Study of Epistemological Beliefs, Attitudes towards Learning and Conceptual Understanding of Newtonian Force Concept among Physics Education Undergraduates

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ABSTRACT

This research is to probe the epistemological beliefs, learning attitudes and conceptual understanding towards learning Physics among the first year and final year Physics Education undergraduates (N = 68) from Universiti Teknologi Malaysia for 2009/2010 session. This is a descriptive quantitative research. Data are collected by using Physics Epistemological Beliefs & Attitudes Test and Force Concept Inventory. The data analysis indicates that generally the undergraduates hold high sophistication of epistemological beliefs and favorable attitudes in learning Physics. The t-tests also show that there are statistically significant differences in mean scores between first and final year undergraduates for epistemological beliefs and learning attitudes. Higher mean scores in both aspects are in favor of final year undergraduates. However, poor conceptual understanding due to misconceptions is detected among them. Gender differences are detected in both epistemological beliefs and learning attitudes tests which are in favor of female undergraduates. Pearson correlations show that there are some significant relationships between epistemological beliefs, learning attitudes and conceptual understanding. Significant correlation coefficients of .607 at alpha level .01 are detected between epistemological beliefs and conceptual understanding whereas (r = .563) between epistemological beliefs and learning attitudes.

Keywords: Epistemological beliefs, learning attitudes, conceptual understanding

Introduction

Epistemological beliefs are defined as the systems of implicit assumptions and beliefs that students have about the nature of knowledge and its acquisition (Paulsen & Feldman, 2005). Epistemological beliefs involve learners' theories about knowing, the nature of knowledge, and knowledge acquisition (Schommer, 1990). Kortemeyer (2007) described epistemological beliefs about Physics and Physics learning as the beliefs which concern on what constitutes knowledge in Physics and how knowledge in Physics is developed. Hofer and Pintrich (2002) suggested that epistemological beliefs affect Physics understanding through their indirect effect on learning, text comprehension, and metacomprehension strategies, an argument made also by Ryan (1984) and Schommer *et al.* (1992). Hofer and Pintrich (1997) have also suggested that epistemological beliefs can influence academic achievement indirectly, by affecting goal orientation. In other words, epistemological beliefs can give rise to certain types of learning goals, such as mastery, performance, and completion goals, which in turn, can function as guides for cognitive and metacognitive strategy use.

According to Gray *et al.* (2008), students' beliefs about Physics, about the structure of Physics knowledge, the connection between Physics and the real world, how to approach problem solving and how to learn Physics, play a substantial role in a student's ability to learn Physics. Therefore, study on epistemological beliefs & attitudes of students towards learning Physics is needed to tap into the students' mind frame to probe their beliefs and perception towards Physics and learning the subject. Rohana and Shaharom (2008) in a study on "Relationship between laboratory work and form 4 Physics students' achievement in the topic of force" reported that generally students failed to master the conceptual understanding of force in Newtonian force concept in Physics and they were poor in giving correct answers to problems which related to force and motion. The study shows that the students are weak in understanding and applying the concept of force in problem solving and generally are poor decision makers when come to deal with force concept problems. Generally speaking, a student requires good conceptual understanding in Physics in order to master the subject. The respondents under studied in this research are Physics education students and they are the pre-service Physics teachers in our country. To study and understand the epistemological beliefs and attitudes of this group of future Physics teachers is important as their attitudes and competencies in learning Physics may characterize our future generation of Physics teachers' traits and behaviors in teaching in the future (Barros & Elia, 1998).

In recent years, there have been several popular studies conducted related to the relationship between students' epistemology, attitudes and the learning of Physics. Among them were survey done by Redish *et al.* (1998) to probe students' expectations in university Physics by using *Maryland Physics Expectations Survey* (MPEX), study done by Stathopoulou & Vosniadou (2007) to explore the relationship between Physics-related epistemological beliefs and Physics understanding using *Greek Epistemological Beliefs Evaluation Instrument for Physics* (GEBEP) and study on students' beliefs about Physics and learning Physics using *The Colorado Learning Attitudes About Science Survey* (CLASS) done by Adams *et al.* (2006). Although epistemological beliefs & attitudes have been the subject of extensive research for so many years in Western countries, but less has been done in non-Western countries. So far there has yet to be any detailed study or education research to probe students' epistemological beliefs towards learning Physics among our Malaysian students. Thus, this study is initiated with the aim of probing the Universiti Teknologi Malaysia, Faculty of Education's Physics education undergraduates' epistemological beliefs & attitudes towards learning Physics and their conceptual understanding on Newtonian force concept in Physics.

