Students' Academic Performance in Physics 1: Basis for Teaching and Learning Enhancement

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Abstract
One of the primary goals in physics education is to identify potential and obstacles to student learning, and then to address these obstacles in a way that leads to more effective learning. These obstacles include factors that originate during instruction - such as instructional method as well as those that relate to students' pre-instruction preparation, with mathematics skills being the most common factor. In this study, the measures of performance adopted are student grades on course exams that emphasized quantitative problem solving. The study examines students' mathematics skills and their initial physics conceptual knowledge as factors that may underlie variations in student learning. Another objective of the study is to determine whether individual students' performance are correlated with initial English communication skills. The most common way of detecting whether an improvement is achieved by a course is through measuring the students' achievement in a test. Testing is generally thought of as a means of assessing the knowledge and skills students have acquired through learning. Test results in formative and summative assessments of students, provide vital information that could be the basis for the following: (a) assigning final course grade to a student; (b) distinguishing students' strengths and weaknesses in a particular subject; (c) assessing student performance in class as a whole; and (d) improving teaching methods or techniques in carrying out a teacher's day-to-day lessons; (e) assessing teachers' needs in a certain program or curriculum; (f) allowing a teacher to make decisions at the beginning, and at the end of instruction; (g) evaluating the effectiveness of specific teaching methods; and (h) serving as one of the criteria upon which to evaluate a certain curriculum. The Physics performance of students in the test is affected and found significantly by the students' pre-instruction preparation in Mathematics and English courses.
Keywords: academic achievement, University Physics, teaching and learning

1. Introduction

Innovation is a watchword in almost all areas of endeavor. In the field of higher education, the school administrators and teachers are concerned with ways and means of improving student achievement and performance, physical facilities, curricula, and learning in general. Innovations in these areas need to be designed and applied to meet the demands upon these schools making education more responsive to the needs of a fast growing society.

Physics is mystified to be a tough and abstract discipline, and university physics courses do little to change this negative attitude towards physics (Blickenstaff, 2010). Yet, there has been research studies showing that students usually enjoy working in the laboratory (Deacon and Hajek, 2011). This could mean that laboratory sessions may be a chance to dispel the bad reputation of physics. Universities invest considerable funds in building laboratories, furnishing them, buying sets of appropriate equipment for the experiments, and writing laboratory manuals. However, traditionally very little attention is paid to the teachers of the laboratory courses. Even though laboratories are expensive insofar as resources and the time spent by students and teachers, laboratory sessions generally are not considered to be a valuable learning experience (Kirshner and Meester, 1988).

In this regard, it is important to make sure that the students enjoy the teaching-learning sessions and ascertain whether they are able to develop conceptual understandings about difficult topics in physics. There has been different kinds of issues that need improvement in laboratory instructional designs, despite the fact that students have positive attitudes towards physics laboratories. Although laboratory experience is considered to be important in student learning, there is a need to conduct a research in AMAIUB which investigates students' perceptions of the Physics laboratory where the cookbook implementation is predominant.

It is now well established that the Physics course is supposed to develop in students, a variety of important cognitive and psycho-motor abilities related to the conduct of experiments as well activities in physics, which include, conceptual understanding, experimental skills, experimental problem solving ability, among others. But it has been noted that the strategies adopted for the assessment of what students learned through a laboratory course, are often inconsistent with the objectives of the laboratory courses. The results / marks given are often too subjective and poorly discriminate among the students. It is felt that these strategies are often non-discriminatory, inadequate from the point of reliability and validity and unsatisfactory as an achievement test.

The objectives of physics courses include fostering conceptual understanding and development of several important cognitive, psychomotor, attitudinal and affective abilities. It is no exaggeration to state that the teaching and learning of physics is inadequate unless students gain a significant "hands-on-minds-on" experience in performing experiments in physics through well-thought laboratory instruction. In most universities, the usual practice of performing a set of experiments, in a 'cookbook' mode, hardly help students achieve the objectives of the physics laboratory courses. A need was felt to develop novel approaches which will encourage students active participation, independent thinking and offer an opportunity to learn 'how to think scientifically' during traditional physics instruction without major curriculum and content changes. This study is sought to assess the students' skills, abilities and performance in Physics 1 course.

