Student Voices regarding Practical Instruction in a Solar Energy Course indicates Student Satisfaction

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***Abstract*- Within higher education, student voices or perceptions are useful in measuring effective instruction and are important to evaluate the nature and quality of educational interventions. Student voices are often considered in determining whether student academic satisfaction exists with regard to the quality of engineering education being offered. The question thus arises "What does student voices say regarding practical instruction offered in a Solar Energy course at the Central University of Technology in South Africa". Research has shown that voices of undergraduate engineering students indicated that they really enjoy practical work scheduled in a laboratory, thereby indicating a measure of student satisfaction. However, this was reported on only for students in an electronic communications course, with fewer results published for undergraduate engineering students in other disciplines at a university of technology. The purpose of this paper is to consider student voices regarding practical instruction offered in a Solar Energy course at a university of technology. An exploratory case study is employed along with descriptive statistics for the quantitative data relating to the student voices. An electronic response system was used in a classroom environment to listen to student voices relating to the practical work done in the laboratory. These student voices did confirm that many of the students felt that the practical work was beneficial, relevant and practical in helping them apply new knowledge in solving engineering problems, resulting in a measure of student satisfaction. This has the potential to result in the retention of the best and brightest students from among these participants for future postgraduate studies which will most likely involve more intensive laboratory work!**

Keywords: Solar energy, student voices, learning outcomes, graduate attributes

I. Introduction and Rationale

"Your most unhappy customers are your greatest source of learning" [1]. These words, by Bill Gates, illustrate the value of feedback which can be used to rectify deficiencies or improve products or services. Within higher education, student voices or perceptions are useful in measuring effective instruction [2] and are important to evaluate the nature and quality of educational interventions [3]. Student voices are often considered in determining whether student academic satisfaction exists with regard to the quality of engineering education being offered. In fact, a key dispositional factor, emerging from the literature that serves to enhance or inhibit student retention is their satisfaction with their course experience [4-7].

Student retention is defined as the ability of an institution to retain a student from admission through graduation [8]. However, at the operational level, student retention includes continuing further studies at the same university [9]. This suggests that undergraduate students who perceive their current educational experience to be satisfying will most likely continue their postgraduate studies at the same institute. In fact, laboratory work, or hands-on activities, can improve student understanding, providing high student satisfaction with the learning experience [10, 11].

Undergraduate engineering students at the Central University of Technology (CUT) have the choice to enrol for a National Diploma or Certificate in a number of different engineering disciplines which include both theoretical and practical work. This affords students the opportunity to demonstrate vital graduate attributes such as problem-solving, technical competence, teamwork and technological literacy. Problem-solving requires students to use prior knowledge to find a solution to a problem [12] while a technologically literate person must have a certain amount of basic knowledge about technology [13]. Technical competence refers to the application of knowledge and skill in the completion of a task [14] while teamwork points to the ability of students to work effectively in a group [15]. These attributes may be assessed by means of practical assignments scheduled in a laboratory.

Research has shown that many undergraduate engineering students really enjoy practical work scheduled in a laboratory [16-18], thereby indicating a measure of student satisfaction. However, this was reported on only for students in an electronic communications course, with fewer results published for undergraduate engineering students in other disciplines at a university of technology (UoT). The following research questions, therefore, arise: What are the perceptions of undergraduate students about practical work done in a Solar Energy course? Do they find it enjoyable, challenging, relevant and constructive?

The purpose of this paper is to consider student voices regarding practical instruction offered in a Solar Energy course at CUT. Listening to student voices on aspects relating to their educational experiences is an inexpensive, simple and efficient research method to gather information [8] that allows different aspects of the learning environment to be assessed by the individual student [9]. It must though be noted that these voices are only personal assessments [19]. However, students can validly comment on the quality of teaching as they directly experience it [20], as it constitutes a mental representation of learning activities that affect student's conscious and unconscious choices in the learning environment [21].

