The transition from high-school Physics to first-year Physics: How well prepared are our students?

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Abstract.

Premature withdrawal from university due to academic failure has the potential to present problems to both students and educators. The demand from industry for a larger pool of science and engineering graduates in South Africa is in line with international norms. This state of affairs is compounded by a shrinking pool of good quality school leavers. For the desired growth in graduate numbers to occur, physics educators are required to respond effectively through curriculum reform to optimize success and retention of students at first year level. The research project in this regard aims to investigate the level of preparedness in relation to Physics I students and to identify key success factors in this course. This course is compulsory for most first year science students and is largely perceived as difficult in comparison with other first year courses. More students are pursuing Physical Science at school and consequently study science, engineering and technology at universities (DoE, 2010) and University of Johannesburg is no exception. For many students, the first year at university represents a transition during which a variety of academic and social challenges are encountered. To this end, students' entry-level preparedness was investigated through analysis of their high school examination results, administration of a diagnostic test and first year university assessment results. The results reveal that high school examination results appear not to be the only independent factor characterizing students' readiness for first year physics studies at university.

1. Introduction

For many students, the first year of university is one of transition, in which a variety of academic and social challenges are encountered. This is because it is a time when students lay a foundation on which their subsequent academic success and persistence rest. A lot of literature on the prediction of academic success and retention among first year university students showed that most students, despite of the academic, emotional, social, and other challenges, successfully complete the transition stage and achieve academic success (Aboma, O, 2004). Others do not manage these challenges and are forced to leave their study at its early stage, semester 1. According to Tinto (1993), the majority of students (75%) leave college during the first two years, and 57% of them do so without graduating. And University of Johannesburg (UJ) first year first semester mark is one of the major responsible factors for early drop-out from university, since the first semester is the pre-requisite to enroll for second semester.

The problem of attrition and its results can have different form in different context. Since the introduction of Outcomes Based Education (OBE), more students are passing grade 12 with university entry Admission Point Score (APS) required. Within the past two years South African universities

witness an over flow of students registering for mainstream physics I (PHYI). PHYI at UJ is a key module as it is not only chosen by students who are doing Bachelor of Science degree (BSc), but is also requirement for studies in other degrees such as Bachelor of Science (BSc LE)-Life and Environmental Sciences, BSc Eng (Mechanical, Civil, Electrical and Engineering with IT). However, irrespective of the increment in enrolment rate, attrition rate has been frequently reported to be high in UJ. The problem has been pronounced since 2009, the year in which universities have started admitting students passing through the newly introduced (OBE). Evidently, the results of premature departure from university become more severe to students in mainstream and BSc-LE physics I. With the evidence given by (DoE, 2010), the number of graduates in science, engineering and technology (SET) demanded by industry and the profession in South Africa is small as compared with other fields of studies

It is known that strong academic background, achievement of good grade, and academic motivation are needed for students to persist in their science studies. It is realized that if physics educators are to respond to industry calls for an increased number of SET graduates, a large portion of that increase is likely to come from a more diverse range of students, including women, as well as students with lower entry-level qualifications in mathematics and physical science. It is also realized that while these students may initially struggle academically they may well have the potential and motivation to make a significant contribution to the SET profession, provided appropriate academic and social support systems, remedial and "catch-up" courses are provided.

For first year courses, the diversity of students' academic backgrounds is a continuous challenge, particularly in courses where a level of pre-requisite knowledge is assumed. In South Africa (SA), Senior Certificate Examination (SEC) was a well-established, indicator for University entrance for many years, providing a certain measure of surety about levels of pre-requisite knowledge based on higher and standard grades (HG&SG) and curricula. The current situation, with recently introduced curricula (OBE) has been the subject of debate, challenging previous assumptions about the commonality of prior knowledge. The dual objectives of identifying students with the ability to succeed in SET, and ensuring their academic success and retention to graduate were the motivation for the project from which results for this paper were drawn.

The first year physics course is compulsory for most first year science and engineering students and is largely perceived as difficult in comparison with other first year courses. Pass rates are consistently lower than in other year one courses, despite the course being taught by well motivated and experienced lecturers who have interest in the teaching and use innovative assessment and technology methods. Given that the physics module has the minimum rating of 4 for any science and minimum rating of 5 for engineering degree for entry qualification at UJ, and given also that the course has clearly identifiable pre-requisite knowledge, the situation was ripe for investigation.

