1-1-2014

Decoding student satisfaction: how to manage and improve the laboratory experience

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Abstract

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Keywords

improve, student, experience, decoding, manage, laboratory, satisfaction

Disciplines

Engineering | Science and Technology Studies

Publication Details

S. Nikolic, C. Ritz, P. James. Vial, M. Ros & D. Stirling, "Decoding student satisfaction: how to manage and improve the laboratory experience," IEEE Transactions on Education, vol. 58, (3) pp. 151-1588, 2015.

This article has been accepted for inclusion in a future issue of this journal. Content is final as presented, with the exception of pagination.

Decoding Student Satisfaction: How to Manage and Improve the Laboratory Experience

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***Abstract*—The laboratory plays an important role in teaching engineering skills. An Electrical Engineering department at an Australian University implemented a reform to monitor and improve student satisfaction with the teaching laboratories. A Laboratory Manager was employed to oversee the quality of 27 courses containing instructional laboratories. Student satisfaction surveys were carried out on all relevant laboratories every year, and the data were used for continuous improvement. This paper will investigate the reforms that were implemented and outline a number of the improvements made. It also examines the program's overall impact on: 1) overall satisfaction; 2) laboratory notes; 3) learning experiences; 4) computer facilities; 5) engineering equipment; and 6) condition of the laboratory. Student satisfaction with the laboratories increased by 32% between 2007 and 2013. The results show that the laboratory notes (activity and clarity) and the quality of the equipment used are among the most influential factors on student satisfaction. In particular, it is important to have notes or resources that explain in some detail how to use and troubleshoot equipment and software used in the laboratory.**

***Index Terms*—Engineering education, engineering facilities, laboratory, laboratory management, student satisfaction.**

I. Introduction

A COMMON issue facing many engineering and science faculties across universities in Australia and around the world is the need to improve student satisfaction with teaching laboratories. "From the earliest days of engineering education, instructional laboratories have been an essential part of undergraduate and graduate programs. Indeed prior to the emphasis on engineering science, it could be said that most engineering instruction took place in the laboratory" [1].

Student satisfaction has grown in importance because of the competitive education environment and government-driven reforms [2], [3]. In Australia, a new government Web site [4] allowing students to rank student satisfaction with universities, and disciplines within them, has added to that competition for domestic and international students [5]. In addition, all the major accreditation bodies, such as the Quality Assurance Agency (QAA) in the U.K., ABET in the USA, and Engineers Australia in Australia, list laboratory abilities/skills as part of engineering teaching and learning outcomes [6].

Manuscript received April 07, 2014; revised July 08, 2014; accepted July 16, 2014.

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Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TE.2014.2346474

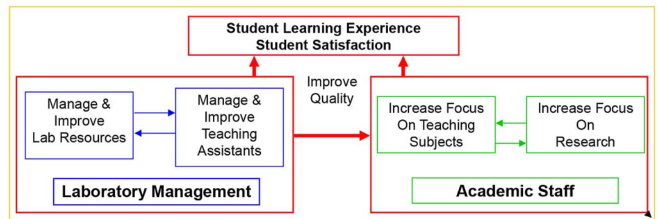

Fig. 1. Laboratory management model.

The importance of incorporating teaching laboratories in engineering education led the School of Electrical, Computer and Telecommunications Engineering (SECTE) at the University of Wollongong (UOW), Wollongong, Australia, to employ a Laboratory Manager to improve quality and student satisfaction. One reform was to facilitate a professional approach to managing and improving the teaching assistants used in the laboratory [7]. The other major reform was to centralize the management of all facilities and resources under the Laboratory Manager. Included in this was having the Laboratory Manager conduct student surveys to measure student satisfaction with the experiments and the facilities. The Laboratory Manager would work closely with course coordinators to implement necessary improvements. The overview of this model is depicted in Fig. 1.

This paper outlines and examines how a centralized management approach, together with quantification of student satisfaction, can lead to substantial improvement in student satisfaction with teaching laboratories. The study also investigated the relationship between experiments and facilities to determine the factors that influence student satisfaction in the laboratory. This research is valuable to anybody developing laboratory-based courses or managing such an environment.

