ENGINEERING STUDENTS' EXPECTATIONS AND PERFORMANCE IN INTRODUCTORY PHYSICS

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Abstract

Admittedly, the expectations of engineering students can play a significant role in what they benefit from their physics courses. The study aimed to determine the predictors of student grades in introductory physics course at Batangas State University (BSU) by using descriptive/correlational methods to investigate and describe/explain relationships of students' physics grades with their physics expectations, gender, and class sessions. The responses of the 99 engineering students at BSU on the items in the Maryland Physics Expectations (MPEX) survey instrument were compared with the experts' responses. The result showed that students' overall expectation scores improved significantly between the beginning and the end of the physics course during the first semester of the SY 2010-2011. Males are more likely to have higher percentage of agreement to favorable responses prior to instruction than females. Both respondents, however, were more likely to have similar physics expectations after one semester instruction. Respondents in different sessions were more likely to have similar physics expectations before and after one semester instruction. Their overall post instruction physics expectations are significantly correlated with their physics performance. Moreover, the study revealed that an expert-like belief in the concept and effort link dimensions correlate highly with good physics performance.

Introduction

For the past years, engineering courses have attracted many students. In our own institution, the BSU, approximately 800 students enter the engineering programs as freshmen each year, but not all of them actually graduate as engineers. Most of those who leave the engineering program actually graduated in some other disciplines. It is observed that most of the courses failures and drop-outs occur in the first two years, before entering into major discipline courses. Since the decrease in the enrolment occurs when the students are studying pre-engineering mathematics and science courses (one of them is Physics), a great deal of effort and major resources must be devoted to Physics instruction in that it is considered as the fundamental science underlying all of engineering, science and technology courses. For all engineering majors, the Physics courses are prerequisite to entering and performing well in subsequent engineering courses.

Considering the experiences of the researcher in teaching Physics to engineering students for thirteen years and observing the students' attitudes in the physics class, and interviewing physics instructors, he can say that they find Physics though necessary, the most formidable subject in the general engineering curriculum. It has been observed that many students approach the course with a negative attitude, because they think that it is a very difficult subject even before they actually take it.

Most professors in an introductory physics course expect students to do and think "like a physicist" (Redish, 1997) regardless of what students expect. Indeed, more than a large yawning gap exists between students' expectations and their professors; for instance, in the Maryland Physics Expectations (MPEX) project, the Physics Education Research Group at the University of Maryland investigated the

distribution of student expectations at the beginning of the course, the effect of their expectations on the behavior during the course, and the effect of the course on changing their expectations (Redish, 2002). The result of the study indicates that there was a significant gap between expert responses to the survey and those of novice students.

The phrase *course* expectation was used (Redish, Saul, and Steinberg, 1998) to represent students' prior conceptions, attitudes, beliefs, and assumptions about what sorts of things they will learn, what skills will be required, and what they will be expected to do in addition to their view of the nature of scientific information in a physics classroom. The present study used such term in the same context as above.

Instructors in science courses may have implicit expectations about what students should learn and how to learn it (Lin, 1982). To illustrate, in reports of Hammer (1994), it was found out that some students consider physics as weakly connected pieces of information to be learned separately, whereas others see it as a coherent set of ideas to be learned together. Some of them even perceive learning physics as memorizing formulas and problem solving algorithms, while others think that learning it involves developing a deeper conceptual understanding. Still some hold wrongly that physics is disconnected to the real world, while a number hold that ideas learned in physics are relevant and useful in a wide variety of real contexts. These preconceptions may inhibit student's learning of the required material in their physics course (Mistades, 2007).

The students' views, expectations, and beliefs about physics and science in general were measured using surveys, guided interviews, and observations (Kortemeyer, 2007). Surveys are the most frequently used

instruments for this purpose. Examples of these are the MPEX developed by Redish and his colleagues (1998) to determine students' expectations about what they know and believe about physics and learning physics; the VASS (View about Science Survey) developed by Halloun (1997) which probes students' view about the nature of science and about what it takes to learn science; the EBAPS (Epistemological Beliefs Assessment Survey) by Elby et. al. (1999) which measures how students function in a real science class rather than what they think about how they should function in an idealized situation. The most recent is CLASS (Colorado Learning Attitudes about Science Survey) developed by Adam et. al. (2004) that measures various facets of student attitudes and beliefs about learning physics.