The overall goal of the research project, from which this paper is drawn, is to maximize the achievement of the students enrolled in the compulsory PHY1 module. It was seen as essential to identify the academic preparedness of students for their first year studies in order to enable the curriculum, assessment and teaching methods to respond effectively, but it had also been perceived that the new and more diverse entry qualifications introduced over the last few years had made this identification task very difficult. Recent government moves to "cap" student enrolments at universities to provide some surety in government spending have also increased the importance of student recruitment, selection and retention.

Specifically, this research study aims to identify the level of preparedness the year-one cohort brings to PHYI, to determine key factors that lead to success in this module. Specific objectives include:

- To analyze educational background of the students in PHYI.
- To determine the educational achievement of the students in PHYI. Analysis of assessment results.

Current selection methods and criteria from high school qualification are examined as predictors of academic success. The results of diagnostic test completed in the orientation week, including continuous assessment, provided results which were constructive for course delivery.

The faculty of science services the engineering faculty by teaching some of science courses to their engineering students and our interest is specifically with PHYI. The approximately 1182 students register for PHYI are divided across the science and engineering faculties. Since more students apply to study SET exceeds the allowed number of places, selection is necessary at first year level. This does allow the luxury of selecting for a background that includes some strength in mathematics and physical science. The increasing numbers of high school students studying physical science, combined with demographic trends have, however, resulted in a perceived decrease in quality and quantity in the application pool.

With high demands of places, and selection occurring at this first-year level, retention in PHYI is critical at UJ since the rate of attrition is high. Approximately 55% of each year intake does not continue with physics in the second semester. PHYI is one of the compulsory core modules for all first year SET undergraduates and a pre-requisite for second semester physics.

2. Methodology

Student entry level preparedness was investigated by analysis of their high school examination results, administration of a diagnostic test, and first year assessment results.

3. Results

3.1. Entry Level Preparedness

The first year cohort in 2011 was composed of 1182 new students of whom 59% had qualified for entry via the National Senior Certificate (NSC) APS to study mainstream physics and life science physics and 41% were close but not meeting the required APS and were registered for a four year extend program. The balance was from a wide range of backgrounds including the university level qualification. Of the 59% of students admitted from their NSC-APS 76% of students are registered for major in physics and engineering and 24% of the students are registered for life science physics. This has been a trend in UJ for the past few years to date.

Part of the investigation into the educational background of the students entailed an analysis of their high-school examination results. These are compared with their first semester marks at university level. A minimum rating of 5 for physical science where PHYI is included in the study of physics major and engineering programs (mainstream) is calculated with other specified groups of subjects to calculate a minimum total APS of 27. A histogram of the 2011 entry cohort's physical science subject achievements is represented in figure 1. Encouraging features of this histogram is the high percentage of the students passing (3) or have bare passed (2). It is evident from the Gaussian fit (solid line in the figure) according to the expression below that the average achievement performance is 52.5% and more students are qualifying to study PHYI.

$$y = a\exp^{[-0.5(x-\bar{x}/b)]}$$

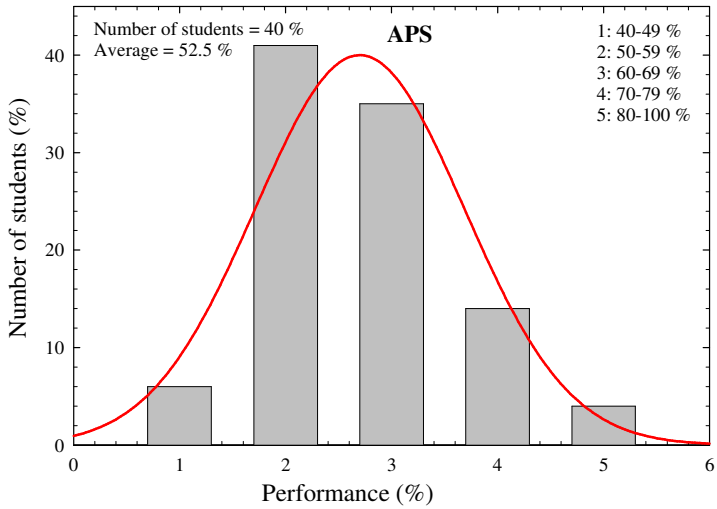

Figure 1: Performance of the cohort in the NSC physical science subject

As a further step in gathering information about the student's level of preparedness, a diagnostic test was administered during the orientation week for the PHYI course. This 20 minutes assessment consisted of 10 questions. All questions were multiple-choice questions worth 3 marks each. They covered motions (graphs), vectors, force exerted on two parallel conductors, electric circuit, projectile motion, Newton first law, momentum and Newton's law of Universal Gravitational force. These questions were based on high school physics concept.

