

Personal Epistemological Development of Thai Students During Their Undergraduate University Education

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Abstract: The objective of this study was to investigate whether an undergraduate education contributes to the epistemological development of Thai university students. That is to examine whether students change their beliefs and views on knowledge and knowledge acquisition while they study in university. A questionnaire, asking participants to indicate how they agree or disagree to statements on knowledge and knowing, was administered to a total of 467 students of a university in Thailand, composed of 257 first-year students and 210 students that just finished their undergraduate programs. Through factor analysis, four dimensions were identified: Quick Learning, Stable Knowledge, Simple Knowledge, and Fixed Ability. These four factors represent the four conceptual hypothetical dimensions. This finding appears to confirm a dimensional structure of the Thai university students' personal epistemology, as it was previously endorsed by the authors. Yet further investigations are necessary to clarify the nature of these relatively independent dimensions. Significant differences were identified between the first-year students and the students who were to graduate in terms of their personal epistemological development level. The students already completed their undergraduate study were significantly more epistemologically developed than the students who were about to begin their undergraduate study. This tendency of development was only noticeable among the largest categories of the students: those graduated from local Thai high schools and arts and business majors. These results suggest that undergraduate education facilitates the development of perspectives toward knowledge and knowing, provided that these two groups of students share similarities in many aspects, at least in this particular educational institution.

Keywords: beliefs about knowledge and knowing, undergraduate education, student development, personal epistemology, Thai students

Introduction

It is only two decades ago since researchers from various disciplines actively began to empirically investigate individuals' beliefs about knowledge and knowledge acquisition (Hofer 2005; Schraw & Sinatra, 2004). However the scope of each study seems to be somewhat different, and there has been numerous terms used to categorize this area of research (e.g., Baxter Magolda, 1992; Belenky et al., 1986; Hofer, 2000; King & Kitchener, 1994; Kuhn, 1991; Schommer, 1990). Hofer and Pintrich (1997) was among the series of the

first attempts to address this chaotic situation, reviewing and integrating what was identified in the studies of this topic to date. This was followed by Hofer and Pintrich (2002), who proposed the umbrella term “personal epistemology” to categorize this area of studies. Hofer (2004) defined personal epistemology as “a field that examines what individuals believe about how knowing occurs, what counts as knowledge and where it resides, and how knowledge is constructed and evaluated (p.1).” Only during the last five years, academic journals such as *Educational Psychology Review* (Sinatra, 2001), *Contemporary Educational Psychology* (Schraw & Sinatra, 2004), and *Educational Psychologist* (Hofer, 2004) featured the topic in their special issues, providing more forums of discussions among researchers of the field.

Two Streams in Personal Epistemology Study

There are two lines in the personal epistemology studies (Chan & Elliot, 2004; Hofer, 2001). One is mainly concerned with its developmental aspects, trying to identify and describe positions of individuals’ personal epistemological development. Most of the studies in this category can be traced back to Perry (1970), who examined undergraduate Harvard students through interviews during 1950s and 1960s in longitudinal studies. Individuals are measured to identify their stages, position or perspectives of personal epistemological development. The developmental models suggest that individuals move “from a dualistic, objectivist view of knowledge to a more subjective, relativistic stance and ultimately to a contextual, constructivist perspective of knowledge (Hofer, 2002, p.7).” The major models include Belenky et al. (1986), Bexter Magolda (1992), King and Kitchener (1994), and Kuhn (1991), as summarized by Hofer and Pintrich (1997).

Another stream focuses on the dimensional structure of epistemological beliefs, intending to uncover its components and nature. Schommer (Schommer, 1990; Schommer et al., 1992) is regarded as a pioneer in this second approach, a clear departure from the developmental approach dominant at that time (Hofer, 2001). Schommer conceptualized the personal epistemology as a system with five distinct independent dimensional factors: (a) structure of knowledge, (b) certainty of knowledge, (c) sources of knowledge, (d) control of knowledge acquisition, and (e) speed of knowledge acquisition. However, she has been successful in identifying empirically only four of these five factors, and not the source of knowledge (Schommer, 1990). Schommer also developed the first questionnaire on personal epistemology that has been widely recognized and used in research (Hofer & Pintrich, 2002). Quantitative research in this field contributed to the investigation of the relationships between personal epistemology and other metacognitive activities in learning such as comprehension in text reading, conceptual changes, and study strategies (Chan & Elliot, 2004).

