Physics Motivation and Research: Understanding the 21st Century Learners of Today

Von Anthony Gayas Torio
Faculty member, Institute of Teaching and Learning
Philippine Normal University
Taft Avenue, Manila
torio.vag@pnu.edu.ph
+639286232806

Abstract

Motivation and Research are significant determinants in a student's success in the future. This study aimed to give a picture of the physics motivation of students in a tertiary level institution as well as gender differences in its components. Research and working preference of the learners were also provided.

Results revealed that male students (*M=4.27; SD=0.74)* have significantly higher motivation as compared to female students (*M=3.77; SD=0.89)* with a computed t(64) value of 2.41 with $p<0.05$ and Cohen's d of 0.61. It was further found that male students have higher motivation than female students in all other components of motivation.

These results gave a picture of 21st century learners of today in terms of motivation and conduct of research. The students' preference to work in groups of three rather than working individually suggests that students of the batch have small working groups that they depend on rather than self-belief.

Keywords: Motivation, Physics, Research, Physics Motivation, Physics Education, Philippines

1. Introduction

The recognition of the diversity of 21st century learners is crucial in pushing for educational reforms. Understanding the students of today will help educators better guide them in the career that will define the quality of citizens that the students will become in the coming future. Their motivation to study science and to pursue research are critical in nation building. Educators play a significant role in defining students of today and identifying their motivational needs in the fields of science. Their needs and interest towards the conduct of research to generate new knowledge and to find solutions to current difficulties are also essential needs for national reforms.

The Basic Education Curriculum (BEC) of the Philippines is on its way to complete reformation. This year is the last year of the BEC 2002 in our country. The Enhanced Basic

Education Curriculum of the Philippines dubbed as "K12 curriculum" is already on its third year of implementation in the public schools. Both curricula aims to lead students towards productive citizens of the nation. One leading conception towards productivity in the work field and even early in school is motivation.

The gender differences in science led researchers to look into motivation as plausible reason. In other countries, gender differences led to the under representation of women in the field of science as cited in the paper of Taasoobshirazi (2007). Mattern and Schau (2002) found that women showed substantially low motivation to participate in science classes and in pursuing science careers. Klein and Hodges (2001) conducted two studies about college students that together resulted to suggest that there are motivational differences between men and women which are not due to simple differences of abilities.

In the study of Glynn and Koballa (2006), they identified six components of motivation. These components include the following: intrinsic motivation, extrinsic motivation, relevance of the task to personal goals, self-determination, self-efficacy, and assessment anxiety. A wide range of literature discusses these different motivational components.

Oudeyer and Kaplan (2008) described intrinsic motivation as the drive/r of spontaneous exploration and curiosity. They even proposed a way of defining intrinsic motivation in a manner that will help spark research in more systematic studies about it. According to Ryan and Deci (2000),*"Intrinsic motivation is defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence. When intrinsically motivated, a person is moved to act for the fun or challenge entailed rather than because of external products, pressures or rewards."*

Froiland, et. al. (2012) in their study about intrinsic motivation noted that, *"Intrinsic motivation to learn, if cultivated, can lead to many academic and social/emotional improvements among K-12 students.*" The study of Froiland (2012) also stressed the requirement of "autonomy supportive home and school environment." Benefits of intrinsic motivated students include the following: more learning, better behaviour, happier, greater sense of well-being, more engaged in the classroom, treat others well, and are truly contributing to the betterment of the society.

Extrinsic motivation on the other hand, was defined by Ryan and Deci (2000) as, *"a construct that pertains whenever an activity is done in order to attain some separable outcome. Extrinsic motivation thus contrasts with intrinsic motivation, which refers to doing an activity simply for the enjoyment of the activity itself, rather than its instrumental value."*

Deci, Koestner and Ryan (2001) conducted a meta-analysis that provides a strong support to the idea that tangible rewards have substantial undermining effect on intrinsic motivation. The belief that extrinsic and intrinsic motivation are antagonistic in nature, meaning, that the will to learn associated with intrinsic motivation is inhibited by the presence of extrinsic motivation, was countered by the study of Covington and Mueller (2001). They claimed that the antagonistic nature is dependent upon the theoretical perspective adopted. The use of the need achievement theory leads to a different conclusion. With this new perspective, intrinsic motives may coexist with extrinsic motives and that learning can be stimulated in their own right in the school settings.