A total of 547 students completed the 10 question test. The 20 minutes allocated to the test appeared to be sufficient, as a significant number of students appeared to finish with adequate time to spare. The students also appeared to take the assessment seriously, as evidenced by the fact that they did spend most of the allocated 20 minutes working on their answers. The histogram is provided in Figure 2

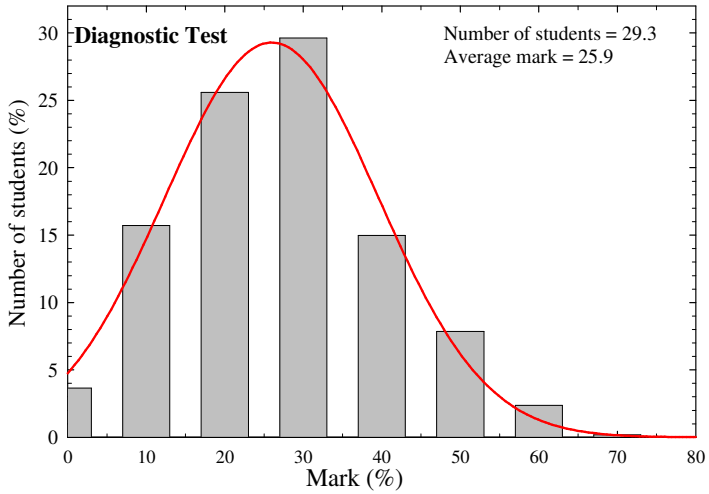

Figure 2: Mark the histogram for 2011 diagnostic test

The average mark obtained by the students that wrote the test was 27.08%. As there were apparently 4 choices to each of the questions, the average mark for random guessing would have been 25.97%. The results were clearly very disappointing. They appeared to indicate that most of the students either had not understood or had forgotten much of the basic physics they had covered in their three years of high school.

3.2. Predictors of Success

The key factors that lead to success in this course were investigated by comparing high school examination results with semester 1 PHYI examination results. Only students registered for mainstream physics are included in the analysis. Care must be taken in interpreting the results as those students who achieved a rating of 4 from the NSC APS were required to take four year program PHYI to strengthen their physics background and are therefore not included in this analysis including the life science students. Two facets of the entry cohort's NSC scores were compared with PHY1 examination results, namely the overall NSC rating score achieved and the achievement level in the NSC diagnostic test physical science subject. The figure 3 below shows the achievement performance of student in PHYI.

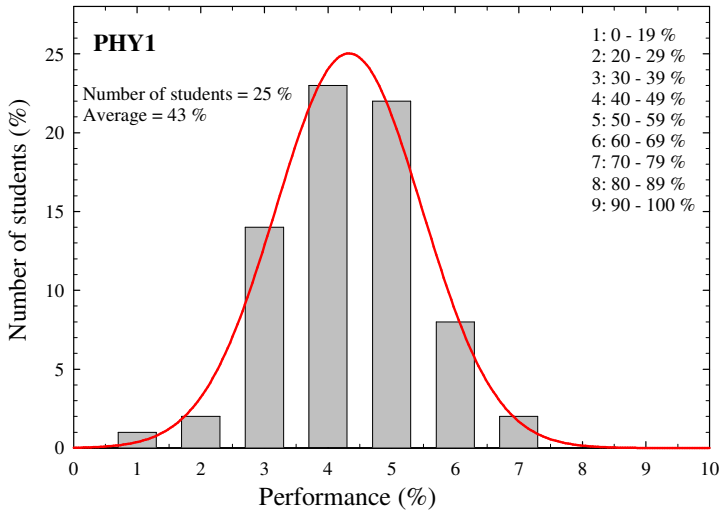

Figure 3: Histogram of PHYI performance achievement

3.3. Predicting ability of NSC rating score

The PHYI mark is plotted against the NSC rating score in Figure 4**.** The maximum possible NSC APS is 49 while enrolment selection policy at UJ prevented enrolment of students with an NSC APS lower than 27. Analysis shows that the NSC APS exhibited a 40% of admitted students obtained an average of 52.5%, this implies that they are prepared to study PHYI. But their final PHYI results show a 10% drop of the 25% of students achieving an average 43%.