In spite of the accumulated findings from numerous researchers in personal epistemology,

there are still a few areas that need exploration. One of these areas concerns the longitudinal development of personal epistemology (Schraw & Sinatra, 2004). They argue that very few studies examined the epistemological development over a period of time at dimensional levels. This current study is an endeavor to empirically investigate this particular aspect of personal epistemology. As an alternative to a longitudinal study, two groups of students within the same college in a university but at different stages of their education, i.e., one at the time of enrollment and the other at the time of graduation, will be measured and compared in terms of their development of personal epistemology at factorial levels.

Purpose of the Study

The objective of this study is to investigate whether an undergraduate education contributes to the epistemological development of Thai university students. This is to examine whether these students' beliefs and views on knowledge and knowledge acquisition develop while they study at a university. First-year students and graduating students in a university will be measured and compared in terms of their epistemological development through a questionnaire. All the students were studying at the same university and were admitted through the same admission policies. Consequently these two groups of students could be considered very similar in terms of their major characteristics potential to influence their epistemological development.

Methodology

Participants

The questionnaire was completed by a total of 467 students in a university in Thailand: 257 first-year students at the beginning of their first term and 210 students that had just finished their 4-year undergraduate programs. All students were of Thai nationality, and their native language was Thai. They all enrolled in an international undergraduate program where English was used as the language of instruction. The program is a part of a large research university in the greater Bangkok metropolitan area in Thailand.

The age of the first-year students was between 15 and 24 years old, the mean being 18.4. The majority was either 18 years old (32.8 %) or 19 years old (30.5 %). In the graduate group, their age was between 19 and 29 years old, and the mean was 23.0. In this cohort, the largest age group was 23 years old (40.7 %), followed by 22 years old (25.8 %).

These two groups of students are comparable in terms of their sex, major, high school type, overseas experience. Pearson chi-square tests confirmed that these two groups were not statistically significantly different in terms of these four aspects (sex, $\chi^2 = 3.524$, $df = 1$, $p = .060$; major, $\chi^2 = 2.350$, $df = 2$, $p = .309$; high school type, $\chi^2 = 1.201$, $df = 3$, $p = .753$; and overseas experience, $\chi^2 = .098$, $df = 1$, $p = .755$).

About sixty percent of the students in this sample were female. A little more than half of the students were majoring in business administration, followed by science (25.5 %) and arts (24.0 %). These students had four different types of secondary educational backgrounds. The largest group (45.4 %) graduated from a local Thai school, followed by those graduating from a high school abroad mostly in English-speaking countries (30.5 %), and those graduating from an international school in Thailand (20.2 %). The fourth and smallest group (3.9 %) is composed of students graduated from a bilingual school in Thailand, where both the English and Thai languages are used as a means of instruction. Two third of all the students (66.3 %) have stayed outside Thailand for purposes other than short-term vacations. The demographic characteristics are summarized in Table 1 below, together with the percentages within each group of different student type.

Table 1: *Demographic Characteristics of the Two Types of Students*

Category	Level	First-year (N=257)		Graduates (N=210)		Total (N=467)	
		N	%	N	%	N	%
Age	15-16 years	19	7.4			19	4.1
	17-18 years	114	44.5			114	24.5
	19-20 years	113	44.1	5	2.4	118	25.4
	21-22 years	9	3.5	69	33.0	78	16.8
	23-24 years	1	0.4	115	55.0	116	24.9
	25-26 years			15	7.2	15	3.2
	27 and more			5	2.4	5	1.1
Sex	Male	110	42.8	72	34.3	182	39.0
	Female	147	57.2	138	65.7	285	61.0
Major	Science	58	22.7	60	29.0	118	25.5
	Arts	64	25.1	47	22.7	111	24.0
	Business Admin	133	52.2	100	48.3	233	50.4
High School Type	Local Thai	118	46.1	93	44.5	211	45.4
	Local Bilingual	9	3.5	9	4.3	18	3.9
	International	55	21.5	39	18.7	94	20.2
	Abroad	74	28.9	68	32.5	142	30.5
Overseas Stay	Yes	170	66.9	137	65.6	307	66.3
	No	84	33.1	72	34.4	156	33.7

Materials

A 28-item questionnaire was developed based on Schommer et al.'s middle school version (Schommer-Aikins et al., 2000) that included 29 statements about the four

hypothetical dimensions of personal epistemology: (a) ability to learn, (b) speed of learning, (c) stability of knowledge, and (d) structure of knowledge.