II. Literature Review

A. Laboratory

There was a time when laboratories were "so central to an engineering degree that no one could even consider teaching an engineering course without an accompanying laboratory" [1]. New technologies such as simulations [8], remote laboratories [9], and educational opportunities such as massive open online courses (MOOCs) [10] are introducing new ways of teaching engineering in higher education. Even with new forms of teaching, the laboratory will play an important role in engineering education well into the future.

Teaching laboratories are acknowledged as a unique learning environment, enabling scientific discovery and inquiry-based learning [11]. Laboratories foster a range of skills including communication, knowledge, teamwork, ethics, and encouraging information acquisition [12] and are used to support learning in lectures by enhancing student understanding of theoretical concepts [6]. The importance of laboratories was highlighted in a study [13] that surveyed all the 34 universities in Australia that provide an engineering degree. The study found that 100% of executive staff believed that the laboratory was integral to engineering education, and that 62% of academics believe that the laboratory is the most important component of their courses.

The importance of laboratories has resulted in much research on how best to conduct them. Most of the research focused on teaching laboratories consists of studies into individual approaches/areas. For example Stanisavljevic *et al.* [8] undertook a study to investigate the effect a new simulation package had on students. Howard and Boone [14] investigated what influenced students to enjoy science laboratories by comparing student satisfaction of an old and newly designed experiment. Lewis [15] determined how video introductions could be used to increase student satisfaction in the laboratory. Boxall and Tait [16] investigated how inquiry-based learning affected student satisfaction in a laboratory environment. Gallardo *et al.* [17] investigated how learner satisfaction could be used to design an electronic laboratory course. These studies have provided an insight into specific areas of interest that students find satisfying within the laboratory environment.

A significant amount of literature is available for investigating a broad range of university facilities such as general computing, the library, accommodation, furniture, parking, lecture theatres, and recreation facilities [18]–[20]. This research is important as it has been found that students learn better in their favorite environment [20]. Broad investigations into laboratories tend to be a one-off event to determine what drives satisfaction of their students at a particular point in time. As an example, Gonsai *et al.* [21] undertook a single investigation to determine student satisfaction in the computer science laboratories of a particular university. The study provided evidence of measures required to improve student satisfaction at that university. No management process or follow-up activity was mentioned as to how the issues would be rectified.

B. Laboratory Management

The management of laboratories in many institutions and companies is carried out by a Laboratory Manager. Laboratory management "is the integration and coordination of organizational resources (people, equipment, procedures, supplies) to provide quality laboratory services as efficiently and effectively as possible" [22]. There have been a number of studies looking at laboratory management and how it can be used to manage quality, safety, and resources effectively [23]–[25]. For successful management, someone must be made accountable and ensure people are aware of their areas of responsibility [24]. Accountability is needed because "exceeding student's expectations does not happen by mistake, it must be deliberately managed" [26].

Among common ways to manage engineering teaching laboratories are: 1) subject coordinators playing the central role in managing the laboratory; 2) management being spread across one or more technical groups; and 3) a centralized laboratory manager overseeing all laboratories. Research suggests that a centralized laboratory manager is one of the most effective ways to manage the laboratory environment [22]–[25]. No study took a holistic approach to measuring and monitoring student satisfaction with the teaching laboratory experiments and facilities across all courses.

C. Student Satisfaction

Competition between universities to attract quality students has intensified as institutions try to grow domestically and internationally [3], [27]. This competitive environment has resulted in students having a greater variety of institutions to select from. Consequently, the student is seen as the primary customer of a university, resulting in targeted programs aimed at selling an exceptional learning experience [28]. Governments are increasingly implementing policies and tools to ensure the quality of higher education and stimulate competition [2], [19], [29]. A prime example of this is an Australian government Web site [4] that allows students to compare student satisfaction and performance data between universities and individual disciplines. For example, the Web site allows students to compare electrical engineering schools across all universities within Australia. This freely available data lets domestic and international students [5] shop around for what they interpret as the institution providing the best quality. As a consequence, universities are striving to increase student satisfaction in order to remain competitive.

This competitive environment, as well as pushing the student satisfaction bar increasingly higher, is resulting in a number of positive benefits for both the student and the institution. According to Elliott and Shin [30], improved student satisfaction increases motivation, lowers attrition rates, improves recruiting efforts, and helps with fundraising.

