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GENDER, PERCEPTION OF LEARNING PHYSICS AND PERFORMANCE IN UNIVERSITY PHYSICS: A CASE STUDY FROM CHINA

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Introduction

In China, a large number of university students are required to take calculus-based university physics course. University level physics is studied mainly by three groups: (1) students of engineering and physical sciences; (2) medical students; and (3) those who need some background in physics. University physics courses deal with topics such as mechanics, heat, electricity, magnetism, light and atomic structure.

Problem of Research

Some students believe that physics learning is primarily learning facts and independent pieces of information while other students see learning as development an understanding of how information is obtained and how it all fits together. So studying perception of physics is important because it influence motivation and affect the selection of learning strategies by students (Hofer and Pintrich, 1997; Etten et al., 1997; Maloney, et. al., 2001). These perceptions play a critical role in how the students approach the coursework in a physics course and consequently, what they learn in the course (Prosser 1996). Students who believe that they must memorize all the details of lectures and reading assignments will have different learning outcomes than students who spend their studying energies on trying to discern and understand the big concepts presented in the course and how these concepts are supported through observations. Work by Sadler and Tai (2001) indicate that students' perceptions are better predictors of university science performance than the amount of high-school science or math they have completed.

Abstract. *In this study, the researcher has developed and validated an instrument focus on perception of learning physics, which builds on Maryland Physics Expectations survey (MPEX). It was administered to first-year university students in a Chinese university during the autumn semester of 2011. It was found that female students preferred physics learning by relating and by analysis, which were positively correlated to better performance in physics. Male students preferred physics learning by rote which was negatively correlated to performance in university physics. So physics learning perception differences based on the gender also exist in China. At the same time, no significant gender difference found on the performance in university physics. The results were similar to the studies in the Western countries and have pedagogical implications for instructors of university physics and potentially for other science courses.*

Key words: *gender, perception of learning, physics education, science education.*

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Over the past decade, there are considerable research in western countries have indicated that male and female students are different in their perceptions of physics (DeBoer 1986; Zohar, 2003; McCullough, 2004; Lorenzo et al., 2006). Feminist scholars report about women's need to relate and connect with their objects of study (Belenky et al., 1986; Maccoby & Jacklin 1974). Kahle & Meece (1994) found that girls seemed to think they understand a concept only if they can put it into a broader world view while boys appeared to view physics as valuable and learned the concepts in an internal coherent way. With regard to social and linguistic behavior, Stadler et al. (2000) reported that high school boys and girls hold different notions of physics. Kost et al (2009) reported that there are gender differences in students' performance on conceptual surveys, attitudes and beliefs about physics, and high school education.

A number of surveys have been created to measure various aspects of student's perception of learning or understanding physics and expectations of the physics course. Two well known student perception surveys were the Colorado Learning Attitude about Science Survey (CLASS) constructed by Adams et al (2004; 2006) at the University of Colorado and the Maryland Physics Expectations survey (MPEX) developed by Redish et al (1997; 1998)). The CLASS is an instrument designed to measure student beliefs about physics and learning physics. The survey contains 42 items that ask students to rate their agreement. Students taking the MPEX survey are asked to rate their agreement with 34 items using a five option Likert scale, that ranges from strongly disagree to strongly agree to probe students' epistemological beliefs about learning and understanding physics as well as their expectations about the physics course. In this study, the researcher has developed and validated an instrument, which is built on the basis of MPEX. This survey probes students' perception only about learning physics and not includes perception of physics.

Research Focus

In this study, the meaning of "perception of learning" is about students' understanding of the process of learning physics rather than "perception" namely feelings about the content of physics knowledge itself. Students always focus on what they need to do to succeed in the grade and ignore main goal in physics training, to learn how to think logically and analytically. The "perception of learning" should refer to the real learning goal.

While the perception survey has been used widely by many physics education researchers in western countries' universities, no single research in China is reported where the path based on the nature of gender and the perception of university physics learning has been investigated. Because of this reason, the study conducted in China is much needed. It should be noted here that our research work has been carried out in a Chinese Confucian Heritage Cultures (CHC) environment which is different from other western countries (Watkins & Biggs, 1996; Chan & Watkins, 1994). In China, students tend to be shy and have a high respect for their instructors and professors. During classes, they are generally sitting, listening, taking notes, and rarely asking questions (Holbrook, 1990). Many students take physics courses because it is one of the subjects required in the university. Most of them focus on passing the course and learning by memorization rather than understanding the physics concept. In this study, we conducted a survey to find answers to these questions as follows: 1. Were perceptions of physics learning in China associated with their performance in university physics course? 2. Were male and female students in China significantly different in their performance in university physics? 3. Were there differences between Chinese male and female students in their learning perceptions in university physics courses?

Methodology of Research

General Background of Research

The purpose of this study is to investigate the relationships between gender and perception of learning physics and performance of university physics in a Chinese university (University of Science and Technology Liaoning). The variables were the students' gender, perceptions of learning university physics course, and performance in the course.