Self-determination and relevance to personal goals are part of the self-determination continuum (Deci & Ryan, 2002). Ryan and Deci (2000) referred to self-determination as a student's freedom to have some choice and control of their learning. The goal setting theory is believed to be consistent with the cognitive revolution (Locke, 1996). It emphasizes the significant relationship between goals and performance (Lunenberg, 2011). Locke proposed 14 categories to present the basic contents of goal setting theory. Some of the striking categories include the following: (1) The more difficult the goal, the greater the achievement; (2) The more specific or explicit the goal, the more precisely performance is regulated; (3) Goals that are both specific and difficult lead to the highest performance; (5) High commitment to goals is attained when (a) the individual is convinced that the goal is important; and (b) the individual is convinced that the goal is attainable (or that, at least, progress can be made toward it); and (9) Goals affect performance by affecting the direction of action, the degree of effort exerted, and the persistence of action over time.

Self-efficacy has several other names including social cognitive theory and social learning theory (Lunenburg, 2011). Bandura (1997) defined self-efficacy as a person's belief that he/she is capable of performing a particular task successfully. Bandura (1982) enumerated three ways in which self-efficacy affects learning and performance:

1) Self-efficacy influences the goals that employees choose for themselves;
2) Self-efficacy influences learning as well as the effort that people exert on the job; and
3) Self-efficacy influences the persistence with which people attempt new and difficult tasks.

In the paper of Lunenburg (2011) about Self-efficacy, he noted that self-efficacy influences the tasks chosen by an individual to learn and the goals that they set for themselves. In addition, four sources of self-efficacy were also cited which includes past performance, vicarious experience, verbal persuasion, and emotional cues.

The final component is assessment anxiety. Huberty (2009) defined anxiety as, "a normal human emotion that can be detrimental in a school setting, but good communication and support can help minimize its negative impact." He further classified anxiety into two, "trait anxiety" and "state anxiety". While taking examinations, a student may experience both types, high trait anxiety may be a sign of significant emotional problems and may be a precursor to depression. Cassady and Johnson (2002) cited that a moderate level of anxiety is necessary for students to perform best.

In this study, physics motivation is examined in order to define the learners of an institution who are on their last year of their secondary level. Gender differences in motivation were also examined to give a better picture of the nature of the students. Research interest and working preference (individual, pair or group of 3) were also examined.

2. Methods

Participants

Two sections of secondary Physics and Research classes were included as samples of this study. Section A has thirty-five students and section B has thirty four students. All the subjects are on their last year in the secondary school. There are 26 males (37.68%) and 43 females (62.32%). This makes a total of 69 subjects in all.

All of the subjects have taken three quarters of Secondary level Physics classes before they were asked to respond in the Physics Motivation Questionnaire. They have also completed a year of research and are all on their final quarter of completing their second year of research. They are also part of the batch of students who are the last to belong in the 2002 Basic Education curriculum of the Philippines.

Currently, the Enhanced Basic Education Curriculum of the Philippines is on the third year of implementation. The first batch of students are already on their Grade 9.

Methods

All the students were introduced to the subject research as an additional course in their Basic Education Curriculum. The course was introduced on their third year level and was given two hours of meeting time per week for the entire year. The students were introduced to topics that will help them be equipped with knowledge about research.

They are also given specific tasks that will help them hone their research skills. Specifically, the students were tasked to come up with a research proposal which they have defended as a terminal course requirement on their third year.

On their fourth year in the secondary level, the students took their physics class as the terminal science course and their second year of research. The same time allotment of two hours per week was given to the two sections.

