

with its measures (Fornell, Tellis, & Zinkhan, 1982). The variance shared by any two constructs is obtained by squaring the correlation between them. The variance shared between a construct and its measures corresponds to average variance extracted. Discriminant validity was assessed by comparing the square root of the average variance extracted for a given construct with the correlations between that construct and all other constructs. Table 5 shows the correlation matrix for the constructs. The diagonal elements have been replaced by the square roots of the average variance extracted. For discriminant validity to be judged adequate, these diagonal elements should be greater than the off-diagonal elements in the corresponding rows and columns. Discriminant validity appears satisfactory at the construct level in the case of all constructs. This indicates that each construct shared more variance with its items than it does with other constructs. Having achieved discriminant validity at both the item and construct levels, the constructs in the proposed research model are deemed to be adequate.

To ascertain how beliefs about learning, beliefs about knowledge, and beliefs about teaching were interrelated, a zero-order correlation was computed (Table 5). Within the beliefs about learning, *Learning Effort/Process* is negatively related with *Innate Ability*. As for the beliefs about knowledge, *Certainty of Knowledge* is positively related to *Authority/Expert Knowledge*. For beliefs about teaching, *Constructivist Teaching* is negatively related to *Traditionalist Teaching*. All these correlations were significant at the $p < 0.01$ level (2-tailed). All other correlations were significant at either .05 or .01 levels except for *Learning effort/process* and *Traditionalist Teaching*.

Structural equation modelling

James, Mulaik, and Brett (1982) recommended the two-step approach to structural equation modelling. This approach emphasizes the analysis of the measurement and structural models as two conceptually distinct models. The authors explained that the two-step approach expanded the idea of assessing the fit of the structural equation model among latent variables (structural model) independently of assessing the fit of the observed variables to the latent variables (measurement model). The rationale for the two-step approach is supported by Anderson and Gerbing (1988) who stated that testing the initially specified theory (structural model) may not be meaningful unless the measurement model holds.

Test of the measurement model

To test the measurement model, which specifies the relations between manifest (observed) variables and latent variables, confirmatory factor analysis (CFA) is often used. The extent to which a latent variable is accurately defined depends on how strongly related the observed indicators are. It is apparent that if one indicator is weakly related to other indicators, this will result in a poor definition of the latent variable, resulting in model misspecification in the hypothesized relationships among variables. The confirmatory factor analysis (CFA) approach to scale estimations and construct reliability has the advantage of overcoming the limitations of the exploratory factor model by allowing the researcher to determine on the basis of theories (1) which pairs of common factors are correlated, (2) which observed variables are affected by which common factors, (3) which observed variables are affected by an error term factor, and (4) which pairs of error terms are correlated. Statistical tests can then be employed to determine whether the data confirm the substantively generated model (Garver & Mentzer, 1999). Figure 2 shows the first-order measurement
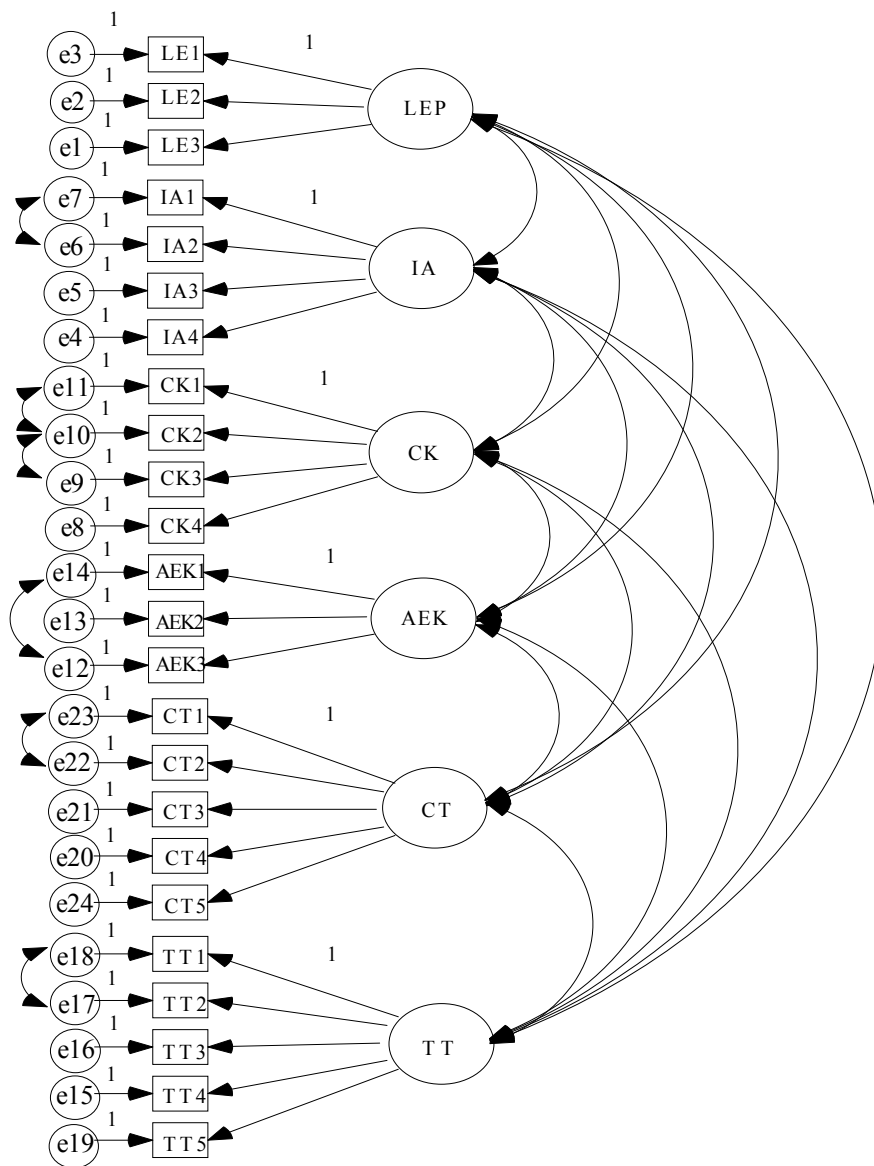