2. 1 Research Paradigm
The following research paradigm has been conceptualized for a better illustration of the study's framework.

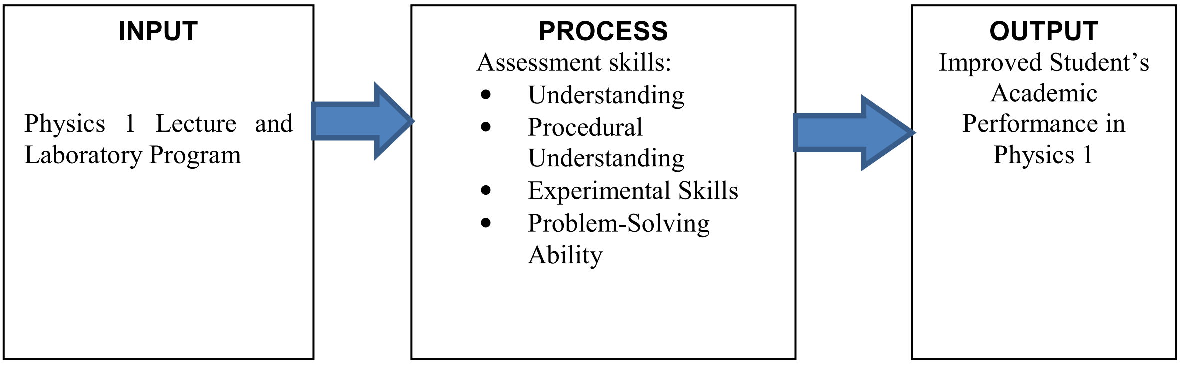

Figure 1 illustrates the research paradigm of the study. The independent variable illustrates the core skills to be developed in the Physics course in terms of: conceptual understanding; procedural understanding; experimental skills and problem-solving ability that will lead to the improvement of students' performance in Physics 1 course.

2.2 Review of the Literature
Various studies have been considered with the common objective of determining variables that are associated with or are considered good predictors of achievement in the field of science. One of the goals of Physics education is the identification of potential and actual obstacles to student learning, and how to address these obstacles in a way that leads to more effective learning. These obstacles include factors that originate during instruction such as instructional method as well as those that relate to students' pre-instruction preparation like Mathematics and English courses in relation to students' performance in Physics. Specifically, those studies which had similarities in the field of Mathematics as their area were those of Hudson and Rottman, and Hudson and McIntire. That of Winsberg and Ste-Marie was in the field of Physics which is the same area in the present investigation. The studies were included inasmuch as these were correlation studies with students' performance in Science. On the other hand, the study of Hudson and McIntire was similar with the present study considering that it was a correlation study specifically of the functional ability in Algebra and Trigonometry with performance in Introductory Physics. The following similar literatures serve as good background for the formulation of effective instructional strategies and vital information to be used in University Physics instructions.

2.3 Teaching - Learning in Physics Laboratory Courses
The reason why there is a higher imaginative level [in modern science] is not because there is a finer imagination, but because there are better instruments (Alfred North Whitehead, 1993). The role of experimental technologies for student cognition and learning in laboratory is a neglected aspect in physics and science education research. Laboratory-learning activities is commonly described as "direct experience with physical phenomena" (Trumper, 2003) and in a similar vein the National Research Councils' America's Lab Report (Singer, Hilton, & Schweingruber, 2006) as "opportunities for students to interact directly with the material world." Laboratory equipment is seen as something that is just "manipulated" (e.g. Lunetta, Hofstein, & Clough, 2007) and observation in the laboratory is seen as unproblematic requiring only low level of cognition. This is in line with the "[traditional belief] that instruments and experimental devices per se has no cognitive value" (Lelas, 1993). A consequence of this is that emphasis in research is placed mainly on instructions, concepts, and ideas or on organization of laboratories and the role of instrumental technologies for student learning in laboratories are rarely studied and their role is usually either neglected or taken-for-granted (Bernhard, 2012; Ihde, 1991).