Interestingly, previous research has found correlations between epistemological beliefs and academic performance. In a case study made by Capizzo, Nuzzo, and Zarcone (2006), for example, they investigated the relationship among some pre-instructional knowledge, the learning gain, and the final physics performance of a sample of 47 computing engineering freshmen students in an introductory physics course at the University of Palerno, Italy. Their study yielded that students' learning gain in physics was independent of their initial level of mathematics skills and physics knowledge. Initial logic skills and reading comprehension abilities were not significant factors either for the learning physics gain and the performance in physics. Another research conducted by Mistades (2006) at the De La Salle University utilizing the MPEX revealed that the beliefs of the students obtaining the highest grades those who obtained low grades are significantly different. His study has shown that an expert-like belief in the coherence dimension correlates highly with good academic performance. Similarly,

Kortemeyer (2007) correlated the MPEX and the measure of student learning (final exam, Force Concept Inventory, and course grade). The highest reported correlation, r = 0.36, was determined between the score on the coherence cluster and the course grade percentage.

The MPEX was also used by Ornek, Robinson, and Haugan (2008) to investigate how those expectations, attitudes, and beliefs about the university physics course based on modelling instruction and interactive engagement are compared to those of students in other physics courses and how they are changed as a result of physics instruction. The results yielded that the innovative instruction produces an average deterioration in the students' expectations, attitudes and beliefs. The beliefs of those students under innovative instruction appear more sophisticated and professional than those in other physics courses. For their part, the study conducted by Sahin and Yorek (2009) utilized the MPEX to compare problem-based learning (PBL) and traditional lecture students' expectations about physics and physics learning and course grades in an introductory physics classroom. Results of this study suggested that PBL approach has no positive influence on students' achievement in physics and in the expectations about physics for the freshman engineering students of Dokuz Eylul University in Turkey. Significant differences were also determined in some components of the MPEX with respect to gender and instruction type.

In the present research, the focus is on the studies using the MPEX because there are many investigations collecting data using the MPEX. Also, the MPEX was translated into Thai language and often used in exploring Thai students' expectations in introductory physics (Wutchana et al., 2007). To this effect Wutchana and Emarat (2011)

found that pre-course MPEX scores of Thai first year students taking an introductory physics course positively correlated with their conceptual understanding and problem solving abilities. Administered at the beginning of the course during academic years 2007- 2008, the MPEX were correlated with each student's normalized gains from Force and Motion Conceptual Evaluation (FMCE) results and student's scores on the final exam. The study revealed that students' MPEX scores showed significantly positive correlation with their final exam scores for all MPEX clusters, except for the effort cluster. A follow-up interview with two groups of students that had low and high favourable scores on the precourse MPEX effort cluster was also conducted. The finding yielded that the student responses on the MPEX effort cluster did not match their behaviours in studying physics.

Similarly, May and Etkina (2002) found that students with high conceptual gain were more likely to show learning activities in line with those identified as beneficial in the literature. They were able to reflect on the knowledge construction by reasoning process, interpreting of experimental results, and associating knowledge to their personal experience. The Force Concept Inventory (FCI) was administered before and after the instruction and structured interviews were done to obtain students' epistemology views and learning strategies. The study revealed that students with low conceptual gain were frequently referred to learning activities that are less desirable epistemologically such as memorizing formulas, learning from authority, and solving problems without interpretations. This study confirmed that sets of beliefs and expectations or epistemology aspects impact on students' conceptual understanding.

With the hope to add to the previous researches in examining the role of expectations in physics learning and concern for the quality physics instruction, the present study deals with finding out the physics expectations and the physics performance of general engineering students at the Batangas State University. Specifically, the present study seeks to:

1. Identify the profile of general engineering students in terms of

    1.1 gender

    1.2 physics performance

    1.3 class session

    1.4 physics expectation

2. Determine a significant difference between the physics performance of the students when grouped according to

    2.1 gender

    2.2 class session

3. Compare the initial and final state of students' expectation in university physics from the experts.

4. Find out how the expectations of a class changed as a result of one semester physics instruction.

5. Ascertain a significant difference between the physics expectations of the students when grouped according to

    5.1 gender

    5.2 class session

6. Establish a significant relationship between physics performance and physics expectation.

7. Look into the MPEX dimensions that can significantly predict the performance of students in physics.

Hypotheses

The study hypothesizes that:

1. There is no significant difference between the physics performance of the students when grouped according to
   a. gender
   b. class session

2. There is no significant difference between the initial used final state of students' expectation in university physics and that of the experts.

