First year university physics students' understanding of units and measurements

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Abstract. Competency in units and measurements is a key skill required for undertaking studies in science. Ability to convert and manipulate both fundamental and derived units is a key requirement to achieve success in both theoretical and practical components of Physics courses. In light of this imperative, this investigation probed students' conceptual competence in units and measurements as crucial aspects associated with both theory and practical work in Physics. The sample in this research comprised students enrolled for diploma programmes in the Faculties of Engineering and Health Sciences at the University of Johannesburg. Key findings in this research strongly suggest that students' conceptual competence in units and measurements appears to be a function of the intrinsic requirements of the respective academic programmes.

1. Introduction

Students' conceptual competence in units and measurements is arguably of crucial significance for laying a solid foundation required to navigate other conceptual knowledge areas in Physics as an intellectually stimulating discipline. Hence, this investigation primarily focused on the assessment of students' conceptual competence in units and measurements as crucial aspects associated with both theory and practical work in Physics. The sample used in this inquiry comprised students enrolled for diploma programmes in Chemical Engineering and Electrical Engineering in the Faculty of Engineering and Chiropractic and Homoeopathy in the Faculty of Health Sciences at the Doornfontein Campus of the University of Johannesburg. In terms of the intrinsic requirements of the respective academic programmes, students are granted admission based on their admission point system (APS) scores as indicated in Table 1 below. The Physics modules for these programmes are structured to provide applied physics flavor for meaningful provision of tailor-made tuition. The Physics theory and practical modules are offered as separate entities for which students have to obtain pass credits. The assessment for the theory module is based on semester tests and a summative semester examination while continuous assessment is adopted for the practical module.

Table 1. Admission Point System (APS) scores for the two Faculties

Faculty	Qualification	Admission Point System Score
Health Sciences	Chiropractic Diploma	27
Health Sciences	Homoeopathy Diploma	27
Engineering	Chemical Engineering Diploma	24

2. Conceptual understanding and practical work

Meaningful practical work is a critical component of studies in science. It has been argued that it is necessary to introduce students to the relevant scientific concepts prior to their undertaking of any practical work if the task is to be effective as a means of enhancing the development of conceptual understanding [1]. At another pragmatic level, concerns have been expressed about whether the observation of specific phenomena within the context of a practical task can lead to the development of conceptual understanding unaided [2]. This discourse presents a complex dichotomy that ought to be unraveled in order to provide insightful elucidation on the relationship between meaningful practical work and the development of appropriate level of conceptual understanding. In this regard, it has further been maintained that the function of practical work might be better understood in terms of a link or bridge between previously taught scientific concepts and subsequent observations [3]. However, it is recommended that much more must be done to assist instructors in engaging students in science laboratory experiences in ways that optimize the potential of laboratory activities as a unique and crucial medium that promotes the learning of science concepts and procedures, the nature of science, and other important goals in science education [4].

3. Research design and methodology

A diagnostic conceptual assessment instrument was administered as part of a survey to assess students' conceptual competence in units and measurements. Specific conceptual areas covered by the diagnostic conceptual assessment instrument are depicted in Table 2 below.

Table 2. Conceptual areas covered by the diagnostic conceptual assessment instrument

Section A	Scientific notation
Section B	Elementary Conversions
Section C	Multiple conversions
Section D	Multiple conversions in dimensional formulae
Section E	Multiple conversions in graphical interpretations

4. Findings

The comparative performance of the three groups is provided in Figure 1 below. Chiropractic and Homoeopathy students demonstrated a better performance as compared to the Electrical and Chemical Engineering students. The performance disparity seems to suggest that competence in the conceptual areas investigated appears to be a function of the intrinsic requirements of the respective academic programmes. In terms of the required APS score, the admission criterion for the Faculty of Health Sciences is stringent as compared to the Faculty of Engineering and hence better quality students enroll for Chiropractic and Homoeopathy programmes. The nature of the students' performance may be attributed to the demands of the admission point system as a reflection of the quality of students admitted into each programme as well as their competence in units and measurements.