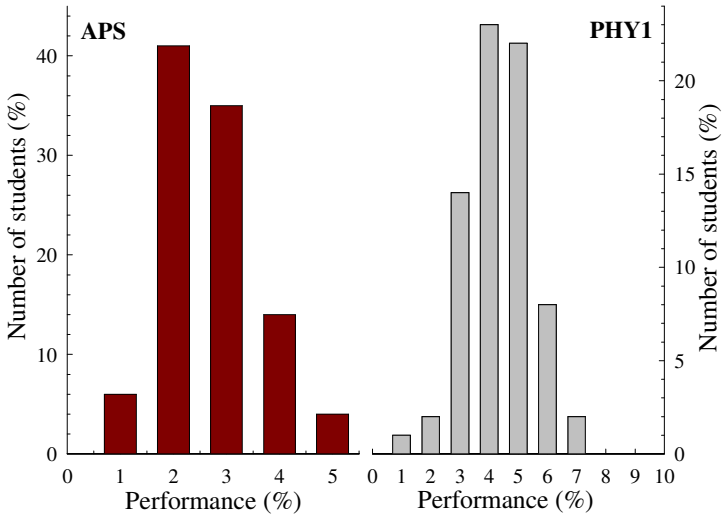

Figure 4: Grade 12 NSC APS v/s PHYI marks

3.4. Predicting ability of achievement in the Physics 1 semester1 module

When interpreting the NSC APS results in relation to their preparedness it implies that NSC score in the subject does provide indication of likely success, but as evidenced in the diagnostic test v/s PHYI figure 5 below, there is a considerable change of students passing PHYI as compared to the diagnostic test results.

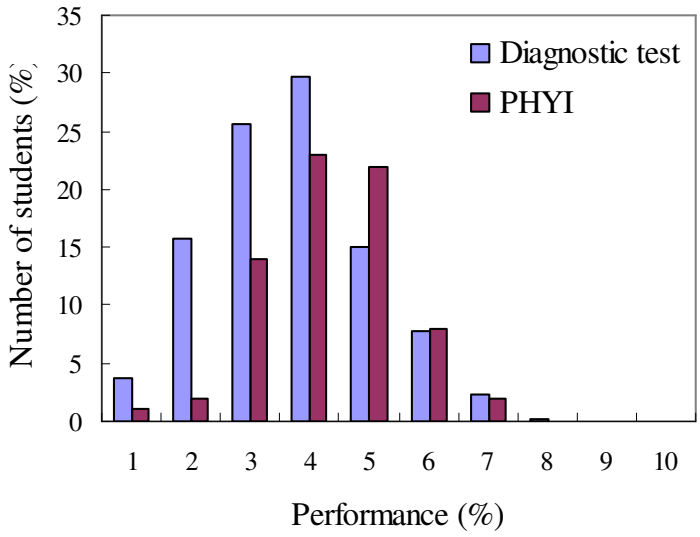

Figure 5: Comparison of Diagnostic Test and PHYI

Of particular relevance for the formulation of entry-selection policy was clear evidence that a significant number of students who had not achieved in the diagnostic test, or who had not attempted the test, were still able to achieve passing mark of 50% at university.

4. Conclusion

Analysis of the comparison between NSC APS and the first semester module results indicates that the most significant determination of examination success in PHYI was whether students had studied the NSC physics module rather than the APS achieved for the subject.

A diagnostic test was administered in the orientation week for PHYI module with the aim of identifying the level of preparedness the student cohort brought to the PHYI module. This diagnostic test was valuable as a "wake-up call" and led to behavioural changes to the students and to some modification of teaching methods. The results of such test should not be used as a predictor of success, but as a guide to teaching and assessment and to motivate students. This can be of help to first year lecturers to know what students they expect form high school and what measures can be taken to improve retention in the first year class. We intend to continue with the study with the 2012 cohorts of PHY1.

5. Acknowledgements

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