3. The expectations of a class did not change as a result of one semester physics instruction.

4. There is no significant difference between the physics expectations of the students when grouped according to
   a. gender
   b. class session

5. There is no significant relationship between physics performance and physics expectations.

6. The MPEX dimensions did not significantly predict the student's performance in physics.

Methodology

This descriptive/correlational study attempts to determine and compare engineering students' expectations in an introductory physics course as well as identifies correlational relationships of students' performance in physics, scores on the MPEX, and selected demographic variables, such as gender (male or female) and class session (AM or PM).

The students' physics performance was determined from their final numerical grade point in PHY-251 (Fundamentals of Physics-I) during the first semester SY 2010-2011. These grades were calculated from 4 major sources - examinations, quizzes, homework exercises, and laboratory performance. Only the available students' final grades measured their physics performance and used as the dependent variable. At the BSU, all engineering students are regarded as having similar science and mathematics background. The respondents were taught by the same physics professor, hence, assessed them using the same tests in all exams. In this study, the physics performance was interpreted as follows:

NUMERICAL GRADE POINT	INTERPRETATION
1.0	1 = Outstanding
1.25, 1.5, 1.75	2 = Very Satisfactory
2.0, 2.25, 2.5	3 = Satisfactory
2.75, 3.0	4 = Fair
5.0, dropped	5 = Poor

The students' expectations were documented using the Maryland Physics Expectation (MPEX) Survey, a 34-item Likert-scale (Agree-Disagree) survey developed by the Maryland Physics Education Research Group as part of the project to study the attitudes, beliefs, and expectations of students that have an effect on what they learn in an introductory physics course. A description of the development, validation, and calibration of the instrument may be found in the paper by Redish, Saul, and Steinberg (1998). It consists of six dimensions along which to classify student beliefs about the nature of learning

physics: Independence, Coherence, Concepts, Reality Link, Math Link, and Effort Link.

Independence – beliefs about learning physics – whether it means receiving information or involves an active process of reconstructing one's own understanding. MPEX ITEMS: 1, 8, 13, 14, 17, 27, 33, 34

Coherence – beliefs about the structure of physics knowledge – as a collection of isolated pieces or as a single coherent system. MPEX ITEMS: 12, 15, 16, 21, 29

Concepts – beliefs about the content of physics knowledge – as formulas or as concepts that underlie the formulas. MPEX ITEMS: 4, 9, 19, 23, 26, 27, 32

Reality Link – beliefs about the connection between physics and reality – whether physics is unrelated to experiences outside the classroom or whether it is useful to think about them together. MPEX ITEMS: 5, 10, 11, 18, 22, 25, 30

Math Link – beliefs about the role of math in learning physics – whether the mathematical formalism is just used to calculate numbers or is used as a way of representing information about physical phenomena. MPEX ITEMS: 2, 6, 8, 15, 16, 20

Effort – beliefs about the kind of activities and work necessary to make sense out of physics – whether they expect to think carefully and evaluate what they are doing based on available materials and feedback or not. MPEX ITEMS: 3, 6, 7, 24, 31, 28

The MPEX was administered to the second year general engineering students of the BSU during the first semester of the SY

2010-2011 on the first day of physics class and again before the final exams at the end of the semester. Pre-administration data were collected from 105 students; however, to obtain matched pre-post data, only 99 students who took the MPEX as both a pre- and a post-assessment were included. The results were presented by specifying the percentage of favorable versus unfavorable responses to the items in six dimensions. A "favorable" response is defined as one in agreement with the responses of experts (experienced physics instructors who have a high concern for educational issues and a high sensitivity to students) and an "unfavorable" response as one in disagreement with that on the expert. Following the data analysis made by Redish (1998), agree and strongly agree responses (4 and 5) were added together and disagree and strongly disagree responses (1 and 2) fused. The percentage of neutrals and unanswered responses can be obtained by subtracting the sum of the favorable and unfavorable responses from 100.

Data were analyzed using SPSS 11.5 statistical analysis program. Means, standard deviations, and standard errors were determined, while the t-test, correlation, and linear regression analyses conducted.