For the university, student satisfaction is linked to an institution's image. Universities with high levels of student satisfaction promote this attribute to attract students. This link was supported by research conducted by Plank and Chiagouris [31], whose study found that the perceived quality provided by an institution is an important driver for recruiting students. A report by James *et al.* [32] that investigated factors influencing tertiary applications in Australia supported this finding. The rise in popularity of social networking and product review Web sites allows for perceptions of quality at a university to change very quickly [33]. Therefore, programs that increase student satisfaction are very important.

Increasing the level of student satisfaction can benefit student learning. The link between learning and student satisfaction was investigated by Lim *et al.* [34], who found that when the students were more satisfied, their achievement increased. A similar study conducted by Mason *et al.* [35], comparing two different methods of classroom delivery in an engineering course, found that, on average, students had better grades when working with the learning style they enjoyed the most. In addition, Hirschfeld [36] reported that a positive outlook, influenced by a positive learning experience, is required for

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greater achievement. It is important to note that improvements that increase student satisfaction do not necessarily translate into better grades. A study by Lewis [15] found that when student satisfaction increases, students can perceive that their learning is better, but this is no guarantee of improved assessment marks. Therefore, a major focus for universities seeking to improve student satisfaction is to also improve the learning experience.

D. Summary

The laboratory plays an extremely important role in engineering education, especially in the fields of electrical, computer, and related disciplines. Cementing theoretical concepts and developing practical skills is important for the development of future engineers. Therefore, the laboratory plays a critical role for student satisfaction and must be of the highest quality. Universities cannot be complacent in regards to the satisfaction of their students. In this interconnected world, a market leader can easily become a market follower. To ensure quality, a disciplined and effective form of management is required.

III. Creating Change

A. Background

The typical teaching contact hours for SECTE courses at the University of Wollongong consist of 4 h of lecture, 2 h of tutorial, and 3 h of laboratory work every 2 weeks. In 2013, 27 courses (69%) had a laboratory component, five (13%) were project-based and only seven (18%) had no laboratory/practical component. The reasoning for the high proportion of laboratory work can be correlated with the study conducted by Kostulski and Murray [13].

A consensus among academics was that with so many laboratory-based courses, it was hard to manage and ensure quality. As a consequence, in December 2006, the first author was hired as the Laboratory Manger to address these concerns. The major advantage of using a Laboratory Manager is that he or she would have an overview of the requirements and the material studied in the laboratory for all courses.

Course coordinators regularly change; having a permanent member of staff facilitated easy transfer of knowledge, requirements, and history. In addition, having someone take a holistic overview provides a means to identify strengths and weaknesses across a variety of courses. Before having a Laboratory Manager, constantly changing course coordinators and heavy workloads impeded any continuous improvement cycle. In many instances, course coordinators were unaware of the resource requirements for other courses sharing the same teaching space.

B. Measuring Student Satisfaction

In 2007, a trial student survey was conducted to gauge the level of student satisfaction in the laboratories. Students responded to six statements about the experiments and facilities on a five-point Likert-scale from “Strongly Disagree” (1) to “Strongly Agree” (5). The responses were calculated using a weighted average. A comments field was also available to capture qualitative feedback. The average score across all laboratories in 2007 was 66.4, meaning that substantial work was required to improve student satisfaction.

Fig. 2. Comparison of student satisfaction over time.

In 2008, a new permanent policy and procedure [37] was submitted and approved for monitoring student satisfaction with the laboratories and sessional teaching staff [7]. A set of questions for the survey was approved and has been in effect since 2009. All data reported here will concentrate where possible on survey results from 2009 onwards since the statements in the 2007 survey were worded slightly differently. Approximately 400 student survey responses were collected each teaching semester.

The survey statements, designed to measure the core components of student satisfaction with the laboratories and kept short so as not to overburden the students, are the following.

— Statement 1: I have a great overall impression of the laboratory component for this course.
— Statement 2: The contents of the laboratory notes provided me with enough information to successfully complete the required exercises.
— Statement 3: The experiments undertaken in this laboratory are worthwhile learning experiences.
— Statement 4: The computers in the laboratory are suitable for the work required.
— Statement 5: The electronic equipment in the lab, other than the computers, is suitable for the work required.
— Statement 6: The laboratory is in a good condition.

C. Continuous Improvement

The score derived from the survey data provided a means to measure and track student satisfaction over time and to indicate significant areas of concern. The qualitative data were used to focus on the actual cause of students’ concern with a particular laboratory. In many cases, the survey data alone were not sufficient to provide a complete understanding of a problem and the associated solution. Commonly, the Laboratory Manager talked to both the students and laboratory demonstrators to gain a deeper insight.