2.4 Approaches to Students' Independent Thinking in Physics Subject
The objectives of physics courses include fostering conceptual understanding and development of several important cognitive, psycho-motor, attitudinal and affective abilities1. It is no exaggeration to state that the

teaching and learning of physics is inadequate unless students gain a significant 'hands-on-minds-on' experience in experimental physics through well-thought laboratory training. In most of colleges and universities in many places, the usual practice of performing a set of experiments, in a 'cookbook' mode, hardly help students achieve the objectives of the physics laboratory courses. A need was felt to develop novel approaches which will encourage students active participation, independent thinking and offer an opportunity to learn 'how to think scientifically' during traditional physics laboratory courses without major curriculum and content changes.

2.5 Beyond Recipe-Based Practical Exercises

Traditional "recipe-based" practical exercises may have a high degree of 'outcome predictability', but, because they absolve the student of a great deal of thinking, they arguably have a low degree of value as learning experiences and hence they fall short of achieving the goals of laboratory programmes. Practical exercises could be improved by becoming problem-solving exercises, where the student is given prior warning only of the broad outcome of the task and must devise a method as well as generate an answer to a question. The student is confronted with a collection of apparatus and must figure out how to use it to perform the specified task. A common objection to this sort of exercise is that, realistically, they can only be performed by students after – and preferably soon after - the relevant theory has been 'covered'. Also, all students in a given group would, by preference if not of necessity, have to perform the same exercise simultaneously. This could present a difficulty for service courses where large groups of students must often be catered for, and logistic and economic factors become an issue. Where this is the case, practical exercises are usually performed in rotation to avoid having to purchase and store expensive apparatus in large quantities. As a result, the practical and theoretical parts of the curriculum become almost entirely independent of each other as the practical exercises being performed at any given time are mostly not linked to the theory then being covered. Hence, economic and logistic obstacles are allowed to impact negatively on the educational value of the curriculum.

2.6 Improving Student Learning in Physics Classes

An essential component of all physics degrees is the laboratory program. Laboratories enable students develop many of the practical and theoretical skills required to be successful scientists, as well as providing the basis for a deeper understanding of the scientific method. Students learn to link theory to practice, problem-solve, control parameters, take measurements, understand and calculate experimental uncertainties, graph and interpret data, work in teams, and communicate by writing cohesive reports and papers. Universities invest considerable funds in building laboratories, furnishing them, buying sets of appropriate equipment for the experiments, and writing laboratory manuals. However, traditionally very little attention is paid to the instructors of the laboratories sessions. These instructors (called "laboratory demonstrators" in Australia) are often Ph.D. and Honours students who are the least experienced members of the teaching staff. The laboratory demonstrators normally begin their teaching careers in first year laboratories where both they and their students are new to the laboratory experience. In these situations, the laboratory demonstrator can have a profound influence (either positive or negative) on the student learning experience.

2.7 Promoting Active Learning in Experimental Physics Using the Moodle

The purpose of the reported activity was to promote active learning and higher engagement of students of Basic Experimental Physics courses of the Engineering career. In general, engineering students are not really motivated by Physics Laboratories, and it is difficult to achieve a real engagement of them in the proposed experimental activities, that in most of cases are presented as "cookbook Labs". Due to the massive character of our courses, students have only six attendance classes (3hours, bi-weekly) per semester (on the second year of their university career). In each class they have to perform an experimental activity and deliver a written report a week after. This structure does not promote sufficient communication and interaction between students and with the teacher. We decided to complement face to face classes with online activities and to work on a blended form mixing cookbook and less guided activities. There are several studies about the use of inquiry versus more guided techniques, specifically in the field of laboratory courses (Kirschner 2006, Wenning 2006).

