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A REGIONAL UNIVERSITY PERSPECTIVE ON ENGINEERING EDUCATION OF MULTI-CULTURAL FRESHMAN STUDENTS FROM SOUTH PACIFIC COUNTRIES

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ABSTRACT

Of late, there is a growing need for quality engineers who have the ability to solve complex engineering problems with reasonable knowledge of ethics and economics. This has led many universities to pursue accreditation by professional engineering bodies. While the accreditation process installs a standardized system of quality teaching, it is important that the engineering entrants have a degree of understanding that allows implementation of quality teaching methods. This study looks at the performance of first year engineering students in a bid to identify major issues that students face in a Bachelor of Engineering program. The learning of students in the School of Engineering and Physics at the University of the South Pacific is influenced by interactions of at least 12 different cultures from the 12 member countries of the university. The study looks at how students perform across cultures in the first year mechanical engineering courses, mainly engineering mechanics and engineering graphics & design. The general trend over the last five years shows that while the student numbers in the program have been increasing, student performance in one course seems to be improving but declining in the other; the two courses differ considerable in contents, required skill sets, and assessment methodologies. The study also presents possible reasons for the varied performance by considering issues such as cultural and academic backgrounds, use of teaching tools and resources, and revisions to the course and program and looks at how multi-cultural engineering education can be improved. The number of female students taking up engineering as their major is also looked at and positive trends are seen with female participation increasing from 7.6% in 2008 to 13.9% in 2013.

INTRODUCTION

Engineers continue to play a key role in the economic growth of developed countries and their role in developing countries and regions cannot be overemphasized. While the process of transforming an individual into an engineer is a long one, quality engineering education is essential [1]. However, engineering is today a global profession which brings added challenges on higher education institutions to compete for good students and produce engineering graduates fit for the global market [2]. Engineers are vital to the development and advancement of nations. Likewise, in the South Pacific region, there are urgent development issues that must be tackled by well trained engineers. The region looks to the few locally groomed engineers to play a key role in advancing the region. While overseas trained engineers are a short term solution, engineering education in the region will bring about both short and long term sustainability [3]. The South Pacific Engineers Association highlighted the importance of engineering education in the region and stated that engineering could contribute significantly to the earning capability of the nations [4].

The quality of an engineering graduate is often gauged by the quality, or international accreditation, of the academic institution from where he/she graduated. The process of accreditation is a long and complex one where a number of factors come into play. One criterion in the assessment of an academic program for accreditation is the teaching and learning environment [5].

The teaching and learning environment is comprised of two key parties: the teacher and the students, and understanding between them is essential for the teaching and learning process to prosper. For the teacher, this is especially a challenge when it comes to first year students and it often means looking into the background of the students and a history of the performance of the students in first year courses.

First-year engineering curricula offer a critical window of opportunity to retain students in engineering disciplines and provide a strong foundation for future success [6]. With the ultimate goal of producing an engineer fit for the ever-changing industry, there is a need to understand what makes quality engineers. If the later three years of the BE program are intended to teach essential attributes to engineers, then the first year becomes the most important. The first year creates a foundation on which engineering education is further built in later years.

The University of the South Pacific (USP), established in 1968, is a regional university serving twelve member countries - Cook Islands, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu. These small island nations are spread over millions of square kilometers in the Pacific Ocean with each having their own cultures, traditions, and languages. The population of the countries varies from about 1500 for Tokelau to about 850,000 for Fiji [7] with a collective population of about 2.1 million.

The university has a total of fourteen campuses with one campus in each country except Fiji which has three campuses, including the main campus, Laucala campus, located in Suva. USP offers a range of programs from certificate to doctorate and while face-to-face mode is the dominant means of study, a number of courses are also offered through the distance and flexible learning (DFL) mode and more recently fully online and blended modes. The DFL and online modes have been made possible using USPNet, a satellite-based communications network, and the open source online learning management system (LMS) – Moodle. In a case study of Bachelor of Engineering degrees offered through distance learning, Dowling [8] remarks that majority of distance students are employed in the industry and are studying part time. Dowling also adds that this method benefits the industry by adding value to the existing workforce.