The Laboratory Manager would work together with course coordinators and technical staff to coordinate any improvements to each laboratory identified via the student surveys. The Laboratory Manager would also help design laboratory experiments, notes, and learning resources. The survey data were particularly useful in justifying funding for new equipment or resources where necessary. Laboratory improvements were always advertised to the students. Advertising was done via posters, social media, and the school Web site to provide students with the message that their feedback had resulted in action. Fig. 2 shows how student satisfaction has changed over time.

TABLE I
CHANGE IN STUDENT SATISFACTION FOR EACH STATEMENT 2009–2013

	S1	S2	S3	S4	S5	S6
%Change 09-13	14%	13%	10%	9%	14%	11%

TABLE II
CHANGE IN STUDENT SATISFACTION BY IMPROVING LABORATORY NOTES

	E170	E233	E290	E344	E363
Original Score	79.2	78.5	78.4	31.9	67.3
New Score	88.7	90.0	83.9	82.1	82.5
Change in Score	12%	15%	7%	157%	23%

At the beginning and end of each semester, the Laboratory Manager distributed to the course coordinators individual results of the survey that included the history of previous survey results for comparison. This was particularly useful at the start of a semester to enable the coordinator to understand what improvements were required in the semester ahead.

IV. RESULTS

The significant amount of quantitative and qualitative data collected from the 108 laboratory surveys between 2009 and 2013 allows numerous investigations into the nature of student satisfaction.

A. Rapid Detection

The only year student satisfaction fell was in 2012. This was due to the creation of two new power engineering laboratories for two new courses (ECTE412 and ECTE423). One of the new laboratories (ECTE423) had some initial implementation problems that triggered a low student satisfaction score. The advantage of monitoring performance is that the problems with the new laboratory were observed via the quantitative and qualitative data collected, and actions were put in place to rectify the problems for the following year. Further analysis of results for this course is in Section IV-D.

B. Improvement Trends

Table I shows the overall change in students' satisfaction scores for the 5 years between 2009 and 2013 for all the measured laboratories. The data show an increase in scores for all six measured criteria, but overall satisfaction (S1) appears to be most influenced by the laboratory notes (S2) and the equipment used (S5).

C. Laboratory Notes

The data in Table II show that the contents of the laboratory notes play an important factor in determining student satisfaction. Of particular interest is the extremely low score for ECTE344, a laboratory used to teach control, in which the experiments involved connecting a combination of modules to control a dc motor. The laboratory notes contained no information as to the function of the various modules. When troubleshooting was required, the students became increasingly frustrated as they did not understand how the system worked. In addition, many of the students enrolled in the course were from another engineering discipline and had not previously encountered some of the equipment used in the course. The combination of these issues is thought to have created significant frustration, leading to significantly more negative survey responses.

TABLE III
INCREASE IN STUDENT SATISFACTION FOR EACH SURVEY STATEMENT

	ECTE170	ECTE233	ECTE290	ECTE363
S1	11%	18%	9%	56%
S2	6%	12%	9%	69%
S3	4%	10%	9%	17%
S4	6%	23%	3%	-1%
S5	28%	13%	7%	18%
S6	20%	13%	6%	10%

To investigate this further, Table III shows five courses whose laboratory notes were rewritten and redesigned. The experiments, equipment, and facilities remained the same, with the only adjustment being the content of the laboratory notes, adding significant detail on how to use the relevant equipment/software. The increases in student satisfaction were between 7% and 157%.

Table III shows the impact that updating the laboratory notes had on the six individual survey statements. The data for ECTE344 have been omitted as its original score was taken in 2007 with differently worded statements.

The rewriting of the laboratory notes for the four courses increased the scores for almost all of the six survey statements. Interestingly, S2 (which refers to the laboratory notes) does not always lead to the highest percentage of increase in student satisfaction. S5, relating to the hardware used in the laboratory, shows a significant increase in all four cases. ECTE233 (a digital hardware course) requires a significant amount of simulation work, and this is most likely the reason for the big jump in satisfaction for S4.