2.8 Objectives of Teaching University Physics

At the end of the term, the student should be able to:
*Identify the concepts, laws, principles and theories of mechanics, heat, electromagnetism and optics;
*Describe and explain correctly the fundamental concepts and laws governing natural occurrences in the laboratory and in everyday life;
*Cite common happenings that can be explained by Newton's Laws of motion and gravitation;
*Combine and relate these physical ideas to form a unified view of physics and mechanics in particular;
*Effectively use the tools of algebra and trigonometry, and the theoretical concepts and laws in problem-solving;
*Integrate basic concepts in the application of mechanics like static equilibrium and the study of fluid behaviour;

*Extend the role of critical thinking especially developed in the laboratory, to acquire a good problem-solving attitude;
*Use his background in mechanics as a solid foundation in coping with his specialized field;
*Practice the conservation of finite and useful energy sources; and
*Appreciate physics as an empirical science, depending on experimental verification.

2.9 Physics as a Liberal Arts Subject

The study of Physics as part of general education can be one of the most rewarding in terms of teaching the students to develop an analytical mind. An analytical mind indicates the ability to reason in an orderly and logical manner, the ability to make conclusions consistent with the evidences. presented, and the ability to discern faulty arguments and erroneous assumptions. In addition, the study of Physics can help the students to be more imaginative, creative and speculative. The study of Physics gives us not only knowledge and information about the world around us but also the key to practical solution of the problems that confront us. It teaches us to doubt arguments not based on sound evidence. It teaches us to listen, estimate and think. It teaches us the right way of doing things. It inspires us to advance farther towards new inventions and happier living. The teacher can help create the atmosphere and scenario for accomplishing the above objectives. He can help the students sharpen their imagination and develop students' creativity. Recent trends in the teaching of Physics include curriculum planning to give the students a better understanding and background in mathematics, the construction of demonstration apparatus by the instructors to heighten interest in learning, re-evaluation of the content of the physics course to keep it in harmony with present day developments in Physics and in advances in science and technology; and the establishment of training programs for physics instructors, to enable them to refresh their knowledge of Physics, and to give opportunity to discuss with other Physics instructors their common problems and solutions to the problems they encounter in the teaching the subject area.

3. Research Design

The descriptive-correlation method of research is used in this study. Conducted in AMA International University-Bahrain. The instrument that is used study is a test question developed by the researcher himself. This test is used to measure the level of academic performance of student-learners in Physics 1. The test question consists of items on the major topics: Vectors; Motion; Newton's Laws of Motion; Work and Energy; Momentum; and Temperature and Heat. The data and information of respondents' grades in Mathematics and English subjects is also considered.

The research made use of the descriptive-correlation statistics where the student-respondents are divided into five category levels: Excellent, Above average, Average performance, Below average and Poor performance. They are classified based on the results of the mean scores and standard deviation of the respondents. The relationship of the students' performance in Physics test and the level of performance in the preparatory subjects: Mathematics and English are analyzed using Pearson Product Moment of Correlation (r) at 5 per cent level of significance.

4. Results and Discussion

Table 1.Table of Specifications for the Test Question in Physics 1

Topic: Taxonomy	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total
Vectors	1	0	1	3	0	2	7
Motion	0	2	3	2	1	0	8
Newton's Laws	1	1	4	4	2	2	14
Momentum	0	0	2	2	0	0	4
Work & Energy	0	1	2	4	2	0	9
Temperature & Heat	0	0	3	5	0	0	8
Total	2	4	15	20	5	4	50

Table 1 presents the table of specifications of the 50-item test which provided the researcher the needed information for the research. The items in the test are questions taken from the major topics in Physics 1 along: Vectors; Motion; Newton's Laws of Motion; Momentum; Work Power and Energy; and Temperature and Heat Concept categorized using Bloom's Taxonomy.