Except for two schools, all other academic schools of the university are based at its main campus. This includes the school of engineering and physics (SEP) which currently offers two engineering programs: Bachelor of Engineering (BE) in electrical and electronic engineering (EEE) and mechanical engineering (ME).

The university first started offering credible engineering programs in 1996 with two programs: Bachelor of Technology (BTech) in electrical and electronic engineering, and mechanical and manufacturing engineering. These initial, 20-unit, three year programs have been revised a number of times since. These were revised to 24-unit Bachelor of Engineering Technology (BETech) programs in 2006, and are now fully upgraded to 32-unit, four-year BE programs since 2011. The word ‘unit’ is used interchangeably with ‘course’; hence 20 units mean 20 courses. Each unit/course teaches a particular subject with its own set of learning outcomes.

USP is in pursuit of international accreditation of both of its engineering programs and is currently working in this direction in collaboration with national and international engineering institutes and associations. Various studies are being planned in light of the uniqueness of the university, the program outcomes of which should not only address national but regional needs.

The study reported in this paper seeks to gauge the performance of first year engineering students and identify issues affecting their performance. The study involves two first year engineering courses, engineering graphics & design and engineering mechanics, both of which are compulsory courses in the two engineering programs. In this study, a comparison is made between students who reside in Fiji and students who are from the USP region namely from Solomons Islands, Vanuatu, Tonga, Samoa, Kiribati , Tuvalu, Niue, Cook Islands, Tokelau, Marshall Islands and Nauru. It is essential that possible hindrances to engineering education of these students be identified and rectified in the first year itself. Additionally, for the same reason, the study looks at the intake of females in engineering and looks at avenues to increase this intake.

This paper looks at the enrolment and pass rates of two key first year (mechanical) engineering courses and combines these data with surveys to identify critical issues in student performance and possible directions for the engineering programs.

OVERVIEW OF THE COURSES

The two courses under evaluation are MM101 – engineering graphics and design, and MM103 – engineering mechanics. Both these courses have gone through transformations over the years.

MM101 – Engineering Graphics and Design

There are no pre-requisites for MM101 apart from entry into the BE program. Entry into the BE program requires a pass in pre-university English and 60% or above in Physics, Mathematics and any other science subject.

MM101 was initially offered as an engineering graphics and design course but was simplified as an engineering graphics course only under the BETech program in 2008 with engineering design covered in courses which followed. The assessment allocation, in the meantime, remained unchanged with 50% continuous assessment and 50% final exam.

This course was again revised in 2012 under the BE program with the engineering graphics and engineering design components combined once again. However, the assessment was redistributed with 100% continuous assessment. The current learning outcomes of this course are given below.

On successful completion of this course, students will be able to:

- develop skills to produce technical sketches,
- draw orthographic views of 3D objects,
- project points, lines, and planes and apply it to solve problems involving space geometry,

- draw pictorial drawings,
- analyze and draw mechanical engineering drawings using associated standards,
- apply the general engineering design process to solve basic design problems, and
- Produce 2D and 3D computer-aided drawing (CAD).

The components of the continuous assessment in MM101 are given in Table 1.

Table 1: Assessment components and assessment weighting for MM101

Assessment components	Assessment weighting
CAD labs	30%
CAD test	15%
Assignments	10%
Short test	20%
Design project	25%

MM103 – Engineering Mechanics

Under the BTech program, MM103 was offered as an engineering materials and mechanics course and it was naturally a course heavy in content with two different areas compressed into one. This issue has since been rectified and from 2008, the content on engineering materials has been distributed to other courses. Unlike MM101, but in line with most other courses, the assessment weighting is 50% for continuous assessment and 50% for final exam. The learning outcomes for MM103 are given below.