The terminal course requirement is to be able to implement a research study. In order to measure students' motivation in physics, an instrument called Physics Motivation Questionnaire (PMQ) at the end of three quarters of Physics classes. The students were taught Physics using varied strategies. A physics class has six hours of contact time per week.

Instrument

In determining the level of motivation of the students, an instrument was adopted. This instrument is called *Physics Motivation Questionnaire* (PMQ) (Glynn & Koballa, 2006). This PMQ includes 30 items that assesses six key components of motivation.

The following table shows the six components of motivation considered in the PMQ:

Table 1
Physics Motivation Components

Component	Items
Intrinsically Motivated Physics Learning	1, 16, 22, 27, and 30
Extrinsically Motivated Physics Learning	3, 7, 10, 15, and 17
Relevance of Learning Physics to Personal Goals	2, 11, 19, 23 and 25
Self-determination for Learning Physics	5, 8, 9, 20 and 26
Self-efficacy for Learning Physics	12, 21, 24, 28, and 29
Anxiety about Physics Assessment	4, 6, 13, 14, and 18

Students were tasked to respond to the 30-item adopted PMQ which is in the form of a 5-point Likert scale checklist. The scale ranges from 1 (never) to 5 (always). The perspective used in the questionnaire is on the context of, "when learning Physics". The last component among the six, the *Anxiety about Physics Assessment*, corresponds to reverse-scored items since the higher score on this component means less anxiety.

In the study of Glynn and Koballa (2006), they reported that the instrument is reliable with an alpha coefficient alpha of 0.93. The instrument was also reported to be valid in terms of its correlation with college students' decision to major in science, their science grade, interest in science careers and the number of science courses they have taken. The study of Taasoobshirazi (2007) also found a high internal consistency of the instrument when she used it in her study about Gender differences in Physics.

3. Results

There are 69 students considered in the study. Out of the 69 students, five students did not respond to the PMQ given to them. This choice of not responding to the questionnaire was interpreted to mean that the students are not interested to participate in the study. This means that only 64(92.75%) students were considered in determining their motivation towards learning Physics.

Table 2 shows the overall result of the different components of motivation of the students. From the table, it was found that intrinsic motivation followed closely by extrinsic motivation to learn physics were the top motivational components why students learn physics. Students have the least motivation in terms of anxiety about Physics assessment.

Table 2
Physics Motivation Average for all students

Component	Ratings
Intrinsically Motivated Physics Learning	3.95
Extrinsically Motivated Physics Learning	3.87
Relevance of Learning Physics to Personal Goals	3.53
Self-determination for Learning Physics	3.80
Self-efficacy for Learning Physics	3.38
Anxiety about Physics Assessment	2.74

In determining the gender differences in motivation, independent sample t-tests were calculated. Table 3 shows the different means of the components of Physics motivation. Overall, it was found that there was significant difference in the motivation of men (*M = 3.76; SD: 0.99)* and women *(M = 3.42; SD = 1.02)* with a computed $t(64) = 1.296$, $p<0.05$. Cohen's $d = 0.33$ which is interpreted to have an effect size that is medium.

Table 3
Physics Motivation Average for male and female

Component	Male	Female
Intrinsically Motivated Physics Learning	4.27	3.77
Extrinsically Motivated Physics Learning	4.04	3.77
Relevance of Learning Physics to Personal Goals	3.79	3.38
Self-determination for Learning Physics	3.92	3.73
Self-efficacy for Learning Physics	3.73	3.18
Anxiety about Physics Assessment	2.79	2.71
Overall Motivation	**3.76**	**3.42**

In examining the individual components, table 3 shows the top two components common for both genders which are intrinsic and extrinsic motivation to learn physics. There was a significant difference between the intrinsic motivation to learn physics of male *(M=4.27; SD=0.74)* and women *(M=3.77; SD=0.89)* with a computed t(64) value of 2.41, $p<0.05$ and Cohen's d of 0.61. The intrinsic motivation of men was found to be higher than women. There was also a significant difference in the extrinsic motivation of men *(M=4.04; SD=0.82)* and women *(M=3.77; SD=0.96)* with t(64) value of 1.19 and Cohen's d = 0.30. The extrinsic motivation of male students is also higher than that of female students.