Figure 2. *Measurement model*

Table 6
Analysis of the structural model

| Path | | | | | Hypothesis |
From	To	Path coefficient	Standard error	t-statistics	supported?
IA	CT	.002	.039	.059	No
IA	TT	.039	.020	2.002*	Yes
LEP	CT	.501	.071	7.014**	Yes
LEP	TT	-.058	.027	-2.184*	Yes
AEK	CT	.092	.045	2.016*	No
AEK	TT	-.061	.026	-2.311*	No
CK	CT	.035	.037	.963	No
CK	TT	-.059	.024	-2.481*	No

Note: * P < .05; ** P < .001; IA=Innate Ability; LEP=Learning Effort/Process; AEK=Authority/Expert Knowledge; CK=Certainty of Knowledge; CT=Constructivist Teaching; TT=Traditionalist Teaching

model. An analysis using AMOS 7.0 shows a good model fit. The fit indices revealed χ^2 =609.80, df=231; GFI=.965; SRMR=.039; TLI=.956; CFI=.953; RMSEA=.034. The values of these indices are regarded by most researchers as indicative of a good model fit to the data (Hair et al., 2006; Hoyle, 1995; Kline, 2005; Kelloway, 1998; Schumacker & Lomax, 2004).

Test of the structural model

The test of the structural model includes assessing the statistical significance of the path coefficients from one latent variable to another. Table 6 shows the analysis of the structural model. A total of six path coefficients are statistically significant (IA→TT, β= .039; LEP→CT, β = .501; LEP→TT, β = -.581; AEK→CT, β = .092; AEK→TT, β = -.061; CK→TT, β = -.059). Of the eight hypotheses, only three were supported in this study. These are H2: Innate ability will significantly influence traditionalist teaching positively, H3: Learning effort/process will significantly influence constructivist teaching positively, and H4: Learning effort/process will significantly influence traditionalist teaching negatively.

The supported hypotheses are also reflected by the thick lines in Figure 3. The R^2 value of TT and

CT are .407 and .425 respectively. This indicates that the exogenous variables (IA, LEP, AEK, and CK) explained 40.7% and 42.5% of the variance of TT and CT respectively. Fit indices indicated that the structural model has a good fit (χ^2=395.891, df=172; GFI=.951; SRMR=.056; TLI=.926; CFI=.940; RMSEA=.043).

DISCUSSION

In general, the factor analyses indicate that the four constructs on epistemological beliefs and the two constructs on pedagogical beliefs are consistent with Chan and Elliott's (2004) study. More studies are needed to see if similar constructs would emerge from other Asian contexts. In the following paragraphs, we will discuss the findings of the supported hypotheses before proceeding to the unsupported hypotheses.