This paper will firstly highlight the importance of student voices. The context of the study will then be explained, followed by the methodology, results and conclusions.

II. THE IMPORTANCE OF STUDENT VOICES

By purposefully listening [22] to students and by treating them with the appropriate respect [23], educators are empowering students [24] to contribute to their learning experience. If taken into account, student voices may contribute to the development of a module [25] via the efforts of their lecturer. Educators, on the other hand, can gain valuable insight into different aspects of their teaching methods and materials used from a student's perspective [26].

One of the challenges of listening to student voices may include creating an environment where students can make a difference [27]. Students must feel that what they say is taken seriously [28] and that it will be taken into account concerning their learning experience. It may further be challenging to engage in dialogue with students and respond in ways that validate the students input and honour the educators pedagogical commitments [29]. Study's where student voices were used by researchers include:

- An investigation into how specific influences were perceived by Mäori students [30].
- Identifying the best practices for civic education in 22 schools in Philadelphia [31].
- Choosing between online and face-to-face courses at the Teachers College at Columbia University [32].
- Improving the quality of course evaluations at the Colorado School of Mines [33].

These are just a few of many cases where researchers used student voices to try and improve the learning experiences. In fact, a search for the words "student voices" on Google Scholar returns more than 13 000 hits.

III. RESEARCH CONTEXT

The Department of Electrical, Electronic and Computer Engineering at CUT offers courses in electrical and computer engineering. These courses deal with the study and application of electricity, electronics, electrostatics and electromagnetism. Sub-studies include power electronics, control systems, signal processing and telecommunications. Undergraduate electrical engineering students at CUT have the choice to enrol for either a National Diploma or a Higher Certificate.

Students have to obtain a minimum of 360 credits for the National Diploma, which is a NQF (National Qualifications Framework) level 6 qualification. The majority of modules in this programme have a credit value of 10 (students should dedicate at least 100 notional hours to each module), requiring students to register for approximately six modules per semester (13 weeks in duration). Four semesters (or two full academic years) are usually required to obtain all the credits with a third year devoted to compulsory work integrated learning where the student will work in the industry and obtain 60 credits per semester.

The Higher Certificate in Renewable Energy Technologies (HSRET) is the first pre-graduate course in renewable energy that was approved by the South African Qualification Authority (SAQA). This certificate was designed for those individuals that want to enter the renewable energy field as technicians, thereby enabling students to prove that they have achieved a basic knowledge of the fundamental principles of the application, design, installation and operation of Photovoltaic (PV), Solar and Small Wind energy systems. A total of 120 credits is required for the HSRET and is currently an NQF level 5 certificate. This certificate requires a full year of instruction [34] where one of the required modules is termed Solar Energy Systems II. This module forms the basis for this research paper (its structure is shown in Table 1.)

Table 1: Module structure and assessments of Solar Energy Systems II

Module	Solar Energy Systems II	Structure
Main sections in syllabus (theory sections)	1. Introduction to solar energy 2. Solar system configurations 3. Components of a Solar Electric System 4. Design of photovoltaic systems 5. DC and AC measurements on PV systems	5 learning outcomes 4 learning outcomes 4 learning outcomes 5 learning outcomes 2 learning outcomes
Formative assessments	Two written classroom tests where the first test contributes 25%, and the second test 40% to the total course mark	• Test 1 includes 25 marks from section 1 and 2 • Test 2 includes 50 marks from section 1 to 5
Practical instruction	5 x practical experiments which contribute 35% to the total course mark	Each practical is linked to a theory section
Summative assessment	1 x closed book examination The student's final mark comprises 40% of the course mark and 60% of the examination mark	20 marks per theory section covered in the examination

Students are required to complete two written class tests that contributed 25% and 40% towards their total course mark. The other 35% of the course mark is derived from the practical instruction which is completed in a laboratory using an innovative jig and accompanying software that was developed by the authors [35]. Students are given a final summative written assessment (examination) at the end of the semester, which covers both the theoretical and practical instruction. The student's final mark is calculated using 40% of the course mark and 60% of the examination mark. Student voices regarding the practical instruction offered in this certificate were obtained to determine if students were satisfied with the learning experience.