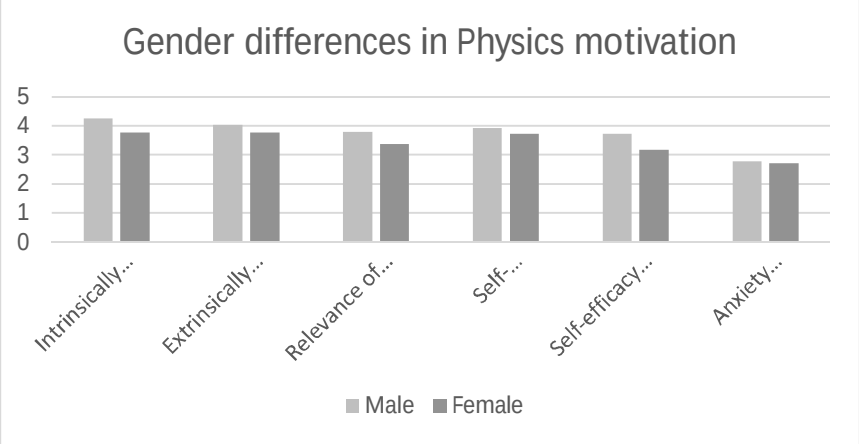

Figure 1

Figure 1 shows that the lowest motivation component for both male and female is assessment anxiety. Male students have higher assessment anxiety in Physics *(M=3.79; SD=1.20)* as compared to female *(M=2.71; SD=1.22)*. There was a significant difference in their assessment anxiety with a computed t(64) value of 3.43, with $p<0.05$ and Cohen's d = 0.89.

In the remaining three components, male students showed a significantly higher motivation as compared to female. In the component relevance of learning physics to personal goals, male students *(M= 3.79; SD=0.79)* have significantly higher motivation than female *(M=3.38; SD= 0.79)*. The computed t(64) being 2.00, with $p<0.05$ with a Cohen's d of 0.52.

In terms of self-determination for learning physics, male students have significantly higher motivation *(M=3.92; SD=0.82)* than female students *(M=3.73; SD=0.91)*. The computed t(64) was 0.85, with $p<0.05$ and Cohen's d = 0.22. Finally, in terms of self-efficacy in learning physics, male students still have higher motivation *(M=3.73; SD = 0.76)* than female students *(M=3.18; SD = 0.74)*. The computed t(64) value is 2.80, with $p<0.05$ and Cohen's d = 0.73.

Research Themes

The subjects of the study were also introduced to two research subjects as additional courses in their basic education curriculum. The first research subject was introduced on their third year. The main objective of the third year research subject is for the students to be acquainted with basic research skills and concepts in order to arrive at a research proposal. The second research course aims to implement the research proposal and to present the completed research project.

The students were allowed to choose among multidisciplinary research themes of their choice. There are five disciplines that a student can choose on. The five disciplines are Applied Science, Environmental Science, Social Science, ICT, and Health Science. The distribution of the 69 students are given in the table below.

Table 4
Research Interest of the Subjects of the Study

Research Themes	Male	Female	Total
Applied Science	5	6	**11**
Environmental Science	9	14	**23**
Social Science	10	16	**26**
Information and Communication Technology	3	3	**6**
Health Science	1	2	**3**
Total	**28**	**41**	**69**

Majority of the students, as shown in Table 4, chose the Social Science field. Both male with 10 students (35.71%) and female with 16 students (39.02%) conducted studies about social science with greatest numbers. The least number of students were interested in studying Health Science with 1 male student (3.57%) and 2 female students (4.88%).

The top 2 choice of the students both for female with 14 students (34.15%) and male with 9 students (32.14%) is Environmental Science. This choice is followed closely by Applied Science and ICT. The choice of research themes follows a similar trend for male and female.