Objectives of the study

The objectives of this study are:

1. To determine the epistemological beliefs towards Physics and learning Physics held by the Physics education undergraduates.
2. To determine if there is any significant difference between male and female undergraduates' level of epistemological beliefs towards learning Physics.
3. To determine if there is any significant difference between First Year and Final Year Physics education undergraduates in the level of epistemological beliefs towards learning Physics.
4. To determine the attitudes towards learning Physics among the Physics education undergraduates.
5. To determine if there is any significant difference between male and female undergraduates' attitudes in learning Physics.
6. To determine if there is any significant difference between First Year and Final Physics education undergraduates' attitudes in learning Physics.
7. To determine the level of conceptual understanding in Newtonian force concept among the Physics education undergraduates.
8. To determine if there is any significant difference between male and female undergraduates in the level of conceptual understanding in Newtonian force concept.
9. To determine if there is any significant difference between First Year and Final Year Physics education undergraduates in the level of conceptual understanding in Newtonian force concept.
10. To determine if there is any significant relationship between Physics education undergraduates' epistemological beliefs, attitudes in learning Physics and their level of conceptual understanding in Newtonian force concept.

Research Method

This is a descriptive quantitative research. Instruments in the form of questionnaires are used to collect the data.

Instruments

There are two instruments involved in this research, namely the Physics Epistemological Beliefs & Attitudes Test and the Force Concept Inventory. The Physics Epistemological Beliefs & Attitudes Test instrument is adapted from two well-known and validated instruments namely, the *Colorado Learning Attitudes about Science Survey* (CLASS) which is developed by Adams *et al.* (2006) and the *Maryland Physics Expectations Survey* (MPEX) which is developed by Redish *et al.* (1998). The Physics Epistemological Beliefs & Attitudes test is a Likert 5-point scaled questionnaire, consists of 53 statements and is used to probe the epistemological beliefs and attitudes towards learning Physics. The subscales in the epistemological beliefs are *Structure of Physics Knowledge, Application of Physics Knowledge*, *Acquisition of Physics Knowledge* and *Problem Solving in Physics* whereas the subscales in the attitudes aspect are aimed at measuring the students' affective and behavioral components in learning Physics like *Interests, Motivation* and *Readiness* to learn Physics.

Pilot Study

In the pilot study, the Physics Epistemological Beliefs & Attitudes Test and Force Concept Inventory were administered to a group of second year Physics education students (N = 22) who were not involved as respondents in the actual study. It was found that the internal consistency obtained for Epistemological Beliefs scale was $\alpha = 0.79$ whereas the reliability coefficients for the Attitude scale and Force Concept Inventory were found to be $\alpha = 0.71$ and 0.65 respectively. These coefficients ensured that the instruments were reliable to be used in actual data collection.

Sample of the study

The Physics education undergraduates in Universiti Teknologi Malaysia undergo four years of study in their Physics education course. However, there is no enrolment for third year Physics education undergraduates in this academic session (2009/2010). The Physics education undergraduates who are in their second year of studies have already involved earlier in the pilot study so they are not included in the actual research. Since the population of Physics education undergraduates in the university is small ($N < 100$), so for this research all the Physics education students who are in their first year and final year of study are tagged as respondents. Moreover, one of the objectives of the research is to find out if there is any significant increase in epistemological beliefs, learning attitudes and conceptual understanding between the first year (entry point) and final year (exit point) Physics

education undergraduates, so the sample of respondents include all the first year and final year Physics education course students (N = 68).

Research Procedure

During the study, the Physics Epistemological Beliefs & Attitudes Test and the Force Concept Inventory were administered to the respondents (N = 68). The respondents spent approximately 30 minutes on answering the Physics Epistemological Beliefs & Attitudes Test, and spent about an hour on answering the Force Concept Inventory.