IV. Research Methodology

An exploratory case study is employed along with descriptive statistics for the quantitative data relating to the student voices. According to Yin [36], an exploratory case study is appropriate for preliminary inquiries and is ideal for analysing what is common and different across cases that share some key criteria. The analysis of common and different student voices is sought regarding the same criteria, namely benefits, relevance and practicality of the practical work done in a laboratory. Descriptive statistics are used as the results are interpreted by individual African engineering students enrolled at CUT.

Quantitative analysis is important as it brings a methodical approach to the decision-making process, given that qualitative factors such as "gut feel" may make decisions biased and less than rational [37]. The target population was restricted to 33 African engineering students enrolled for Solar Energy Systems II during 2014 and 2015. The sample size is small as these were the first students to enrol for this new Certificate. An electronic response system was used in a classroom environment at the end of the semester to listen to student voices relating to the practical work done in the laboratory and its submission via a learning management system[38]. These voices were heard by posting specific questions relating to student satisfaction of the learning experience which were based on previous research [39, 40].

Student voices are considered with regard to the perceived benefits of the practical instruction. This is especially considered with regard to problem solving skills and whether the practical instruction was relevant to the theory presented in the classroom. The practicality of the work was also ascertained by asking students to what degree they engaged with design principles for standalone and grid connected solar engineering systems. Positive responses to the perceived benefits, relevance, and practicality of the practical instruction are viewed as indicators of student satisfaction that may lead to improved student retention.

V. Results

Results of the student voices regarding the practical instruction which they received are divided into four sections, namely benefits, relevance, practicality and suggestions. Answers from students regarding benefits (Figure 1), relevance (Figure 2) and practicality (Figure 3) are presented on a Likert scale that range from strongly agree to strongly disagree. Students were also given the opportunity to make suggestions regarding the practical work done in the module (see Figure 4).