Table 2. Frequency and Percentage Distribution of the Performance Level of the Respondents in Physics Test

Performance Level in the Physics Test	Frequency	Percent
Excellent	3	10.00
Above Average	5	16.67
Average	9	30.00
Below Average	6	20.00
Poor	7	23.33
Total	30	100.00

Mean = 26.3

Table 2 presents the frequency and percentage distribution of the performance level of the respondents in Physics 1. The table clearly shows that 10.00 per cent or three (3) of the respondents performed “excellent” in the Physics test and 23.33 per cent or seven (7) of them are “poor”. Nine students or 30.00 per cent performed in the “average” level while five (5) or 16.67 per cent are in the “above average” level while six (6) or 20.00 per cent performed in the “below average” performance level. The mean score of the students in the examination is 26.3. This means that the students’ regularity in attendance in the lecture sessions could be contributory in the acquisition of Physics proficiency.

Table 3. Frequency and Percentage Distribution of the Students’ Marks in Mathematics Preparatory Subject

Preparatory Math Marks	Frequency	Percent
Above Average (86.00 & above)	8	26.67
Average (76.00-85.00)	15	50.00
Below Average (50.00-75.00)	7	23.33
Total	30	100.00

Mean = 78.30

Table 3 presents the frequency and percentage distribution of the students’ marks in Mathematics (Math1A: Algebra and Math1B:Trigonometry). The table clearly shows that majority of the respondents; 15 or 50.00 per cent belong to the “average” level marks; 8 or 26.67 per cent of the respondents belong to the “above average” level marks while 7 or 23.33 are in the “below average” category. This means that the majority of the student-respondents; 23 or 76.67 per cent are in the average and above average range while 7 belong to the “below average” marks in the two pre-instruction preparatory courses. This implies that the students of engineering and computer science had a good performance in math preparatory courses.

Table 4. Frequency and Percentage Distribution of the Students’ Marks in English Courses

Preparatory English Marks	Frequency	Percent
Above Average (86.00 & above)	6	20.00
Average (76.00-85.00)	12	40.00
Below Average (50.00-75.00)	12	40.00
Total	30	100.00

Mean = 76.50

Table 4 presents the frequency and percentage distribution of the students’ marks in the English courses.As can be gleaned from the table, it shows that in the 12 respondents or 40.00 per cent fall in the “average” level marks and the same number of 12 respondents or 40.00 per cent belong to the “below average” level marks, while 6 respondents or 20.00 per cent are in the “above average” category. This means that the student-respondents are equipped with good background in the English preparatory subjects before they registered in the Physics 1 course. These English courses include orientation subjects and English communication skills 1 and 2. This implies that the engineering and computer science students in Physics 1 had good performance in the English courses as shown in their GPA.

Table 5. Correlation Between Test Performance and Preparatory Courses

GPA in Preparatory Courses		Physics Performance	Decision	Interpretation
Mathematics	Pearson Correlation	0.721	Significant	High degree of correlation
	Sig. (2-tailed)	.000*		
	N	30		
English	Pearson Correlation	0.582	Significant	Moderate degree of correlation
	Sig. (2-tailed)	.000*		
	N	30		

Table 5 presents the significant relationship between students’ Physics performance in the test and the GPA in preparatory mathematics: Math1A (Algebra) and Math1B (Trigonometry). As shown from the table, there is a high degree of correlation using the Pearson Product Moment of Correlation (r = +0.721), which means that there is a significant relationship at 0.05 level (2-tailed) between the Physics performance of students in the test and the Grade Point Average in Math1A and Math1B. Hence, the null hypothesis is rejected. This means that the students' GPA in Math1A (Algebra) and Math1B (Trigonometry) are good predictors of Physics academic performance. Further, students who had outstanding and very satisfactory grades in both Algebra and Trigonometry had better performance in the Physics test. It can be implied, that students with higher levels of preparatory mathematics had substantially higher learning gains on the Physics concepts – independent of their initial knowledge of those concepts when compared to students with lower Mathematics skill levels. The study of Meltzer, David E. (2002) shows that mathematical ability (mathematical aptitude or accumulated procedural knowledge) is positively correlated to success in traditional introductory physics courses that emphasize quantitative problem solving.The findings of Multzer reported a positive correlation between students' mathematical skills and their exam grades in college physics – resulting from physics instruction, particularly with regard to qualitative, conceptual understanding. As shown from the table, there is a moderate degree of correlation using the Pearson Product Moment of Correlation (r = +0.582), which means that there is a significant relationship at 0.05 level (2-tailed) between the Physics performance of students in the test and the Grade Point Average in English courses. Hence, the null hypothesis is rejected. Further, students with high GPA in English scored higher in the Physics test than students with low English GPA. This implies that English communication - reading and writing skills as a predictor has a measureable impact on physics performance. It supports the findings of a study by Willingham and Morries (1996), that students who do well in the sciences (Introductory Biology, Chemistry and Physics) owe their success to the communication skills in reading and writing. Other factors may well be involved such as coming from advantaged homes and wealthier communities and attending English schools that emphasize college preparation.