Results and Discussions

The respondents' distribution by gender and physics performance follows: One(1) male respondent and none female had an outstanding performance; six(6) male and six(6) female respondents had a vey satisfactory performance; twenty three(23) male and fourteen(14) female respondents performed satisfactorily in physics; twenty-one(21) male and nineteen(19) female respondents have fair performance in physics; and four(4) male and five(5) female performed poorly. The means and

standard deviations of physics performance of the students by gender are shown in Table 1.

Table 1. Means and standard deviations of the students' physics performance by gender

	GENDER	N	Mean	Std. Deviation	Std. Error Mean
GRADE	Male	55	3.38	0.850	0.115
	Female	44	3.52	0.876	0.132

The physics performance of the male respondents has a mean of 3.38 to indicate a satisfactory performance in introductory physics, while that of the female respondents' is 3.52, considered fair.

Here is the respondents' distribution by class sessions and physics performance: One(1) respondent attending the AM session and none attending the PM session had an outstanding performance; twelve(12) attending the AM session and none attending the PM session had a very satisfactory performance; thirty(30) attending the AM session and seven(7) attending the PM session performed satisfactorily in physics; twenty five(25) attending the AM session and fifteen(15) attending the PM session had fair performance; and three(3) attending the AM session and six(6) attending the PM session performed poorly. As shown in Table 2, the mean performance of the students attending the AM session is 3.24 which indicates satisfactory performance. In contrast, the students attending the PM session performed fairly in physics with a mean performance of 3.96.

Table 2. Means and standard deviations of the students' physics performance by class sessions

	SESSION	N	Mean	Std. Deviation	Std. Error Mean
GRADE	AM session	71	3.24	0.836	0.099
	PM session	28	3.96	0.693	0.131

As seen in Table 3, the computed t-value of -0.809 with a p-value of 0.421 ($p>0.05$) indicates that the null hypothesis is not rejected.

Table 3. T-test analysis of the significant difference between the performances of students when grouped according to Gender

Gender	p-value	Computed t-value	Decision	Verbal Interpretation
Male				
	0.421	-0.809	Do not	Not Significant
Female			reject Ho	

This means that there is no significant difference between the physics performance of the male and female respondents.

As shown in Table 4, the computed t-value of -4.412 with a p-value of 0.000 ($p<0.05$) indicates that the null hypothesis is rejected. This means that there is a significant difference between the physics performance of the respondents attending the AM and PM sessions. The respondents attending the AM session are more likely to perform better in physics than those in the PM session.

Table 4. T-test analysis of the significant difference between the performances of students when grouped according to class sessions

Class Sessions	p-value	Computed t-value	Decision	Verbal Interpretation
AM PM	0.000	-4.412	reject Ho	Significant

The initial state (Pre-MPEX Score) and the final state (Post-MPEX Score) of students' expectations in introductory physics were compared from the experts' view, as shown in Table 5. The respondents agreed with the experts' responses about 9% - 92% of the time during the start of the semester, while 26% - 91% of the time during the end of the semester in the dimensions of the MPEX.

Table 5. Percentage of students' favorable/unfavorable responses on overall and dimensions of the MPEX.

Groups	Overall	Ind.	Coh.	Con.	Reality	Math	Effort	n
Experts	87/6	93/3	85/12	89/6	93/3	92/3	85/4	
BSU Pre	65/34	66/33	9/90	37/62	83/16	50/49	92/7	99
BSU Post	74/25	70/29	26/73	34/65	87/12	76/23	91/8	99

On the overall MPEX, 65% of the respondents are in agreement with the experts during the first application of the survey, while 74% of the students have favorable responses in the post MPEX survey. The students' expectations changed as a result of one semester of instruction.

It was found out that their overall expectation scores improved between the beginning and the end of the physics course, a result consistent with the findings of Redish, et. al. (1998), Ornek et. al. (2008) and Sahin (2009) who reported that MPEX scores deteriorated after one semester instruction. By contrast, the BSU results are in agreement with those of Mistades (2006).

As shown in Table 6, the computed t-value of -2.250 with a p-value of 0.027 ($p<0.05$) indicates that the null hypothesis is rejected. This means that there is a significant difference between the pre-instruction overall MPEX scores of the male and female respondents. Males are more likely to have higher percent of agreement to favorable responses prior to instruction than their female counterparts.

Table 6. T-test Analysis of the Significant difference between the pre-instruction physics expectations of students by Gender

Gender	p-value	Computed t-value	Decision	Verbal Interpretation
Male Female	0.027	-2.250	reject Ho	Significant

As shown in Table 7, the computed t-value of -1.478 with a p-value of 0.143 ($p>0.05$) indicates that the null hypothesis is not rejected.