The major change to the laboratory notes in the four courses was providing an introduction on using the laboratory equipment/software and providing a deeper understanding of how to troubleshoot or to use the equipment to troubleshoot. The motive was to reinforce the fundamentals, allowing students to be more productive in these complex activities. This correlates to the increased scores seen in S4 and S5 (ECTE233). These data imply that good laboratory notes provide a good "uplift factor" to all aspects of student satisfaction with the laboratory. One of the reasons for this is that the useful equipment/software information in good notes helps students better appreciate and understand the task ahead. Therefore, there is a strong relationship between satisfaction with laboratory notes and satisfaction with equipment/software. These data have resulted in a method for improving a number of courses. The design of laboratory notes and their possible consequences are explored in greater detail Section V.

D. Workload

The two new laboratory courses initiated in 2012, ECTE412 and ECTE423, were both in the fourth and final year of the Bachelor's program in Electrical Engineering. Both used the same laboratory and equipment, the only difference being in the experiments and modules used. The equipment used was

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TABLE IV
COMPARISON OF STUDENTS' IMPRESSION OF FACILITIES FOR TWO COURSES THAT USE THE SAME LABORATORY AND EQUIPMENT

	Overall Score	S4	S5	S6
ECTE412	85.1	80.0	89.5	89.5
ECTE423	71.9	81.7	80.0	76.7
Difference	18%	2%	12%	17%

TABLE V
COMPARISON OF STUDENT SATISFACTION WHEN EQUIPMENT ISSUES RECTIFIED

	ECTE233	ECTE333
Original Score	57.8	78.4
New Score	77.7	90.4
Change in Score	34%	15%

LabVolt, which allows the use of different plug-in modules for experiments. One of the courses was rated highly, and the other—as indicated above—poorly, primarily due to the amount of work that was required in each experiment. The standard comment obtained from the survey of ECTE423 was *"Experiments too long, too busy writing numbers and not learning."* Table IV shows the difference in student satisfaction for the three facility-based statements. The data show that for S4 (computers) the scores are similar, although computers are not much used in these labs. The hardware statement (S5) and condition of the laboratory (S6) both varied by over 10%. These data support the work of Lizzio [38], who found higher workloads lead to poorer student satisfaction.

E. Equipment

In two instances, equipment was the only major change to a course laboratory. Table V shows the change in student satisfaction score when the equipment issues were addressed. For ECTE233, the major problem identified was the old prototyping boards used to teach digital logic and some software issues. As a result, new prototyping boards were purchased for the following year.

For ECTE333 (a microcontroller course), the problem identified was that the batch of computers used in the teaching laboratory had unstable serial ports that led to communication problems with the AVR boards used in the laboratory. Both these technical issues caused a reduction in the satisfaction score for the other five survey questions. Therefore, it can be seen that having working and well-functioning equipment is important for student satisfaction.

F. Facilities

Table IV shows how students perceived the condition of the laboratories over time. The university policy is that a vigorous clean only occurs before the start of the semester. In 2011, SECTE organized an individual to undertake weekly dusting and tidying of all the laboratories and a vigorous clean at the start and middle of the semester. The 7% jump in score between 2010 and 2011 showed that the students noticed that the laboratories were in a much better condition in 2011. Therefore, cleanliness does play some part toward student satisfaction.

TABLE VI
CHANGE IN SCORE FOR THE CONDITION OF THE LAB 2009–2013

Year:	2009	2010	2011	2012	2013
Score Q6:	81.3	81.7	87.7	87.5	90

TABLE VII
WEIGHTING OF FACTORS RAISED IN STUDENT COMMENTS

Category	Percentage of Comments
Computers & Software	11%
Demonstrators	12%
Electronic Equipment	22%
Facilities	6%
Laboratory Design	17%
Laboratory Notes	25%
Workload	7%

G. Qualitative Data

The quantitative data were analyzed against the qualitative data. From the 4064 surveys, only 17% of respondents made a comment. The low percentage of comments can be interpreted as meaning that any comments made are of high importance to the individual; the student must have felt very strongly about an issue to take the trouble of writing a comment.

The comments were separated into seven different categories to determine the main issues of concern to students. The data shown in Table VII support the earlier findings. The laboratory design/notes are of most importance, followed by the equipment/computers used.

V. RECOMMENDATIONS

The data from the surveys was used to create significant change during the seven-year period. Through the process of continuous improvement across 27 electrical, computer and telecommunications engineering courses a great understanding of student satisfaction and learning was gained.