A student who successfully completes this course will be able to:

- analyze 2D and 3D force systems,
- compute the center of gravity of 2D and 3D bodies,
- construct free body diagrams from a given problem to: determine shear force and bending moment diagrams, analyze the forces in beams and cables, and determine frictional forces, and
- apply Newton's laws of motion to analyze the motion of a particle along straight lines and curves.

Entry into this course requires passing a first year classical physics course *or* passing a first year mathematics (calculus) course.

The components of the continuous assessment in MM103 are given in Table 2.

Table 2: Assessment components and assessment weighting for MM103

Assessment components	Assessment weighting
Labs	15%
Assignments	15%
Short tests	10%
Project	10%

DATA COLLECTION METHODS

Student intake and assessment records of the past ten years were analyzed. Past course outlines, assessment rubrics and other curriculum related documents were studied. An online survey was carried out in the first year course MM101 which has 202 students in the face to face mode this year. The survey was intended to get feedback from students on how they viewed the diverse cultural experience and gender issues. The survey also collected data on how students viewed the different disciplines in engineering and what issues they were facing in the first semester of their first year.

ENROLMENTS AND PASS RATES

The trends in student numbers from 2004-2013 for MM101 and 2003-2012 for MM103 are shown in Fig. 1 and Fig. 2 respectively. MM101 is offered in the first semester since 2007 and MM103 in the second semester so naturally there is a decline in the student numbers from one course to the next with some students changing programs/institutions and some dropping out. Prior to 2007, MM103 was offered in the first semester and hence the student numbers were large. However, the total number of students in both the courses seems to have picked up significantly since 2012 which is the time when the BE program was introduced.

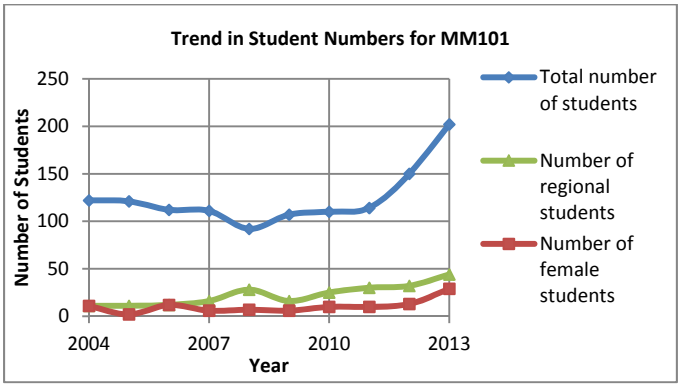

Figure 1. Trends in student numbers for MM101.

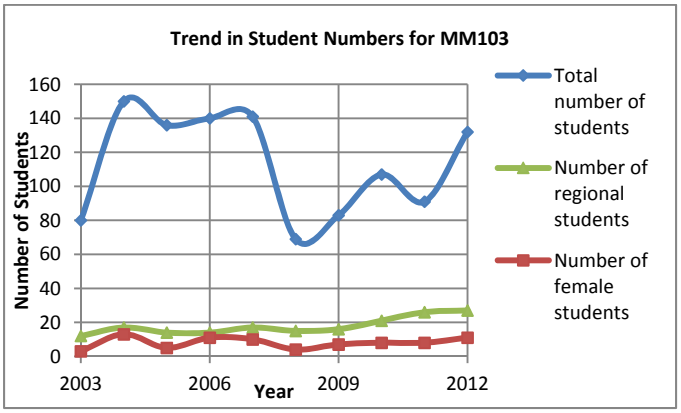

Figure 2. Trend in student numbers for MM103.

There has also been an increase in the number of regional students (the term 'regional students' is commonly used to

refer to students from the 11 member countries other than Fiji), and a significant increase in the number of female students in 2013. In fact due to the new BE program, student intake has gone up by 83% from 2010 to 2013. The year 2010 was the last for the bachelor of engineering technology program which the BE replaced.