Schommer's middle school version was chosen for several reasons, the main being that the language was simpler than in Schommer's original (Schommer, 1998). Although the participants had a minimum of a 550 TOEFL score, the first-year students who were just admitted for the international undergraduate programs still lacked the comprehensive understanding of vocabulary and idioms that a native English speaker would naturally have. The other reason is that this instrument has fewer questions than the original 63-item Schommer questionnaire (Schommer, 1998). In general, Thailand has more of an oral tradition and has less of a developed reading culture. English is not the first language for the participants and they generally consider filling out of a questionnaire in English hard work. By using the middle school version, we aimed to achieve a balance of asking enough questions to measure each dimension and not overloading the students.

After the item expressions were further revised by the authors, the order of the 28 items was randomized. Eighteen items were written so that less epistemologically developed students would agree, while the remaining ten were written so that these students would disagree. The participants were asked to rate these 28 item sentences on a five-point Likert scale, ranging from 5 (strongly agree) to 1 (strongly disagree). In the second part, demographic questions were also included.

Procedure

The questionnaire was administered at gatherings for both first-year and graduating students. As for the first-year students, the survey was conducted during the freshman orientation session held on three separate occasions, to include all new intake students accepted during an academic year. In the first two sessions, students were asked to fill in the questionnaire and return it to the session supervisor during the session. Whereas in the third occasion, students were given two weeks before they were asked to return the questionnaire.

The graduating students were asked to fill in the questionnaire during a compulsory meeting prior to their commencement ceremony. These students must have taken all the necessary courses and credits required for their graduation before attending this meeting.

Results

Dimensional Structure

Factor analysis was used to investigate the dimensional structure of personal epistemology. Prior to the factor analysis, the scale was standardized by recoding the responses so that higher scores (i.e., stronger agreement to the item statements) indicate a

more epistemologically developed beliefs about knowledge and knowing. Following the procedures used by Wood and Kardash (2002), the internal consistency of the 28-item scale was computed. The coefficient alpha was .55, and item-total correlations ranged from -.14 to .38. Five statements with negative item-total correlations and four with item-total correlations less than .10 were eliminated. Using the remaining 19 items, internal consistency was again calculated, producing a higher coefficient alpha of .69.

Four factors were extracted from exploratory factor analysis (principal component analysis, Valimax rotation) with these 19 items. These four factors explained 38.8 percent of the total variance. Cronbach’s coefficient alpha for each factor was .525, .608, .420, and .465, respectively. Although the 5th, 6th and 7th factors had an eigenvalue higher than 1, they were not included in the result because of their relatively small contribution to improve the explanation of the total variance. An inspection of the screen-plot also confirmed this decision. Table 2 below represents the four identified factors and the items constituting each of these four factors. The numbers represent the factor loadings of the items.

Table 2: *Dimensional Structures of Thai Students’ Personal Epistemology*

Items	Factor Loadings			
	Factor 1 Quick Learning	Factor 2 Stable Knowledge	Factor 3 Simple Knowledge	Factor 4 Fixed Ability
5 If I can’t understand something right away, I will keep trying. (SPE-)	-.617			
17 If I can not understand something quickly, I will never understand it. (SPE+)	.596			
16 Working hard on a difficult problem only helps the really smart students. (ABI+)	.502			
22 If I am going to understand something, I will understand it the first time I read it. (SPE+)	.497			
20 Reading the textbook twice will not help me learn more. (SPE+)	.459			
18 If scientists try hard enough, they		.808		

	can find the truth to almost everything. (STA+)	
8	Scientists can get to the truth if they keep looking for it. (STA+)	.788
6	The best thing about a science course is that most problems have only one right answer. (STR+)	.699
9	Most words have one clear meaning. (STR+)	.600
2	I can rely on the facts in my school textbooks for the rest of my life. (STA+)	.567
10	Some people are born smart, and some people are born stupid. (ABI+)	.754
7	The really smart students don't have to work hard to do well in school. (ABI+)	.615
19	An expert is someone who is born smart in something. (ABI+)	.435

The factor structure was rather clear-cut, at least compared to the previous study by the authors that investigated Thai students using the same questionnaire (Fujiwara & Phillips, 2006). This made it simpler and easier to label these identified factors. In two factors (Factor 2 and Factor 4), items from only one hypothetical dimension were included, i.e., stability of knowledge (STA) in Factor 2, and ability to learn (ABI) in Factor 4. Naturally, Factor 2 was named “Stable Knowledge” and Factor 4 “Fixed Ability”, from a less epistemologically developed viewpoint.