Sample of Research

The projected sample was from 500 students majored in engineering who were taking the university physics courses (PHYS 1102) offered by the Department of Physics at the University of Science and Technology Liaoning (USTL) during the Autumn semester of 2011. PHYS 1102 is a 5-credit calculus-based physics course for students majoring in engineering. Only 453 students completed their respective courses and altogether 280 students completed the survey. Prior to any data analysis, 15 surveys were eliminated for containing no name on the consent form, leaving a total of 265 surveys for analysis. One hundred and sixty participants (60%) were male and 105 participants (40%) were female. The number and percentage of participants by gender are presented in Table 1.

Table 1. The number and percentage of participants by gender.

Gender	Number	Percentage
Male	160	60
Female	105	40
Total	265	100

Instrument and Procedures

In order to explore student perceptions of learning physics and the performance in the physics course, a survey instrument was designed for this purpose. The consent form to participate in the study asked students to provide their names, gender and permission to collect their grades from the instructor of the physics course they were taking after the course was completed. Another survey instrument for this study was used to determine students' perceptions from the physics course. Since the MPEX survey was specifically designed for a calculus-based introductory physics course and the author was also familiar with its original version, considering some overlap among MPEX items, the researcher developed and validated an instrument, which builds on MPEX. Five independent statements with 5-Likert scale from strongly disagree (1) to strongly agree (5) were selected from MPEX as five factors to probe the students' perceptions of physics learning. Five statements in English version are shown as follows:

- Statement 1, "Understanding" physics basically means being able to recall something you've read or been shown. (MPEX Q27)
- Statement 2, to understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed. (MPEX Q18)
- Statement 3, I use the mistakes I make on homework and on exam problems as clues to what I need to do to understand the material better. (MPEX Q31)
- Statement 4, all I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems. (MPEX Q2)
- Statement 5, the best way for me to learn physics is by solving many problems rather than by carefully analyzing a few in details. (MPEX Q9)

Five statements were named in short, physics learning by rote (factor 1), physics learning by relating (factor 2), physics learning by analysis (factor 3), physics learning through formula proof (factor 4), and physics learning through practice problems (factor 5).

Since English is not the native language for Chinese people, instruction was given in Chinese and a translation was needed. The translation was carefully performed by a group of two experienced physics professors and two English professors. The Chinese version of the test used technical terms that were understandable by first-year students. Each question was translated in a way that all its original meanings were kept and no further explanations were given. The translation into Chinese was validated by 5



academic staff and 31 students in the physics department at the University of Science and Technology Liaoning (USTL). They were asked to do both Chinese and English versions of the survey. The Chinese version was given first and then the English one. Therefore, the staff and students had no chance to translate the test on their own. With a minor adjustment of the translation, all of the staff and students arrived at the same answers for each question in both the Chinese and English versions.

The survey was approved by the University of Science and Technology Liaoning Institutional Research Board on September 15, 2011. The researcher contacted the physics instructors about surveying their students in the classroom. The purpose of the research was explained to them, they understood that they had no access to the survey results and also agreed to provide the grade reports of the class. The survey was conducted during the two weeks period from September 19 to September 29, 2011. All the instructors announced the date of the survey 3 days prior to the survey. The survey was conducted at the beginning of the class session. All of the instructors introduced the researcher to the students explaining the purpose of research, the benefit to the subjects, their voluntary participation, and the issues of confidentiality. The researcher then explained the consent form, the procedure for data collection, the storage of confidential information, and future contact with the participants. After the concerns of students were answered, the researcher distributed the survey package to students. It took about 5 minutes to complete the surveys. All of the instructors left the classrooms during the survey in order to provide a sense of voluntary participation.

At the end of the semester, the instructors provided the final letter grades for each class to the researcher for statistical analyses. The researcher removed the grades of those students who had not provided consent got the modified grade report for statistical analyses. The confidentiality of the participants, instructors, and the grades reported from the physics course was preserved.

Data Analysis

Descriptive statistical procedures such as number and percentage and inferential statistical procedures such as correlation and t-test were used to analyze the data to determine the relationships among variables. All statistical procedures were performed with the Statistical Package for the Social Science (SPSS version 19.0). The statistical significance in this study was set at a 0.05 level with two-tail tests.

Results of Research

The purpose of this study was to investigate the relationships between gender, learning perceptions in physics, and performance in university physics courses taken at the USTL. The students' final letter grades were submitted by the instructors at the end of the semester. Overall, ninety percent of the participants received a C or better grade while one-tenth received an unsatisfactory grade, D or F. The number and percentage on the performance of the university physics courses are showed in Table 2.

Table 2. Number and percentage on the performance of the university physics courses.

	Final Grade									
	A		B		A		B		B	
	N	%	N	%	N	%	N	%	N	%
Male	53	33	8	36	34	21	10	6	5	3
Female	36	34	38	36	21	20	8	8	2	2
Total	89	34	96	6	55	20	18	6	7	2

Were learning perceptions of students associated with their performance in a university physics course? In order to compare the relationships between these five factors in physics learning perception, as they apply to the participants, and performance in the university physics courses, multiple regression and Pearson correlation were used to perform on these variables.