Prior to 2012, local (Fiji) and regional (non-Fiji) students willing to do a professional engineering program had no option but to travel overseas to attend international engineering institutions which proved costly for the governments and the parents. The rise in the student numbers indicates that there may is now a shift in this trend with a low cost alternative now available at USP.

The trends in the pass rates for MM101 and MM103 over the periods 2004-2013 and 2003-2012 are shown in Figs. 3 and 4 respectively. While the overall pass rate for MM101 has been better than MM103 over the years, in general, the regional students underperformed in all years except for 2009. Compared to MM103, the pass rate of regional students in MM101 is further down from the total and local pass rates. A key suspect is the fact that MM101 utilizes a CAD software package which forms the core of the course. While Fiji students may have greater experience with computers, this may not be the case with regional students. A number of regional countries are underdeveloped and students lack access to computers. Since this course deals with computer-aided drawing, students from some regional countries are slow to get in pace with the rest of the class. While some steps have been taken to address these issues and while indications are that there has been some success, there is still a lot to be done to improve the success rate. In fact, prior to 2010, it was not surprising to find a student with no experience of working on a computer.

MM103 is more of a typical engineering course which requires good mathematical skills; while the overall performance has not been good, in recent years the local students and regional students have similar pass rates since 2006. This course is highly mathematical and does not have any software packages in use. In fact, one can successfully do this course without any knowledge of computers. Even the lab reports are hand written at the end of the lab session. The close pass rates of local and regional students in MM103 proves that it is not the students learning skills but relatively low exposure to IT facilities which caused the disparity in pass rates of MM101.

Another perspective is that students from some regional countries are completely new to the subject of engineering graphics. While there are also local students who encounter the same problem, they have a much larger group in class and they often happen to have friends who would have done engineering/technical drawing in high school. With their help, they are normally able to improve their performance as the semester progresses. Regional students on the other hand have relatively small group of friends to start with and the ones they have normally do not have any prior knowledge in this area. While they normally improve with time, cultural and language differences hinder quick learning.

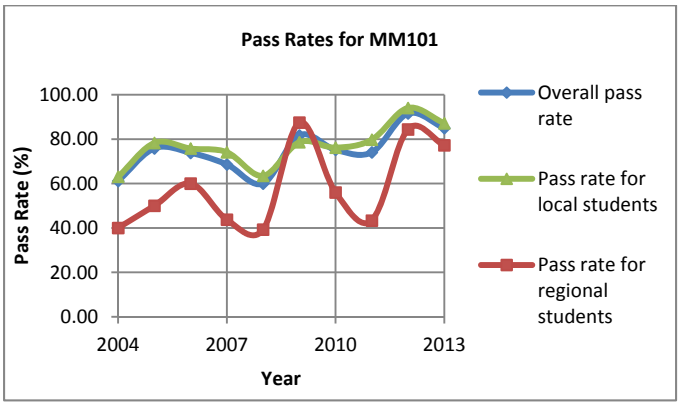

Figure 3. Pass rates for MM101.

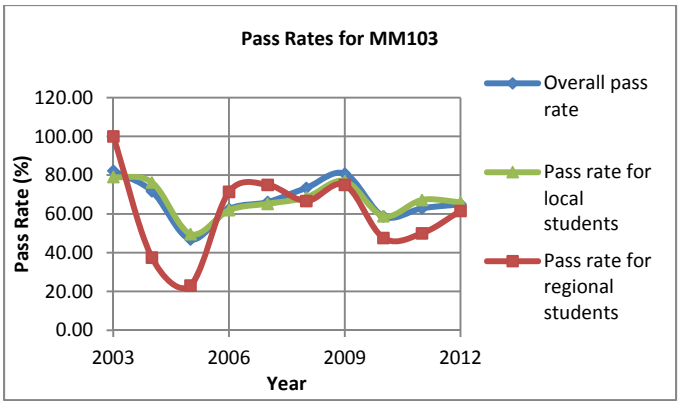

Figure 4. Pass rates for MM103.