Table 7. T-test Analysis of the Significant difference between the post-instruction physics expectations of students by Gender

Gender	p-value	Computed t-value	Decision	Verbal Interpretation
Male Female	0.143	-1.478	Do not reject Ho	Not Significant

This means that there is no significant difference between the post-instruction overall MPEX scores of the male and female respondents. Both are more likely to have similar physics expectations after one semester instruction.

As noted in Table 8, the computed t-value of 1.078 with a p-value of 0.287 (p>0.05) indicates that the null hypothesis is not rejected. This means that there is no significant difference between the pre-instruction overall MPEX scores of the respondents attending different class sessions. The pre-instruction overall MPEX scores of the students whether attending the AM or PM session remain more likely the same.

Table 8. T-test Analysis of the significant difference between the Pre-instruction physics expectations of students by class sessions

Class Sessions	p-value	Computed t-value	Decision	Verbal Interpretation
AM PM	0.287	1.078	Do not reject Ho	Not Significant

As observed in Table 9, the computed t-value of 1.858 with a p-value of 0.070 (p>0.05) indicates that the null hypothesis is not rejected.

Table 9. T-test Analysis of the significant difference between the Post-instruction physics expectations of students by class sessions

Class Sessions	p-value	Computed t-value	Decision	Verbal Interpretation
AM PM	0.070	1.858	Do not reject Ho	Not Significant

This means that there is no significant difference between the post-instruction overall MPEX scores of the respondents attending different class sessions. Respondents in different class sessions are more likely to have similar physics expectations after one semester instruction.

From Table 10, the Pearson correlation coefficient of -0.350 means that the correlations between the physics grade and the overall post-instruction MPEX scores are weak. Students with favorable physics expectations at the end of instruction tended to have a lower grade-point average, indicating a better physics performance. The overall post-instruction physics expectations of the students are significantly correlated with their physics performance.

Table 10. Correlation of students' physics performance and overall post-instruction physics expectations.

		GRADE
Post-Instruction Overall MPEX	Pearson Correlation	-0.350
	Sig. (2-tailed)	0.000
	N	99

Further analyses were conducted to see whether the post-instruction scores on any dimensions of the MPEX can predict the students' physics final grade used as a measure of their physics performance. To test the effects of the post-instruction MPEX dimensions scores on physics performance, a stepwise regression analysis with the physics grade as the dependent variable was carried out (Results are displayed in Table 11). The variables concepts and effort link were identified as significant predictors of the students' physics grade. Two negative beta values for post-instruction concept dimension score ($\beta = -0.229$, $p < 0.05$) and for post-instruction effort link dimension ($\beta = -0.202$, $p < 0.05$) were obtained, indicating that students with higher favorable mean scores on the concept and effort link dimensions tended to have lower grade-point average an indication of a better physics performance.

Table 11. Regression of Variables to determine the predictors of physics grade

Model		Unstandardized Coefficients		Standardized Coefficients	T	p-value
		B	Std. Error	Beta		
1	(Constant)	4.777	0.338		14.132	0.000
	Independence	0.124	0.196	0.066	0.631	0.530
	Coherence	-0.274	0.193	-0.141	-1.422	0.158
	Concepts	-0.413	0.189	-0.229	-2.182	0.032
	Reality Link	-0.296	0.255	-0.113	-1.162	0.248
	Math Link	-0.237	0.226	-0.117	-1.047	0.298
	Effort Link	-0.635	0.308	-0.202	-2.061	0.042
	Overall MPEX	-0.241	0.247	-0.122	-0.975	0.332

a Dependent Variable: GRADE

Conclusions

The physics performances of male and female respondents are not significantly different. The students attending the AM session performed better than those attending the PM session. Their expectations changed as the result of one semester of instruction. Also it was reported that the students' overall expectation scores improved between the beginning and the end of the physics course. Males are more likely to have higher percent of agreement to favorable responses prior to instruction than females. Both respondents, however, are more likely to have similar physics expectations after one semester instruction. Respondents in different sessions are more likely to have similar physics expectations before and after one semester instruction. The overall post-instruction physics expectations of the students are significantly correlated with their physics performance. Moreover the study revealed that an expert-like belief in the concept and effort link dimensions correlate highly with good physics performance.

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