As to the other two factors (Factor 1 and Factor 3), the majority of the items represented the same hypothetical dimension, with only one item originated from a different dimension in each of these two factors. In Factor 1, four of the five items belonged to the dimension of speed of learning (SPE), and consequently it was named “Quick Learning.” Factor 3 contained two items of structure of knowledge (STR) and one item of stability of knowledge (STA), resulting in calling this factor “Simple Knowledge.”

Personal Epistemology and University Education

Overall Comparison between First-Year and Graduates

Mean scores of each identified factor were compared between the two groups of students: the first-year students and the graduating students. As explained earlier, the responses of the 18 items that less epistemologically developed students would agree with were recoded so that all the responses indicated that the higher the score, the more epistemologically developed the respondent was. The analysis didn't include participants who didn't rate all the 13 statements covered by the four factors. The mean scores are described in Table 3 below.

Table 3: *Factor Variations of Students with Different Periods of Study at University*

Type of Students	Factor 1		Factor 2		Factor 3		Factor 4	
	Quick Learning		Stable Knowledge		Simple Knowledge		Fixed Ability	
	Mean Score	SD	Mean Score	SD	Mean Score	SD	Mean Score	SD
First-year Students (N = 241)	3.76	.499	2.41	.809	3.40	.685	3.56	.723
Graduating Students (N = 205)	3.88	.543	2.62	.776	3.45	.654	3.42	.823
Total (N = 446)	3.81	.522	2.50	.800	3.42	.671	3.49	.772

The *t* test identified a significant difference between these two groups in terms of the first two factors, Quick Learning, $t(444) = -2.45, p = .015$, and Stable Knowledge, $t(444) = -2.79, p = .006$. However, no significant difference was identified in the other two factors: Simple Knowledge, $t(444) = -.79, p = 0.429$, and Fixed Ability, $t(444) = 1.91, p = .057$.

Breakdown Comparison between First-Year and Graduates

The participants of the study are divided into four categories in terms of their secondary education and three categories in terms of their subject major. As a next step of the analysis, the mean scores of the identified factors were compared between the first-year and the graduates within each of these categories.

Comparisons within the Groups of the Same Secondary Education

In terms of the secondary schooling experiences, the students are divided into the four categories, as described in a preceding section above. Due to its small sample size (nine students in each group of first-year students and graduates), the group of bilingual school was not included in this analysis. The participants who did not rate all the 13 statements covered by the four factors, or who did not indicate his or her secondary school type, were not included in the analysis neither. The mean scores are given in Table 4 below.

Table 4: *Factor Variations of Students with Different High School Types*

Type of High School	First-Year Graduates	Factor 1		Factor 2		Factor 3		Factor 4	
		Quick Learning		Stable Knowledge		Simple Knowledge		Fixed Ability	
		Mean Score	SD	Mean Score	SD	Mean Score	SD	Mean Score	SD
Local Thai School	(N= 111)	3.66	.448	2.38	.738	3.29	.675	3.56	.653
	(N= 91)	3.85	.547	2.60	.758	3.42	.649	3.38	.809
International School	(N= 49)	3.87	.447	2.39	.862	3.49	.628	3.56	.823
	(N= 38)	3.92	.442	2.54	.757	3.50	.661	3.54	.792
School Abroad	(N= 71)	3.86	.540	2.50	.890	3.54	.714	3.56	.741
	(N= 66)	3.88	.590	2.70	.855	3.49	.630	3.42	.883
Total	(N= 240)	3.77	.492	2.41	.811	3.40	.681	3.56	.718
	(N= 204)	3.88	.544	2.62	.777	3.45	.654	3.42	.823

The *t* test identified that the differences between the first-year and the graduates were only significant within the largest category of students graduating from a local Thai high school in terms of the first two factors, Quick Learning, $t(200) = -2.67, p = .008$, and Stable Knowledge, $t(200) = -2.10, p = .037$. Within the other two types of secondary school, no significant difference was identified between the first-year students and graduates in any of the four factors.

Comparisons within the Groups of the Same Subject Major

Another comparison between the first-year and the graduates was further conducted within the categories of students majoring in the same field of study; the students are divided into the three categories of their intended (for the first-year students) or completed major (for the graduating students). Similar to the previous analysis, the participants who did not rate all the 13 statements covered by the four factors, or who did not indicate his or her major, were not included in the analysis. The mean scores are represented in Table 5 below.