Furthermore, cultural and language differences play some part in determining the learning styles of students, especially at USP where students come to study from many different backgrounds. Culturally, learning in the Pacific is mostly auditory and kinesthetic. In village life, which is still vibrant in many parts of the Pacific, knowledge and skills are passed from one generation to another through verbal communication and through practice. Students from such a background tend to perform better when working in groups. They are also very reserved and relaxed in nature which is very typical of village life. However, students from modern or upcoming town/city areas within the region seem to be able to work in groups and individually as well. These students are relatively vocal and can easily express questions, confusion or complaints if they do not understand a topic. However, this behavior in students changes rapidly over first year as they all mingle and exchange views.

Language also plays a major role in learning; especially at USP where most regional and local students do not have English as their first language but English is the principal language of instruction. Staff and students often have different accents and pace of speaking which leads to communication problems and difficulty in expressing themselves. While the trends can be used to generalize some issues, a detailed study

of failing/passing students along with background and entry will be required to identify exact difficulties.

STUDENT SURVEY

An online survey of students was conducted to receive student feedback. The surveys are ongoing. These surveys are done in addition to the student course evaluation form which students at the university fill out at the end of the semester to rate how the course was delivered to them. The survey was used to find how students felt cultural diversity was affecting their performance, how they view females in engineering especially their fellow female students, what facilities they were not happy with, what they liked or disliked in their first semester and how they viewed mechanical and electrical engineering fields. The survey also contained questions on how the students picked engineering education and the institute. Thirteen percent of the respondents were females. For the question on why they chose engineering, the prominent answer was curiosity and a desire to do engineering since childhood. Other reasons included good pay and a chance to do something for the community. Only 48% students revealed that they did not have difficulty in the first year courses. One of the major challenges students identified was limited access to IT facilities to learn drawing software such as AutoCAD. While the university has several computer labs for students use, most students have had very little experience with computers, and learning specialized software requires that they spend a lot more time with the software in the labs. This can be difficult at times given that the university has well over *20,000* students.

Eighty one percent students reported that being from different cultures did not have any effect on their studies while only 3% reported that cultural differences were hindering their performance. Three percent of the respondents replied that gender issues affected their performance. It is important to note that only 13% of the respondents were females. When questioned about problems and difficulties, 32% reported that they felt homesick at times while 12% disliked the food on campus. One respondent reported that as girls, they did not like being with a group of boys as it made them different from other girls on campus. Sixty one percent respondents thought that female students are setting examples for others by taking up engineering while 34% felt more females should do engineering. Nineteen percent students thought that there were more jobs in electrical and electronics engineering while 13% thought more jobs were available in mechanical engineering. Seventeen percent thought that mechanical engineering has more mathematics compared to 14% who thought it is more in electrical and electronics engineering. This could explain why each year more students choose to do electrical and electronics engineering as opposed to mechanical engineering. Sixty seven percent students appreciated being in a class with different cultures while 25% reported that a multi-cultural experience did not affect them in any way.

FEMALES IN ENGINEERING

There is a vast gap between female and male intakes to engineering colleges and universities around the world. It was reported by Wolcott [9] that only 13% of the engineering graduates in the USA are women. Across the English speaking world, numerous promotional activities have been carried out over the past years to attract and retain more women in engineering [9,10]. In the case of the University of the South Pacific, a greater challenge exists to balance intakes as fewer women in developing pacific island nations are inclined to do engineering. There are a few documented studies on the number of females in engineering in this region. Figure 5 shows percentage of female students registered in MM101 and MM103. It must be noted that MM101 is a first semester course and indicates the enrolment of females into the BE program. The MM103 data indicate the percentage of females who continue engineering into the second semester. Both percentage values are close; however, since MM103 has a smaller class size, the number of females in it is lower. Positive trends are seen with female participation in engineering at the University of the South Pacific increasing from 5.5% in 2007 to 13.9% in 2013. The sharp rise from 2012 (8.7%) to 2013 (14.3%) is in line with the rise in student numbers which also spiked this year. It is noted that enrolment of regional female students has also increased.