A. Management

A centralized Laboratory Manager overseeing all laboratory subjects is very effective. The manager must be accountable for the management of the facilities as well as understanding the experiments and providing support to the subject coordinators. A key advantage is the overview to determine the conflicting needs/requirements for each subject. Previously, a course coordinator could enact a change in a particular laboratory without clearly understanding the impact on other courses.

By understanding common needs across courses the Laboratory Manager can develop effective resources, such as a central knowledge resource shared across all courses. An example of this is the "Training Lab" [39], an online resource developed to house instructions, user manuals and videos on how to use equipment available in the laboratories. Students indicated that they wanted more information on how to use and operate hardware/software.

B. Equipment and Facilities

All assets (computers, measuring equipment, and the like) should be given a specific lifespan and have funding allocated; upgrading equipment on a replacement cycle ensures that students use cutting-edge technology. In the earlier years of the survey, significant negative feedback was directed at old and unreliable equipment. Occasionally, using old equipment can benefit learning. In these cases, the deliberate nature of that choice should be communicated to the students so that they can appreciate the learning outcome. The laboratory software also plays a large role in determining student satisfaction. In ECTE, technology is one of the basic frameworks for the degree. As a consequence, the students want exposure to the latest software and operating systems. A noticeable trend was that the reduction in satisfaction correlated with the degree to which the software was out of date, for software-intensive laboratory experiments. Students also want to know how to use this software productively. Many would find and install the latest versions of software on their home computers and then write about the advantages of a particular software upgrade in the surveys.

To manage the conflicting needs of software, it is important to consider dual boot setups such as Linux and Windows and keep the versions as up to date as possible. Virtual machines can be used as a way around software conflicts and to allow students to dig deep into the operating system without causing damage to the image or security threats. It is important to consider that changing software can result in the need to change laboratory notes for a number of courses.

Data from regular laboratory surveys should be used as evidence in seeking funding for equipment, software, and building work. It can capture the magnitude of student dissatisfaction with the learning environment in a way that senior management cannot ignore.

C. Laboratory Design

Well-designed laboratory notes, resources, and well-thought-out experiments are the most influential factors on student satisfaction. The design of experiments should make it clear what must be completed and achieved, and the relevance of the tasks to the learning outcomes of the course. International students or domestic students who transfer in their second, third, or fourth year, students with advanced standing, or students undertaking electives may not have followed the standard learning path. Not having met skills, equipment, or software introduced in prerequisite courses may create a knowledge shortfall that is not obvious. This shortfall in assumed knowledge can cause very negative survey responses. Providing a resource for students to catch up on missed knowledge, whatever their entry point in the degree, can help alleviate such problems. Additional resources, such as the "Training Lab" [39], help supplement the laboratory notes.

When designing a laboratory experiment to achieve high student satisfaction, the difficulty of the experiment does not need to change. In almost every change to a laboratory redesign in which the first author participated, neither the fundamentals of the learning goals nor the level of difficulty changed. The major change was the way the information was delivered and the resources associated with the experiment. In some instances, the experiments can increase in difficultly and still improve student satisfaction. One such example was the redevelopment of a second-year electronics course in which half of the laboratory sessions taught the fundamentals of soldering, op-amps, and transistors. The second half of the laboratory was a design component more complex than anything they had done previously. The experiment had increased substantially in difficulty, and student satisfaction increased by 18%. Similar changes to experiments indicate that student satisfaction increases when they undertake practical experiments that provide them with hands-on skills they believe can be used out in the real world.

Most of the learning conducted in the laboratory is via a "constructivist" [40] approach. This usually comprises some form of design task, such as building and measuring a circuit. The learning occurs in the process of accomplishing that task. Many of the additional resources developed transfer knowledge via the "behaviorist" [40] approach using observation. This may be a video demonstrating the operation of a CRO or simply the availability of a user manual. This is important because research has shown that a variety of approaches may be needed to assist students in learning [40]. The key is to give enough information to create a fundamental understanding that provides a pathway for the constructivist learning activities.