Based on the findings for the hypotheses, teachers who are more inclined to believe in IA are also inclined to believe in TT. However, the converse, which hypothesize that lesser inclination towards IA would be positively associated with CT, is not necessarily true. Chan and Elliott (2004) obtained similar results in that while path analysis associated IA towards TT, it is not significantly related to constructivist teaching. Beliefs towards
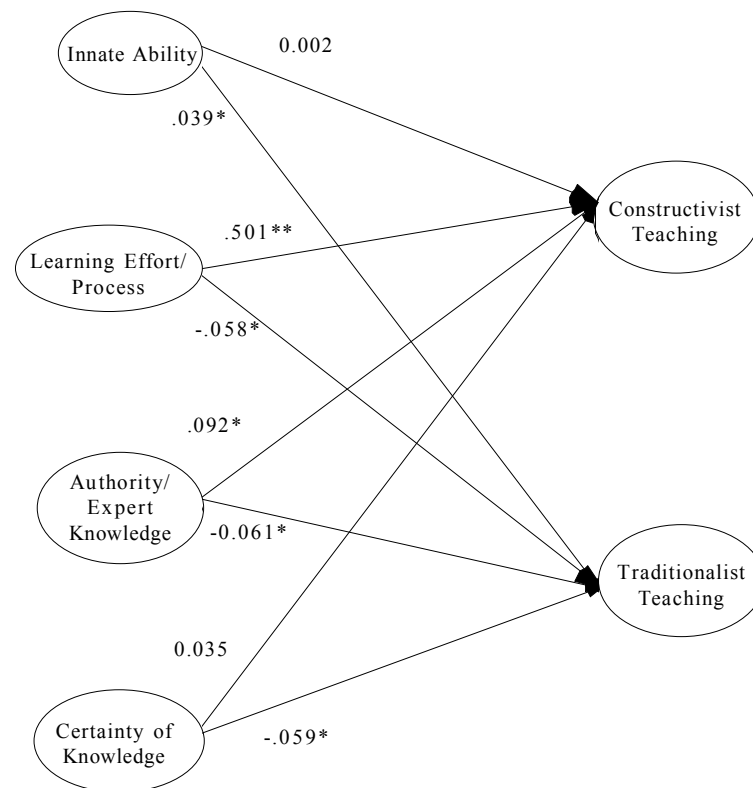
Figure 3. *Path coefficients of the structural model.*
* p < .05; ** p < .01

IA would imply that it is futile to change the teaching methods, which resulted in the non-significant path coefficient in the current study. In addition, the teachers may not perceive constructivist teaching methods as a means to change innate ability among students.

The relationships between teachers' beliefs about LEP are linked to their views of teaching as predicted by our initial model. Teachers who believe more in LEP are inclined towards constructivist teaching and not traditional teaching. An earlier study by Chai (2006) using qualitative methods (N=7) in assessing Singaporean teachers' beliefs about teaching and beliefs about learning suggests that these beliefs are closely aligned. Hong Kong teachers, however, associated learning effort/process negatively with constructivist teaching (Chan & Elliott, 2004). As mentioned in the

literature review, the teachers may perceive LEP in the context of doing more drills and practices. To avoid this interpretation, future research should perhaps re-craft the items pertaining to this dimension with a clear connotation of the learning effort/process for knowledge construction rather than knowledge acquisition.

All four hypothesized relationships among the teachers' beliefs about knowledge and their beliefs about teaching were not supported by the data. In fact, the data suggest an opposite relationship among these dimensions of beliefs. Given the mean scores, these relationships are to be expected though they are theoretically surprising. The means score (AEK=3.46, CK=3.12) of the current sample indicates that the pre-service teachers may not be holding on to relativistic outlooks and instead they are inclined towards constructivist teaching