Findings and Discussions

The data collected from the research are then analyzed accordingly by using descriptive and inferential statistics data analysis techniques. t-test and Pearson correlations are used to determine the significant difference between the groups of respondents and the significant relationships between the variables respectively.

Epistemological beliefs, learning attitudes and conceptual understanding

In this study, the sophistication of epistemological beliefs represents the degree or level of epistemological beliefs variable. As an indicator of epistemological beliefs sophistication, a score range of (68-100%) is categorized as “High”, (34-67%) is categorized as “Moderate” and (0-33%) is categorized as “Low”. As for the learning attitudes variable, score range of (50-100%) is categorized as “Positive” learning attitudes whereas score range of (0-49%) is categorized as “Negative” learning attitudes. For the conceptual understanding variable, score range of (85-100%) is categorized as “High”, (60-84%) is categorized as “Moderate” and (0-59%) is categorized as “Low” conceptual understanding in Newtonian force concept as suggested by Hestenes and Halloun (1995). The findings show that the mean scores obtained by the overall undergraduates in the epistemological beliefs test and learning attitudes test are 69.05% and 72.10% respectively. The results indicate that generally the undergraduates hold high sophistication of epistemological beliefs and favorable or positive attitudes in learning Physics. However, poor conceptual understandings in Newtonian force concept due to misconception are detected among the undergraduates.

Table 4.1: Mean scores for epistemological beliefs, learning attitudes and conceptual understanding (N = 68)

Variable	Mean score (%)	Indicator
Epistemological beliefs	69.05	High
Learning attitudes	72.10	Positive
Conceptual understanding	24.47	Low

Relationships between epistemological beliefs, learning attitudes and conceptual understanding

In this study, Pearson correlation shows that epistemological beliefs variable is significantly correlated with the conceptual understanding variable with the coefficient of .607 at alpha level .01. The data analysis also shows that epistemological beliefs variable is significantly correlated with the learning attitudes variable with the coefficient of .563 at alpha level .01. The result indicates that the undergraduates' epistemological beliefs towards learning Physics correlates with their interest, motivation and readiness in learning Physics. Learning attitudes variable also correlates significantly with conceptual understanding variable with the coefficient of .496 at alpha level .01. The finding indicates that the affective and behavioral components of the learning attitudes like interest, motivation and readiness to learn contribute to the achievement of the students based on their conceptual understanding in Newtonian force concept. The findings in this research show that there are significant relationships between epistemological beliefs, learning attitudes and conceptual understanding. The findings are in line with Hofer's (2001) findings which described that the relationships exist among epistemological beliefs, motivation, and learning are essential, especially in the real educational settings as it has shown that epistemological beliefs affect motivation as well as the students' achievement.

Table 4.2: Pearson correlation results between epistemological beliefs, learning attitudes and conceptual understanding.

		Epistemological Beliefs	Conceptual Understanding	Learning Attitudes
Epistemological Beliefs	Pearson Correlation	1	.607**	.563**
	Sig. (2-tailed)		.000	.000
	N	68	68	68
Conceptual Understanding	Pearson Correlation	.607**	1	.496**
	Sig. (2-tailed)	.000		.000
	N	68	68	68
Learning Attitudes	Pearson Correlation	.563**	.496**	1
	Sig. (2-tailed)	.000	.000	
	N	68	68	68

**. Correlation is significant at the 0.01 level (2-tailed).

Gender differences in epistemological beliefs, learning attitudes and conceptual understanding

The finding in this study shows that there are statistically significant differences (α = .05) across gender in epistemological beliefs. Female undergraduates (M = 70.44; SD = 5.24) obtain higher mean scores in epistemological beliefs test compared to their male (M = 66.81; SD = 4.48) counterpart. Higher mean scores indicate higher sophistication of epistemological beliefs. For instance, the findings show that the female undergraduates with

higher sophistication of epistemological beliefs are more convinced that learning Physics make them understand better of the world and Physics knowledge is relevant, useful in their daily life compared to their male counterpart. The t-test results also indicate that there are statistically significant differences (α = .05) in learning attitudes across gender. Higher mean scores are achieved in both interest and motivation subscales in the learning attitudes tests which are in favor of female undergraduates. Other t-test results also reveal that there are significant differences across gender in epistemological beliefs towards the structure of Physics knowledge subscale and the application of Physics knowledge subscale as shown in Table 4.1.