In the design of an experiment, the amount of time required to complete the tasks should be carefully considered. The laboratory is a place for learning, and as a consequence, time should be available for the students to collect results and evaluate. It is better for the student to undertake less activity but clearly understand the concepts behind the activity than undertake more work and have no understanding. Time in the laboratory can be more efficient if carefully designed pre-laboratory activities are undertaken. For example, a pre-laboratory activity might involve simulating circuits to gain the understanding of a concept, and the laboratory component can be the practical application of the concept and comparing the simulated results to the physical. Therefore, greater workload can be efficiently managed via pre- and post-laboratory activities.

VI. Academic Staff

In January 2014, after 5 years of reform, a survey was administered to the permanent academic staff in SECTE to determine their perceptions of the reforms to the laboratories, sessional demonstrators, and the work conducted by the Laboratory Manager. Of the 27 academic staff member, 23 (85%) completed the survey.

The data in Table VIII show that the implementation of the policy over the 5-year period has had a positive impact on the academic staff in the school. After some initial concern over the need to conduct surveys, the overwhelming opinion of academic staff is now in support. It is also clear that the academics understand the role the surveys play in providing a high-quality learning environment.

TABLE VIII
ACADEMIC PERCEPTION OF SURVEYS

Prior to the commencement of laboratory surveys, I believed that there was no need for them, or that such surveys should not take place				
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
0%	17.4%	8.7%	47.8%	26.1%
I find the data collected from the laboratory surveys beneficial to the ongoing development of the laboratories				
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
78.3%	17.4%	4.3%	0%	0%
I believe that laboratory surveys should be discontinued				
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
0%	0%	0%	34.8%	65.2%

VII. DISCUSSION, CONCLUSION, AND FUTURE WORK

This paper has outlined a detailed process of managing and improving laboratory satisfaction, which increased by 32% from 2007 to 2013. A number of factors contribute to improving student satisfaction; future studies will look at factors other than those discussed here, such as the effect of teaching staff, experiment design, and laboratory resources.

In terms of management, this study has shown the importance of a centralized manager to oversee all the teaching laboratories. In addition, the use of continual quantified student surveys allows laboratories and facilities to be monitored, refined, and improved.

The laboratory surveys have made a big difference in SECTE. The data have enabled a continuous improvement cycle to enhance the learning environment for the students' benefit. By understanding what needs to be improved, improvements can be targeted precisely. From experience, the most important requirement is to advertise to the students what improvements have been made each year. Otherwise, new students have no appreciation of what has occurred for their benefit. As a part-time undergraduate student who graduated in December 2013 commented, "The new students will never appreciate or understand the amount of change and improvement that has occurred in the last seven years." Advertising improvements also shows students that their opinion matters.

Analysis of the laboratory surveys show that the laboratory notes (activity and clarity) and the quality of the equipment used are the most important factors that determine student satisfaction in the laboratory. Laboratory notes or resources that provide significant detail on how to use the hardware and software in the experiments yielded a large increase in satisfaction score. Well-written notes of a good length can provide an "uplift" to other satisfaction factors explored.

Experiments that are not clear in terms of the activity the students are required to perform, do not provide information about the equipment/software used, or are too long for the duration of the laboratory tend to have lower satisfaction scores. In addition, this tends to drag down the other satisfaction factors explored. In particular, information about the equipment/software is important. If students do not understand how to use the equipment correctly, or lack troubleshooting skills, they can believe it to be faulty and thus perceive the entire laboratory to be low in quality, an effect noticed in qualitative comments about some experiments.

Including a laboratory exercise or resource on fault-finding/troubleshooting can improve the laboratory experience and reinforce the notion that, as an engineer, things do not always work. Problems encountered in the laboratory exercises can be viewed as skill building and add to student satisfaction.

Having good hardware/software in the teaching laboratory is equally important. Just as user error can lead to negative misconceptions about equipment and to perception of a low-quality laboratory, so can faulty equipment or unusable software.

The changes conducted in the laboratory have been of great benefit for students learning. A common misconception is that to increase student satisfaction, the laboratory exercises undertaken must be easier. Over the course of the 7 years, the opposite has happened. Time and effort was spent ensuring that the fundamentals were well understood. This resulted in students becoming more independent and capable of more complex constructivist learning activities. Students perceived this change as providing them with better skills for their future, and as a consequence, this has helped increase student satisfaction.

Learning in a good clean environment can be taken for granted. This study has also shown that students do take notice when they are learning in a better environment. A study currently underway will expand on this research by investigating the relationship between increased satisfaction and student achievement.

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