Table 5
Distribution of Students into groups, pairs and individuals

Group of 3	Pair	Individual	Total
14	10	7	31
42	20	7	69

The nature of students in terms of their ability to work individually, in pair and in groups of three was also examined. Majority of the students chose to work in groups of 3 with 14 groups working on a single study. This number of students is closely followed by students who would like to work in pairs. Finally, out of the 69 students, only 7 students worked on a study individually.

Implications for Teaching

The motivation of students to learn a particular subject area is important. The motivation of students to learn Physics, as a terminal science course in the Basic Education Curriculum of the Philippines is a significant factor in making students decide on the career path that they will be taking in the collegiate level. Leading students to particular fields is essential in helping students decide what they really want to pursue in higher degrees. Their ability choose well at an early stage may determine their success in their collegiate level and in the profession that they will engage in.

Glynn and Koballa suggested that there are six components that should be considered in examining the motivation of students to learn science. The components are intrinsic, extrinsic, relevance of task to personal goal, self-determination, self-efficacy and assessment anxiety (2006). Gender differences in choices made in career were also found in the literature to significantly differ

(Taasoobshirazi, 2007). Both male and female follow the same trend in terms of the sequence of motivational components that they consider. The top two motivational factors in learning physics that they consider are intrinsic and extrinsic motivation. The least component that they consider is assessment anxiety. The top 3, 4, and 5 components are self-determination, relevance of physics learning and self-efficacy, respectively.

All the components were found to have significant differences between male and female at p level of 0.05. It was further found that male students have higher motivation in all components as compared to female. This means that there should be greater emphasis in finding ways to motivate female students to learn physics especially in the area of assessment anxiety. The low motivation of students in terms of assessment means that there should be better ways of introducing assessment with the end of diminishing the anxiety brought to students.

Effect sizes (Cohen's d) was also found to range from as low as $d = 0.22$ (low) to as high as $d = 0.89$ (large). These variations in effect sizes may be interpreted to mean that indeed, the calculated differences between male and female students is significant. In four of the six components of motivation, the calculated effect sizes are medium to large which means that the variation in motivation between male and female is as large to even larger difference than the difference between populations. This means further that other than the difference between male and female motivation, there is as well a difference in motivation within the populations.

In terms of the research themes considered by students, majority of the students are interested in studies about social science. Most of the students looked into how students behave and are affected by other members of the society. Some students looked into bullying in the school and even looked at issues about parents' working abroad. This may mean that students of today would like to know themselves in a deeper sense by looking at the factors that will define themselves. The second theme that students are interested to study are environmental related. The combined number of students working on studies about social science and environmental science make the bulk of the subjects considered in this study. Their studies reflect how they would like to have a good knowledge of themselves and the community where they belong. Both male and female follow the same trend in their research choice.

Teachers in the field should look into the idea that students of today are exploring means to define their social identity. This can be deduced from their research interest and the groups that they form in accomplishing big tasks such as working on a proposal and completing a study. Their motivation in the study of physics also helps them in defining their social identity. The students' high intrinsic motivation means that students have great belief in performing a task for its own sake. Their moderate assessment anxiety may be interpreted to be a good indication of their ability to work on physics tasks. In the study by Cassady and Johnson (2002), they reported that students perform best when their anxiety level is average.

4. Conclusion

This study aimed to define the learners of a secondary level grade 10 students taking physics and research. The students' motivation towards learning physics and their research interests were examined. Gender differences were also tested to look at possible variation in motivation. It was

found the male students are more motivated than female students in all the six components of motivation identified using the PMQ. It was found that the students have greatest motivation in the intrinsic component and the least motivation in test anxiety. Students were also found to prefer studies about social sciences. They also prefer to conduct studies in groups of three rather than conduct their study alone. These results suggest that students are interested in defining themselves by conducting studies in the social sciences and would want to conduct these studies in groups. The lower motivation of female students necessitate the need for strategies to help them overcome this motivational difference.

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