In the analysis, it was found that the combination of five perception factors accounted for 25.0% of the variance ($R^2=0.250, p<0.001$) of the performance in university physics. An examination of correlation coefficients was then used to study the individual perception factors to compare the relative strength of each independent variable. Two of the five perception variables, physics learning by analysis ($r=0.320, p<0.01$) and physics learning by relating ($r=0.132, p<0.05$) were positively correlated with performance in university physics course. In contrast, physics learning by rote was negatively correlated ($r=-0.336, p<0.01$) with performance in the physics courses. Pearson correlation coefficients of the five learning perception factors with physics performance are presented in the Table 3.

Table 3. Correlation of the five factors with performance in the physics courses.

Pearson correlations				
Rote	Relating	Analysis	Proof	Practice
-0.336**	0.132*	0.320**	0.049	-0.064

*Multiple correlation $R=0.500$ *** * $p<0.05$ ** $p<0.01$ *** $p<0.001$*

Were male and female students significantly different in their performance in university physics? When comparing the final grades with t-tests to determine whether there were differences between male and female participants, no significant differences by gender were found among 265 participants. The means, standard deviation, and the t-values of the physics performance compared by gender are presented in the Table 4.

Table 4. Gender comparison on means, standard deviation, and the t-Test results on the university physics.

Gender	Number	Mean	SD	Differ	t	df	p
M	160	3.90	1.04	-0.033	-0.26	226	0.795
F	105	3.93	1.01				

M= Male, F= Female

Were there differences between male and female students in their learning perceptions in university physics courses? Table 5 shows the responses in comparing gender with mean and the t-test results of the five learning perceptions in the university physics course.

Table 5. Gender comparison on the learning perceptions in the university physics courses.

Perceptions	Gender	Mean	SD	Differ	t	df	p
Rote	M	3.31	1.05	0.60	5.16	252	0.000
	F	2.71	0.84				
Relating	M	2.72	0.84	-0.27	-2.45	228	0.015
	F	3.27	1.02				
Analysis	M	3.08	0.93	-0.27	-2.41	230	0.017
	F	3.35	0.88				
Proof	M	3.08	0.93	-0.14	-1.12	207	0.265
	F	3.2	1.02				
Practice	M	3.18	0.98	0.05	0.38	207	0.704
	F	3.13	0.99				

M=Male, F=Female



When comparing the differences between male and female participants on the learning perceptions, there were significant differences observed for physics learning by rote, by relating, and by analysis.

The mean scores for female participants on Factor 2 (Relating) and Factor 3 (Analysis) were higher than the mean scores for male participants. This indicates that female participants believed that when learning physics, they tried to relate physics material to their personal experiences and attempt to comprehend the physics concepts by paying more attention in class, reading the textbook more carefully, and working on more practice problems.

In contrast, the mean scores from male participants on Factor 1 (Rote) were higher than the mean scores for female participants. This shows that male participants believed that finding the right equation in solving physics problem and being able to recall the physics material or the equations needed for an exam problem should be the way to learn physics. However, there were no significant differences between male and female participants observed in the other three factors.

Discussion

In this study, no significant gender differences were found in their performance in the university physics courses. So it delivered some messages to physics instructors and physics education researchers: Female students performed comparably with their male counterpart; male students did not outperform female students in the university physics class.

Students perceive that their role as students is to memorize the facts and formulas and reproduce them on exams (Zohar, 2006). So it is essential for students to understand main goal in physics training, which is not only to teach student physics knowledge but also to learn how to think logically and analytically (McDermott 1993). The above findings suggested that students performed well in the introductory physics depending upon how relate and analyze the subjects they had learned. Therefore, in order to change the students' perception of learning, it must be addressed by the university physics teachers. They can use some methods such as warming up questions prior to presenting course material in the class, computer simulations and laboratory demonstrations to help their students to grasp and not just memorize the concepts of physics.

Recommendations for Further Research

Several recommendations for further research are generated as follows:

1. It is recommended that a study must be conducted to investigate the relationships between performance in university physics and demographic characteristics such as age, parents' occupation and level of education, high school senior grade point average. Because in this analysis, it was found that the combination of five perception factors accounted only for 25.0% of the variance ($R^2 = 0.250$, $p < 0.001$) of the performance in university physics.
2. It is recommended that a qualitative study should be conducted. Through unstructured interviews of some students, we can gain more insights into their perception.
3. It is recommended that this quantitative study must be extended to a longitudinal study. The survey should be conducted twice, one as a pre-test and one as a post-test, it can allow comparison of data from the same students.

Conclusions

In this study, a developed instrument which builds on Maryland Physics Expectations survey (MPEx) was used to investigate the relationships between gender and perception of learning physics and performance of university physics in a Chinese university (University of Science and Technology Liaoning). Although no significant gender difference found in their performance in university physics, perception of learning physics differences based on the gender exist in China. Female students preferred physics learning by relating and by analysis, which were positively correlated to better performance in physics. Male students preferred physics learning by rote which was negatively correlated to performance in



university physics. This is consistent with the findings of previous published studies of Western countries. No single research on the topic has been reported before in China, it should be an important supplement to this traditional research for the international compare education.

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