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Evaluation of Laboratory Facilities for Engineering Technology Programs in Malaysian Technical Universities

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Abstract

Malaysia is consolidating and strengthening Engineering Technology (ET) programs to produce skilled human resources to spearhead economic growth and achieve the status of a developed nation by 2020. ET programs need to increase the students' intake to fulfil the industry requirements for technical graduates. The Malaysian Technical University Network (MTUN) institutions and UniKL are among the higher education institutions in Malaysia that offer undergraduate ET programs to produce work-ready graduates. A key component of Engineering Technology curriculum is laboratory facilities. This article evaluated the laboratory facilities at MTUN institutions. We used mainly qualitative data methodology, comprising of focus group interviews, observations and document analysis. We also adopted the quantitative method using survey questionnaires to investigate students' satisfaction on the laboratory facilities related to the practice-oriented learning at the institutions. The results indicate that the laboratory facilities provided by the selected MTUN institutions are adequate for the current number of students.

Keywords: engineering technology, hands-on skill, laboratory, practice-oriented

1. Introduction

The investment of Engineering Technology (ET) programs in Malaysia is part of the economic development policy of the nation as it determines the rate of economy and integration in world markets (11th Malaysia Plan 2016-2020). The significant and dynamic role of the ET profession for the growth of human capital in the country is significant that Malaysia is strengthening and expanding its ET programs in its effort to be a developed country by the year of 2020 (11th Malaysia Plan 2016-2020, Board of Engineers Malaysia, 2003). Engineering technology skills are vital as they provide the basis for an innovative and globally competitive workforce. As a result, there is a paradigm shift in Malaysian education which involved this field to support the country's entry into knowledge age (Megat Johari et al., 2002; Kaur et al., 2008). In promoting engineering technology programs, institutions have to adapt to the market relevance and current needs (Ismail and Puteh 2008).The purpose of ET programs is to complement conventional engineering programs (normally referred to as engineering programs) and to increase the number of technical graduates to fulfil industry needs (Ali et al., 2015).

Engineering programs often focus on creatively applying knowledge of science and mathematics coupled with the use of natural laws and earth resources in designing products, processes or systems (Malaysian Qualifications Agency, 2011). Graduates from this programs usually work as engineers, seek solutions or designs that balance the need for the development of a built environment and the need to protect the natural environment. On the other hand, engineering technology programs focus on the application of scientific and engineering knowledge together with technical skills to support engineering activities (Malaysian Qualifications Agency, 2011). With its roots in theory-application, and the increasing inclusion of technology into all aspects of society, engineering technology education is well positioned to contribute to current global demand (Danielson et al., 2006). The author has shown that out of 100,000 engineers, about 80,000 are performing the job scope of an engineering technologist in this country. Based on this statistic, the Malaysian government aims to produce 60,000 technologists by the year of 2020.

The current technological advancements in the engineering field, qualified workers become the standard market requirement as mentioned by Kulacki and Krueger, (1998). According to Aziz (2015), about 80 percent of engineering-related fields in Malaysia require engineering technologists. Thus, most ET programs require infrastructure and well-equipped laboratories to enable students to apply the concepts and theories learned in class to an actual application. Graduates from engineering technology programs are often referred to as engineering technologists, play important roles in various sectors such as product development, product testing and product improvement; aviation, biomedical, transportation and quality control (Malaysian Qualifications Agency, 2011).

In order to strengthen and to provide quality ET education, students should be given the opportunity to learn relevant knowledge and experience new technological skills. The Malaysian Technical University Network (MTUN) institutions comprise four public universities, and together with Universiti Kuala Lumpur (UniKL) are among the higher education institutions in Malaysia that offer ET programs at the undergraduate level. The aim of these ET programs is to produce skilled engineering manpower to fulfil the needs of the industry and country in general.

Every MTUN has a dedicated faculty, known as the Faculty of Engineering Technology (FTK) to run ET programs offered by the university. The education structure at FTK is different and unique because the emphasis is placed on learning through practice. In other words, the content of practical work is higher compared to theory, with a ratio of 60% to 40% (Hussain, et. al., 2015). Since ET programs require specific equipment for students to develop and enhance their practical skills as well as to engage students in their learning, it is important to ensure the laboratory facilities provided by the faculty are adequate and in a good condition. Thus, it is vital to evaluate the laboratory facilities on a regular basis. This paper reports the results of an evaluation process of the laboratory facilities provided by FTK of MTUN institutions for the ET programs that they offered. These laboratory facilities include number of laboratories, number of workstations, types and number of equipment and tools inside the laboratories.

2. Engineering Technology Laboratory Facilities

The overall goal of engineering technology program is to prepare students to practice engineering and in particular to deal with the nature of problems faced by the society. Therefore, the infrastructure and facilities played a vital role in the operations of enterprises and educational resources. Classrooms, libraries, offices, laboratories, workshops and related tools and equipment must be sufficient to support the achievement of learning outcomes and program outcomes (ABET, 2016-2017). In addition, the facilities provided must be appropriate and adequate to support the process of teaching and learning, as well as research and publication activities of the students and academic staff.

The planning for infrastructure and facilities to support ET programs offered by educational institutions is largely guided by the curriculum of the specific programs. Malaysian Quality Agency (MQA) who is responsible for quality assurance of all programs in higher education for both public and private sectors, highlighted the importance of classrooms, laboratories and workshops for running the engineering and engineering technology programs. Among the laboratories and workshops required are computer laboratories, general and specialised laboratories, testing and prototyping laboratories, and machining workshop (Malaysian Qualifications Agency, 2011).