Table 4.3: t-test results for gender differences in epistemological beliefs, learning attitudes and conceptual understanding

Variable	**Subscale**	**Physics Education Undergraduates N = 68 (α = 0.05)**		
		Gender	**Mean**	**Sig. (2-tailed)**
Epistemological Beliefs	Structure of Physics knowledge	M = 26	64.36	.001
		F = 42	71.31	
	Application of Physics knowledge	M = 26	77.47	.018
		F = 42	82.58	
	Acquisition of Physics knowledge	M = 26	61.00	.467
		F = 42	62.16	
	Problem solving in Physics	M = 26	64.42	.525
		F = 42	65.71	
Learning Attitudes	Interest in learning Physics	M = 26	72.15	.001
		F = 42	80.76	
	Motivation in learning Physics	M = 26	68.72	.011
		F = 42	75.87	
	Readiness in learning Physics	M = 26	63.38	.129
		F = 42	67.14	
Conceptual Understanding	Newtonian force concept	M = 26	23.63	.626
		F = 42	25.00	

Epistemological beliefs, learning attitudes and conceptual understanding between first and final year undergraduates

The data analysis shows that there are statistically significant differences (α = .05) in epistemological beliefs between first and final year undergraduates. The final year undergraduates (M = 70.76; SD = 5.20) obtain higher mean score in sophistication of epistemological beliefs compared to the first year students (M = 65.94; SD = 3.83). The finding shows that the final year undergraduates believe that Physics knowledge is in tentative and constantly evolving mode whereas the first year undergraduates tend to believe that Physics knowledge is fixed and in absolute mode. This finding is consistent with Schommer's (1994) study which suggested that epistemological beliefs change over time. Education is being one factor that is influencing this epistemological development. The higher the educational level achieved by adults, the more likely they are to believe that knowledge is constantly evolving and highly complex (Schommer, 1998). In the learning attitudes aspect, the data analysis in this study shows that there is a statistically significant difference (α = .05) in the aspect of interest to learn Physics between the first year and final year undergraduates. The final year undergraduates (M = 80.00; SD = 10.81) gain higher mean scores compared to the first year undergraduates (M = 72.83; SD = 7.73) in the aspect of learning interest. However, there is no significant difference in learning motivation and readiness to learn Physics between the first and final year undergraduates. In the conceptual understanding aspect, the data analysis in this study shows that there is a statistically significant difference (α = .05) in the conceptual understanding aspect between the first year and final year undergraduates. The final year undergraduates (M = 27.60; SD = 11.41) gain higher mean score compared to the first year undergraduates (M = 18.75; SD = 8.24) in the FCI test score results. In other words, the final year undergraduates performed slightly better compared to the first year undergraduates. Despite that, the final year undergraduates still considered as having poor conceptual understanding in the Newtonian force concepts as their FCI mean score (M = 27.60) is way below the 60% mark as the threshold for understanding Newtonian mechanics as suggested by Hestenes *et al.* (1992).

Conclusion

This study concludes that there are some significant relationships between epistemological beliefs, learning attitudes and conceptual understanding. Gender differences in those three aspects are also being detected in this study. Apart from that, the findings in this study also

indicate that there are significant increase in epistemological beliefs, learning attitudes and conceptual understanding between the first year (entry point) and final year (exit point) Physics education undergraduates. For future research, this kind of study is suitable to be conducted at school level by teachers as an approach to study the epistemological beliefs of the secondary school students and its influence on the students' achievement and conceptual understanding. The study may elucidate the Physics teachers in particular to get an idea on how the Physics students are thinking, their personal epistemological beliefs, perceptions and attitudes towards learning Physics. Thus, an enhanced effort by teachers to improve students' positive epistemological beliefs about learning Physics, perceptions and attitude will certainly result in improved performance in Physics achievement.

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