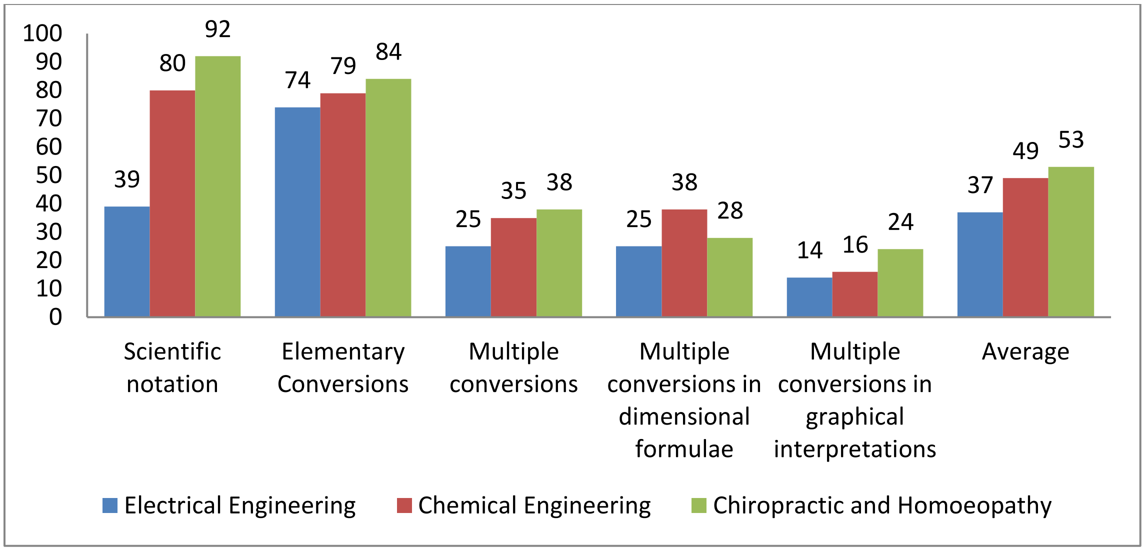

Figure 1. Comparative performance of the three groups

The overall academic performance in terms of the theory module appears to be consistent with the performance in units and measurements as indicated in Figure 2 below.

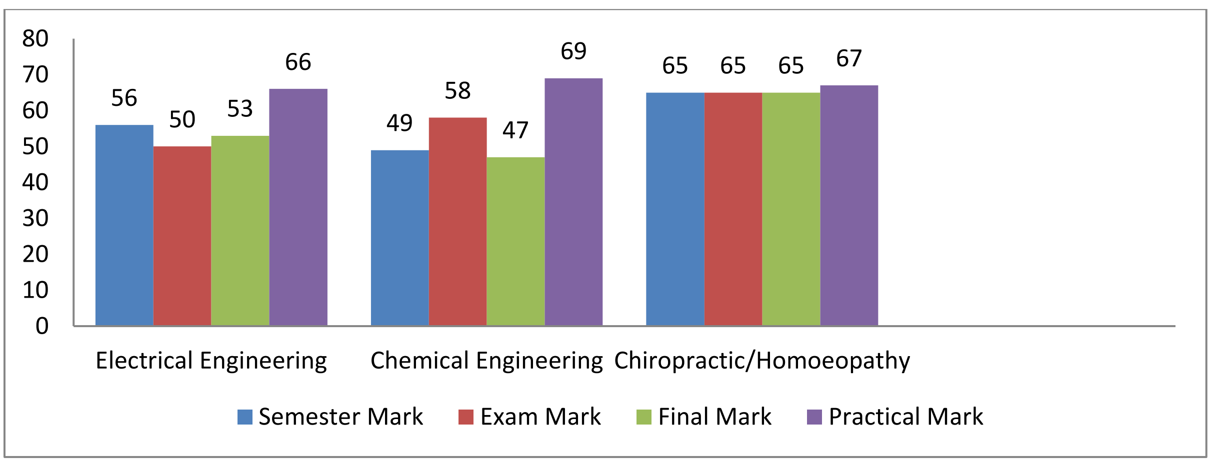

Figure 2. Comparison of academic performance in the theory module

Comparative analysis in terms of the pass rates and throughput rates [Figure 3] appears to reaffirm the fact that students enrolled for Chiropractic and Homoeopathy programmes demonstrated satisfactory performance.