Table 6. Problems Encountered in the Physics Classes

Perceived Problems	Mean	Interpretation
1.English as a medium of instruction	2.79	Occasionally
2.Background in basic mathematics	2.44	Seldom
3.Background in secondary physics	3.11	Occasionally
4.Many assessment works, projects, home works	3.53	Frequently
5.Comprehension of topics, concepts, principles	3.10	Occasionally
6.Textbooks/reference materials/manuals	1.96	Seldom
7.Recall of important physics concepts	3.65	Frequently
8.Motivation and guidance from the teachers	1.64	Never
9.Consultation & interaction time with teacher	1.98	Seldom
10.Regularity of attending physics class	2.82	Occasionally

Overall weighted mean = 2.70 (Occasionally)

Table 6 shows the problems encountered which were rated "frequently": item 7 on recalling of important physics concepts (3.65) and item 4 on many assessment works, projects and home works (3.53). Items 3, 5, 10 and 1 are rated "occasionally": background in secondary physics (3.11); comprehension of topics, concepts and principles (3.10); regularity of attending physics class (2.82) and English as a medium of instruction (2.79). Among the items that are rated "seldom" are items 2 on background of basic mathematics (2.44), consultation & interaction time with the teacher (1.98) and textbooks/reference materials/manuals (1.96). On the motivation and guidance from the teachers, it is rated "never" with a mean of 1.64. The table shows the overall weighted mean of 2.70 with an adjectival description of "occasionally". This means that the occurrence of the perceived problems encountered by the students would affect performance in a course.

5. Conclusions

*The correlation analysis revealed that the Physics performance of the students in the test is affected and found significantly by the students' Grade Point Average (GPA) in the pre-requisite subjects in basic Mathematics courses (Algebra and Trigonometry) and English communication courses.

*There were problems encountered by the student-respondents that had affected their performance in the Physics achievement test. Students had problems in recalling important concepts, principles and theories, and giving of many assessment works, assignments, projects, and the students' regularity in attending classes.

6. Recommendations

*Physics is always part of the engineering and computer science programs, and this needs complete concentration, time and patience of the students. Students should consistently attend all classes and lectures in the classroom so that they will be assisted by the teachers develop their abilities.*Tutorial classes should be undertaken to help students overcome their difficulties especially in the application of Physics laws, theories, concepts and principles through problem solving. Also, students should be encouraged to avail of the opportunity to read textbooks and references in the library and must join department clubs, science-math quiz bee contests and similar events.*Physics and Mathematics instructions should be related to everyday activities of students to help them develop the proper attitude towards the discipline. Formative assessments must be strengthened by giving more problem solving drills, exercises, home works, assignments and to maximize the notional hour requirements to respond to the needs of the students. *Teachers must provide more updated instructional materials / visual aids / power point presentations to equip the students more power of understanding of the lessons and to make teaching and learning more meaningful. The objectives and the course intended learning outcomes (CILOs) must be strictly followed. *Similar studies should be conducted to other disciplines in the natural sciences because the researcher strongly believes that this type of study would enhance and improve teaching and learning activities.

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