rather than traditional teaching (CT=4.31, TT=2.13). This implies that pre-service teachers may not be epistemologically ready for constructivist teaching since they are more likely to see knowledge as certain, and rely on authority for knowledge. Constructivist teaching requires teachers to treat knowing as an emerging process as learners actively make sense of the phenomenon they are trying to understand. The pre-service teachers may be responding to the widespread emphasis on student-centred education as has been propagated by the ministry of education in Singapore since 1997. Within the scope of reported studies, teachers who hold relativistic epistemological outlooks are more likely to endorse constructivist teaching (Schraw & Olafson, 2002; Sinatra & Kardash, 2004). Previous research employing a similar instrument also revealed different epistemological profiles among teachers. Chai and Khine (2008) documented a more relativistic outlook among post-graduate pre-service teachers (AEK=2.58, CK=2.79, N=877). The scores in the dimensions of beliefs about teaching is, however, more comparable (CT=4.11, TT=2.62). The current study differs from Chai and Khine's study by the inclusion of pre-service teachers from the Diploma in Education program, who are non-graduates (N=280, 19.9%). Careful analyses for the two sets of data may be needed to clarify the situation. In another very recent study (Wong, Chan, & Lai, 2009), undergraduate pre-service teachers were found to hold more relativistic (AEK=2.63, CK=2.79, N=604), but comparable beliefs about teaching (CT=4.11, TT=2.62). As mentioned in the literature review, Chan and Elliott's (2004) study also indicate an opposite relationship between teachers' epistemological outlook and teaching beliefs. In their case, the teachers who were attending a sub-degree program were reportedly holding relativistic epistemology but were not supporting constructivist teaching. It seems that there is more congruence between epistemological beliefs and beliefs about teaching among the studies from the West than among those from Asia. There may be some other constructs that are mediating the relationships between epistemological beliefs and beliefs about teaching among Asian teachers such as their perceptions of school environment (Teo, Chai, Hung, & Lee, 2008).

The practical implication of the current results may point towards the need for building pre-service teachers' knowledge about epistemology. As experienced teachers and teacher educators in the Singapore school system, the authors are unaware of such courses for students and pre-service teachers except for the newly introduced Knowledge and Inquiry subject for some selected junior colleges. In fact, the need to study students' or teachers' epistemology was not realized in Singapore until recently. Explicit instruction in this area may help teachers to be more aware of their personal epistemology and how it influences their teaching. Such awareness is desirable as pointed out by many educators (Ertmer, 2005; Windschitl, 2002). Genuine experiences of establishing knowledge claims may also be important. This should be an integral part of pre-service and in-service teachers' learning since Singapore is encouraging its learners to assume the role of knowledge creators. Explicit teaching about epistemology, together with experiences in creating knowledge, would form the foundation of deep changes that may have lasting effects on teaching practice. Currently, some examples on how teacher educators in Singapore are embarking on such effort include engaging teachers' in knowledge building community (Chai & Tan, 2009; Chai, Wong & Bopry, 2009). These works empower teachers to be knowledge creators who are responsible for identifying classroom problems and co-constructing new ways of teaching and learning. Other than helping pre-service teachers in experiencing what knowledge creation means for themselves, additional effort to help them to design and facilitate knowledge construction activities in classrooms should also be an integral part of their school teaching experience. In short, teacher educators should help pre-service teachers uncover and change their personal beliefs about knowledge, learning and teaching.

In summary, we investigated in this study the various types of beliefs that Singaporean pre-service teachers' possess, as well as the strengths of the relationships of such beliefs, through structural equation modelling. The study reveals that pre-service teachers who are more inclined to believe in innate ability also believe in traditional teaching, while pre-service teachers who believe more in learning effort/process are inclined toward constructivist teaching and not traditional teaching. As mentioned earlier, core epistemological constructs such as authority of knowledge and certainty of knowledge were found to be significantly correlated to constructivist teaching and traditional teaching albeit in the opposite direction that we hypothesized. We hypothesize that the current profile of epistemological and pedagogical beliefs is quite different from that in Chai and Khine's (2008) study due to the inclusion of the non-graduate as sample for our study. The inclusion of the non-graduate has also exhibited surprising influence on the profile of pedagogical beliefs among pre-service teachers in Singapore (Teo et al., 2008). There may be some other constructs that mediate the relationships between epistemological beliefs and pedagogical beliefs among Singaporean teachers and perhaps Asian teachers. These may include one's gender, years of teaching, and subject specialization. In addition, the irregularity in our findings may be due to the fact that pre-service teachers in Singapore have not been systematically guided to reflect on their epistemological and pedagogical beliefs. Hence, to provide a more realistic and systemic argument on pre-service teachers' beliefs, more robust research studies must be carried out to substantiate current findings. We suggest that intervention studies employing experimental or quasi-experimental design be carried out among carefully selected pre-service teachers. Explicit or implicit instruction about epistemological and pedagogical beliefs can be implemented to see how participants' would respond to instruction and how the instruction would change the perceived relationships among the constructs.

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