Table 5: *Factor Variations of Students with Different Intended/ Completed Major*

Intended/ Completed Major	First-Year	Factor 1		Factor 2		Factor 3		Factor 4	
		Quick Learning		Stable Knowledge		Simple Knowledge		Fixed Ability	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD

	Graduates	Score		Score		Score		Score	
Science	(N= 57)	3.86	.426	2.43	.873	3.70	.697	3.53	.642
	(N= 59)	3.95	.464	2.68	.730	3.62	.625	3.42	.843
Arts	(N= 60)	3.72	.459	2.32	.725	3.22	.699	3.43	.791
	(N= 45)	3.60	.596	2.73	.766	3.25	.679	3.20	.786
Business	(N= 122)	3.75	.541	2.43	.821	3.35	.636	3.63	.718
	(N= 98)	3.97	.528	2.52	.806	3.43	.646	3.52	.818
Total	(N= 239)	3.76	.496	2.40	.809	3.40	.686	3.56	.722
	(N= 202)	3.88	.545	2.61	.777	3.44	.657	3.42	.824

The *t* test indicated that the differences between the first-year students and the graduating students were only significant within the categories of students majoring in arts and business administration but not in the category of science majors. The difference was significant in terms of Stable Knowledge for the arts majors, $t(103) = -2.85$, $p = .005$, and Quick Learning among the business administration majors, $t(218) = -3.08$, $p = .002$. Within the science majors, no significant difference was identified between the first-year students and the graduates in any of the four factors.

Discussion and Conclusion

The four factors corresponding to the four conceptual hypothetical dimensions proposed by Schommer were empirically identified in the personal epistemology structure of the Thai students: Quick Learning, Stable Knowledge, Simple Knowledge, and Fixed Ability. The students already completed their undergraduate education had significantly higher scores than those who just started their undergraduate university student life in terms of the Quick Learning and Stable Knowledge factors. However, further analyses uncovered that these significant differences were only noticeable among the students graduated from a local Thai high school (for the both factors), the arts majors (Stable Knowledge) and the business majors (Quick Learning).

The first finding appears to endorse Schommer's conceptual framework of a multidimensional system of independent beliefs of personal epistemology. The structure identified in this study is much more clearly formulated than those identified by Fujiwara and Phillips (2006) that examined first-year Thai university students. Each of the four factors identified in this study is composed of items mainly from one hypothetical dimension. Moreover these four factors parallel all the four conceptual dimensions. This dimensional structure provides a global picture of personal epistemology held by Thai university students.

The epistemology structure identified in this study is different from what has been reported by the previous studies in terms of the number of factors and its nature. First, the number of the factors identified in this study is different from Fujiwara and Phillips (2006), which also investigated Thai university students using the same questionnaire. The three-factor structure reported by Fujiwara and Phillips (2006) does not include Quick Learning, a factor clearly identified in this current study. Second, the grouping of the statements in the identified factors in this present research was also different from Fujiwara and Phillips (2006), but the results in this study harmonized more with the hypothesized conceptions. As noted earlier, the items constituting each factor mainly represent only one hypothetical dimension. The composition of the factors is also different from Schommer-Aikins et al. (2000) in which the similar questionnaire was used, although the participants were middle school students, not university students.

Some methodological problems were also encountered regarding the measurement instrument, as also found in the previous study by the authors. The items that remained utilizable in the analysis all had statements worded from a less epistemologically developed point of view, except one. The items with statements that were worded from a more developed epistemological point of view were all eliminated except one before the factor analysis due to their negative or very low item-total correlations. It is possible that nearly half of the first-year students (46.1 %) totaling 118 students who had never studied in English had some difficulty in understanding the expressions of these items. Alternatively, the measurement instrument might have some deficiencies in itself. The latter seems more probable, considering that half of all the participants completed their 4-year undergraduate program using English as a medium of instruction. Issues about Schommer's instrument were also raised by Hofer and Pintrich (1997), claiming that expressions in some of the item statements are ambiguous and not clear about what they are to measure.

This study empirically identified for the first time in the literature the significant differences between the two groups of university students at different stages of the undergraduate student life in terms of their personal epistemological development, not as the holistic stages or positions, but at the dimensional levels. All the participants were studying at the same university. The two groups were comparable, sharing the similarities in all the major characteristics, but differ only in terms of the periods of time already spent in the university. Consequently, it is very likely that these differences are attributable to their university experiences. This result tends to indicate that university education has an effect on some aspects of personal epistemological development.