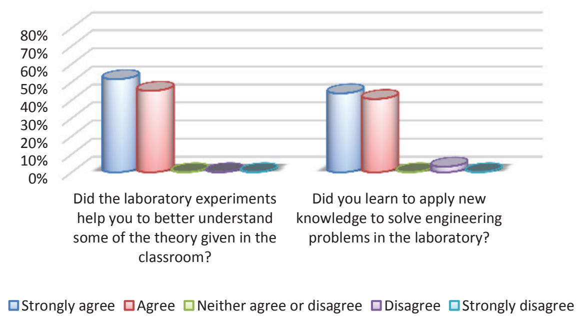

Figure 1: Student voices regarding the benefits of the practical work

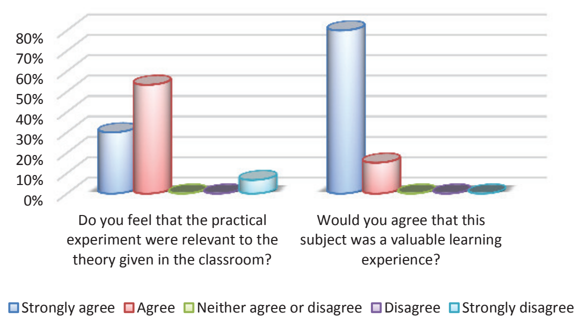

Figure 2: Student voices regarding the relevance of the practical work

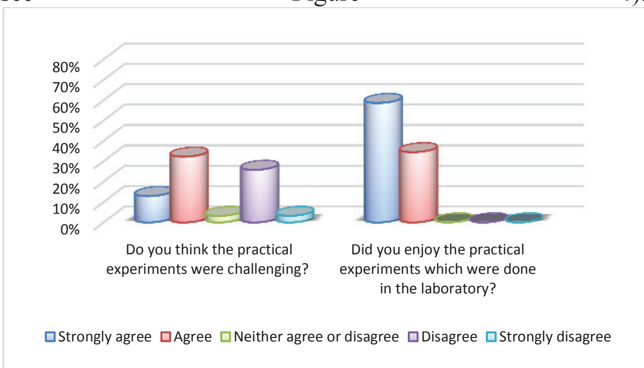

Figure 3: Student voices regarding the practicality of the practical work

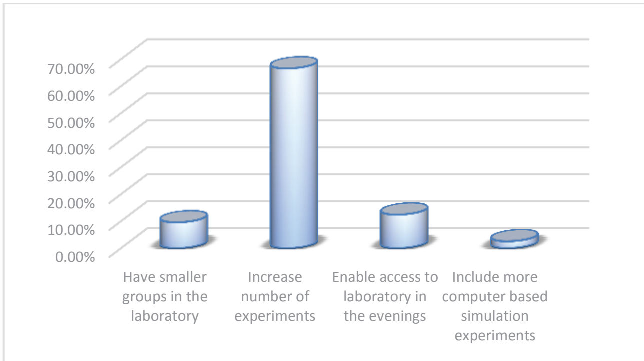

Figure 4: Student voices regarding suggestions for the practical work

VI. Discussion of Results

Figure 1 indicates that 96% (strongly agree and agree) of the students agreed that the practical work helped them to better understand the theory in Solar Energy Systems II. In response to the question regarding the application of new knowledge, 84% indicated that they learned how to apply new knowledge in solving engineering problems (see Figure 1). These results tend to suggest that a measure of student satisfaction was achieved in the practical work, which may enhance student retention [4-7].

Figure 2 highlights that 93% of the students agreed that the practical work was relevant to the theory discussed in the classroom. A further 97% indicated that the module was a valuable learning experience. This suggests that the practical work is aligned to the theoretical work, adhering to the principles of constructive alignment [41].

Figure 3 shows that 34% of the students agreed that the practical work was challenging, while 31% felt that they were not challenging. These opposite responses may suggest that there was a fair degree of difficulty in completing the practical work. In response to the question whether the students enjoyed the practical work, 93% of the students responded affirmatively. These results tend to suggest that a measure of student satisfaction was achieved with regard to the practical work, thereby implying that they will be more motivated to complete their studies [42].

Students were also asked to make recommendations about the practical work done in the Solar Energy Laboratory (Figure 4). Although the practical groups consisted of only five members, 10% of the students felt that the groups should be smaller. The results further show that 67% of the students felt that more practical work was necessary. 12% indicated that more laboratory time should be allocated in the evening. Time-on-task helps students to take ownership of their knowledge, creating linkages and relationships within their own knowledge structures [43]. Results also indicated that 3% of the students would prefer more computer-based simulations, which is similar to results obtained in Australia where a survey was conducted regarding the usefulness of remotely accessible laboratories [44].

VII. Conclusions

The purpose of this paper was to consider student voices regarding practical instruction offered in a Solar Energy course at a UoT. Responses indicate that practical work done in this laboratory has the potential to enable students to develop the right graduate attributes of problem-solving, technical competence, teamwork, and technological literacy.

In response to a question regarding the application of new knowledge, 84% of the students indicated that they learned how to apply new knowledge in solving engineering problems (graduate attribute of problem-solving and technical competence). 93% of the students agreed that the practical instruction was relevant to the theory discussed in the classroom and that it was enjoyable (bear in mind that it was scheduled in groups which means that the graduate attribute of teamwork is addressed). 97% of the students indicated that the module was a valuable learning experience as they engaged with different technologies (graduate attribute of technological literacy).

These student voices confirm that many of the students felt that the practical work was beneficial, relevant and practical in helping them apply new knowledge in solving engineering problems, resulting in a measure of student satisfaction. This has the potential to result in the retention of the best and brightest students from among these participants for future postgraduate studies which will most likely involve more intensive laboratory work!

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