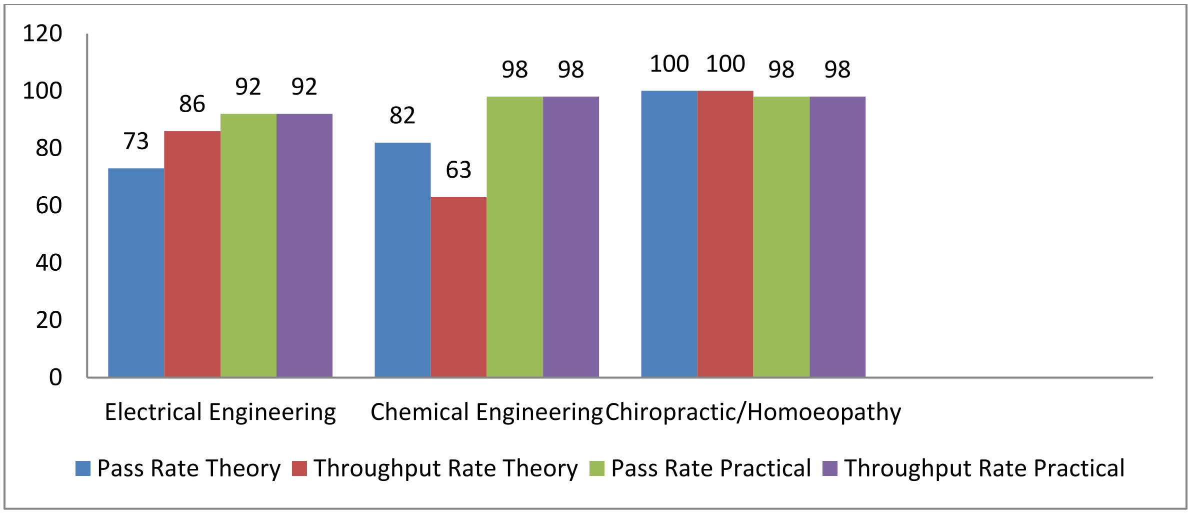

Figure 3. Comparison of pass rates and throughput rates

The pass rate is determined on the basis of the number of students undertaking the assessment while the throughput rate is based on the number of students initially enrolled for the specific module. The pass rate and the throughput rate for the practical module were evidently higher as compared to the theory module.

5. Discussion

Students in the three groups largely experienced difficulties when plotting graphs related to the experiments performed during their laboratory sessions. This inadequacy became evident when their experimental reports were evaluated. Yet, graphs play a highly significant role in providing visual means of presenting information that may be held in a functional relationship or a data set [5]. In addition, being too rigid with the prescription of graphical conventions for statistical data across the school years might stifle students' creativity in thinking of ways to tell the stories in their data sets [5]. The use of software applications to generate graphs is also accompanied by inherent difficulties for students although software applications are designed to enable students to visualize data to promote sense-making from the arrangement of information in space [5].

As an additional consideration, students have a tendency to use a spread of data and the measures of centre to compare data sets in later years of schooling but do not incorporate explicitly these notions with graph interpretation [6]. Within the context of this inquiry, other areas of difficulty for the students appeared to be multiple conversions and multiple conversions in dimensional formulae. These areas of difficulty require adequate attention for the sake of developing meaningful students' conceptual understanding as a key ingredient necessary for grappling with conceptual areas in Physics as well as solving application-type problems.

In a similar vein, practical work is largely viewed as essential part of teaching and learning Physics [3,7,8,9]. In addition, practical work is either considered as a central part of physics classes or its status is wished to be lifted to such a position in many countries [3,8] and South Africa is no exception. In fact, the importance of practical work and theoretical learning supporting each other has been accentuated [10]. However, it has been argued that experimental work is not effective as a tool for promoting understanding or learning the theoretical concepts of physics [3,11,12,13]. Suffice to indicate that although practical work is a somewhat effective tool in getting students to remember the practical aspects of an experiment, the ideas behind the phenomena are rarely learned and even more so recollected later on [7]. Clearly, these contradictions present a complex scientific quagmire that ought to be fully unraveled.

6. Conclusion

The students' performance in semester tests as well as the final examination projects a reasonable correlation with competency levels in units and measurements. Key findings in this research strongly suggest that students' conceptual competence in units and measurements appears to be a function of the intrinsic requirements of the academic programme. Proficiency in units and measurements is a crucial skill necessary to study Physics and its ramifications as a fundamental science. This skill also forms an integral part of the technical expertise required for the performance of key tasks such as the calibration of instruments and equipments used in various scientific fields. In essence, this study has endeavored to provide valuable insights into some of the essential students' competency levels which are critical to becoming rounded professionals in a scientific sense.

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