However, these statistically significant differences were observable only among student

of certain backgrounds, namely, students graduated from a local Thai high school and those majoring in arts and business.

Within each category of the first-year students and the graduating students, through the two separate analyses, the mean scores of each identified factor were compared between the groups of students sharing the same educational experiences; one was with their secondary schooling background, and the other was with their subject major selected at the university. One-way ANOVA identified that among the first-year students the differences were statistically significant only in terms of Quick Learning, $F(3, 236) = 3.44$, $p = .017$. Turkey HSD showed that the first-year students educated abroad before coming to the university (3.86) had a significantly higher mean score than their peers graduated from a local Thai high school (3.66), $p = .038$. Yet among the graduating students, no significant difference was identified between the groups of students with different secondary school backgrounds.

This result indicates that students educated in a local Thai high school were less epistemologically developed at the time of enrollment in the university than were their peers that were educated abroad in terms of Quick Learning, but this difference disappeared in the graduating group of students. It seems that an international university education could have strong developmental influence on students coming from a regular Thai high school. It allowed them to catch up with those students educated abroad that began studying at the university with a more developed personal epistemology. The result suggests that an international undergraduate program in Southeast Asia may shape the way that students learn to learn in much the same way as an undergraduate program does in the Western world.

Subject majors seem to play more complicated roles in individuals' personal epistemological development during the undergraduate study. Among the first-year students, one-way ANOVA identified significant differences in terms of Simple Knowledge, $F(2, 236) = 3.58$, $p = .000$. Turkey HSD disclosed that the first-year students planning to major in science (3.70) had significantly a higher score than their classmates intending to major in arts (3.22), $p = .000$, and business administration (3.35), $p = .004$, respectively. As far as the graduating students are concerned, one-way ANOVA identified significant differences in terms of Quick Learning, $F(2, 199) = 8.12$, $p = .000$, and Simple Knowledge, $F(2, 199) = 4.09$, $p = .018$. Turkey HSD unveiled that the students majored in arts (3.60) had a significantly lower mean score than those majored in science (3.95), $p = .003$, and business (3.97), $p = .000$, respectively, in terms of Quick Learning. Arts majors (3.25) also had a significantly lower score than science majors (3.62), $p = .014$, in Simple Knowledge.

These results indicate that the differences identified between the groups of the first-year students majoring in science and arts were also similarly identified at the graduating students'

level in terms of Simple Knowledge. However, the difference in this factor between the science majors and the business majors was significant among the first-year students, but not in the graduating student body. In Quick Learning, the significant differences were identified only among the graduating students, between the arts majors and the science majors, as well as between the arts majors and the business majors.

Even with the results of these breakdown analyses, it is still difficult to explain the tertiary educational influences on epistemological development of the students with different subject majors. It is likely that the undergraduate education in this particular context was not successful in removing the differences of the epistemological development attributable to the students' subject major. In the case of Quick Learning, a new gap between different majors seems to be created during undergraduate study. This might suggest that students' intended or completed subject majors could play a greater role in epistemological development than individuals' secondary or tertiary educational experiences as a whole.

Another important remark about the findings is that the developmental changes were observed only in the two factors of the four: Quick Learning and Stable Knowledge. One plausible explanation is that the epistemological levels of these two factors were nearly at the most developed level already for beginning undergraduates. Although the differences between the first-year and the graduates was not statistically significant, both at the overall and detailed levels, in some cases the mean scores in the graduate students' category were even lower than those of the first-year students. These counter-intuitive results cast some doubts on the validity of the measurement instrument itself. Alternatively it might be possible that undergraduate university education plays only a limited role in personal epistemological development at the dimensional levels. Yet certainly more empirical investigations are necessary to clarify these issues.

The research results suggest that undergraduate university education has an influence on the students in developing their epistemological viewpoints in certain aspects. Still, many issues remain to be addressed in the future study of individuals' epistemological development. As it was noted in Fujiwara and Phillips (2006), it is very crucial for any further empirical study to develop the measurement instrument with satisfactory psychometric properties, as Chan and Elliot's (2002) questionnaire for Hong Kong students. This is the most urgent issue to be solved. Longitudinal studies following the same group of students over a 4-year undergraduate period will certainly provide more accurate pictures of the epistemology development. In addition, issues related to the individuals' subject major and epistemology also need further empirical exploration. They will undoubtedly lead better understandings and clarification about how students epistemologically develop during their undergraduate study period at the dimensional levels.

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