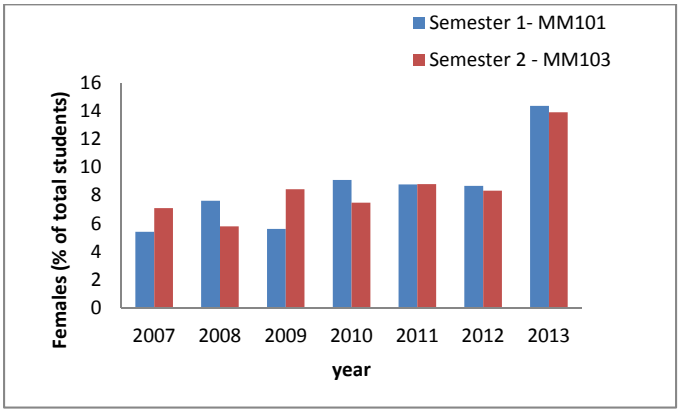

Figure 5. Percentage female enrolments from 2007 to 2013.

It may not be safe to compare these statistics with universities which offer engineering in other fields such as chemical engineering since the choice of females depends on the field of engineering as well. From this year, the engineering curriculum for the first year has reflected intentions to encourage and retain females in the program. For example sentences that read "*As an engineer, he should be ethical…*" have been changed to "*As an engineer, he or she should be ethical…*". An introductory chapter which explains the roles of engineers and engineering problems in the region used to have four male engineers as famous engineering figures; the chapter now has two female and two male engineers who have contributed to engineering.

Organizations promoting females in engineering such as ASME and IEEE were publicized in the class. Events such as

Engineers Week (ASME) and Global Marathon for women in engineering have been posted as discussion topics for students online. The results of this study will be used to implement several measures to ensure retention of females in engineering. The increase in female graduates will lead to more females idolizing women in their communities as engineers and lead to increase in female numbers. In order to respect freedom of choice, marketing cannot be targeted only at females to join engineering. However, creating a comfortable learning environment that would allow females to successfully take up key engineering positions would dispel long-held myths that engineering is only for men. Jacobs [11] in his article reveals methods of attracting females to engineering. He cites means such as outreach, providing access to industry role models and professional associations as means of increasing female enrolments.

CONCLUSIONS

Being a regional university, the University of the South Pacific has a duty to provide tailor-made engineering education to suit the region's needs. The education of future engineers depends on many factors aside from their individual intellect. The study shows a disparity in pass rates of regional students as compared to students living in Fiji or where the main campus is located. While initial survey results have ruled out cultural differences as contributing factors to difference in performance, the same cannot be said for availability of technology in the region. Fiji students have more exposure to IT facilities before they join the university. Since modern teaching relies a lot on these facilities, having exposure to them beforehand may provide local students an added advantage. The nature of the courses also has an effect on the performance. While the design and drawing oriented course saw better results in some years, the mathematically intensive course on engineering mechanics showed poorer performance from all the students. Student survey revealed interesting points of how freshmen viewed females in engineering. More students believe that there are more jobs in Electrical and Electronic engineering and that it has less mathematics when compared to Mechanical engineering. Female intake has improved significantly over the years and is at an all-time high of 14.3% in 2013. A change in class notes and teaching methods is underway to increase female retention. The results of this study are important to identify problems in delivering engineering education in the region. Following this study, several measures will be implemented to promote better performance of regional students and improve the retention as well as the intake of female engineering students. Being the sole provider of professional engineering education to more than 12 developing countries, the University of the South Pacific will continue to examine and improve its engineering education system for the betterment of the region.

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