The laboratory practice is an important part of professional and engineering technology program; the laboratory is an ideal place for active learning (Feisal and Rosa, 2005). Students learn in a real world environment, function as team members, discuss the planning of experiments, and share ideas about the analysis and interpretation of data. Most engineering instruction took place in the laboratory and it demands the active use of knowledge and skill. At MTUN, one of the major functions of laboratories and workshops is to complement the lectures and strengthen the conceptual understanding through practical hands-on work. Thus, through hands-on practice in engineering technology laboratories, students would have opportunities to verify concepts and phenomena described in the theory portion of the course, as well as to familiarise themselves with standard technical equipment which are similar to those used in the industries.

The laboratory facilities for ET programs must be relevant and should support student-centered learning environment which models the real-world situation. These facilities must meet the requirements of each ET program. In addition, the laboratories must fulfil the requirements of a practice-based curriculum that require an appropriate working space for the students. Thus, ET programs have given priority to the laboratory facilities as the most important consideration in the design of its physical layouts, and material-handling systems. This is often a crucial decision that can significantly impact the success of the program. Equally important is the efficient management of these facilities, operations of educational resources that can reduce handling times, increase productivity and allow more flexible usage, and be responsive to educational requirements (COPPA UTeM, 2015). Moreover, with the advances in technology such as automation, laboratory facilities best practices must evolve to align with changes in the industry requirements.

To meet the global standard of engineering education facilities requirement, and to facilitate international mobility of engineers, ET programs need laboratories that are benchmarked to the international standard. According to ABET (2016-2017), classrooms, offices, laboratories, and equipment must be adequate to support the attainment of student learning outcomes and to provide an atmosphere conducive to learning. It is further stated that to attain the student outcomes and to support program needs, modern tools, equipment, computing resources, and laboratories must be available, sufficient, accessible, and systematically maintained (ABET, 2016-2017).

3. Methodology

This study employed qualitative and quantitative research methods. Before data collection activities, the researchers developed the observation checklist, interview protocols and survey instrument. Pilot data collection using these instruments were performed to ensure the reliability and validity of the instruments. In addition, the experts' validations were also obtained. The survey questionnaires were found to be reliable based on the pilot test on students from the researchers' institution. The Cronbach's alpha coefficient is 0.79, which indicates good reliability (Numally, 1978).

Using the self-developed and validated data collection instruments, the researchers collected data from Faculty of Engineering Technology (FTK) of MTUN 1, MTUN 2, and MTUN 3. Interviews were carried out on the teaching staff comprising lecturers and teaching engineers, whereas observations were made in the classroom and laboratories. In total, 24 teaching staff of FTK were interviewed, comprising nine teaching staff from MTUN 1, nine teaching staff from MTUN 2 and six teaching staff from MTUN 3. Each interview session was audio recorded with the permission of the participants and lasted about one hour. Document analysis was also conducted on the official document of MTUN (i.e. Code of Practice for Program Accreditation (COPPA)). However, only MTUN 1 has made its COPPA document available for our study.

The quantitative method using survey questionnaire was used to determine students' satisfaction of the facilities related to the application-based teaching and learning. The total number of respondents was 491. Using Statistical Package for Social Science (SPSS), the quantitative data obtained were analysed descriptively.

4. Discussion

The emphasis on practical hands-on experience using technology and standard technical equipment rely heavily on the laboratory facilities provided by Faculty of Engineering Technology (FTK) of MTUN for the program that they offered. Therefore, the results from the study will be discussed based on the analysis from the COPPA documents, observations, interviews and survey questionnaires. The objective is to ensure that the facilities provided meet the needs and functions of the programs.

4.1 Laboratories Facilities as Stated in the Official Document

The official document analysed for evaluating the facilities provided for ET programs at the FTK of MTUN institution is the Code of Practice for Program Accreditation (COPPA). However, the researchers managed to collect the COPPA document only from MTUN 1. Therefore, the following discussion only focused on MTUN 1.

MTUN institutions are expected to be equipped with the state-of-the-art tools and facilities that support the development and enhancement of hands-on skills. MTUN 1 has documented the following items in its COPPA document (COPPA UTeM, 2015).

- The size of the laboratories and workshop is at the rate of 2-2.2 meter^2 per student as per EPU guidelines.
- The capacity of the laboratories is 30 students, in which the ratio of computer to a student is about 1:1, to support the practice-orientated approach to teaching and learning.
- Laboratories are equipped with necessary equipment required for the running of the courses, and the computers are installed with the latest software. The ratio of equipment to a student is about 1:5, which is sufficient to ensure practice-oriented teaching and learning.
- All facilities and equipment are well-maintained where students can use the facilities with ease and comfort throughout their learning process.

MTUN 1 provides 101 laboratories for ET programs, comprising 22 laboratories for the Electrical Engineering program, 25 laboratories for the Electronics and Computer Science program, 33 laboratories for the Mechanical Engineering program, and 20 laboratories for the Manufacturing program (COPPA UTeM, 2015). Laboratories for Electrical Engineering Technology program include Electrical and Electronic Lab I, Sensor and Transducer Lab, Control, Instrumentation, and Mechatronic Lab, Power System Lab, and PLC and Process Control Lab. The analysis of the COPPA document indicates that the FTK of MTUN 1 has sufficient laboratories with an adequate quantity of equipment in the laboratory to accommodate laboratory sessions for all courses offered in the ET programs.

4.2 Laboratories Facilities as per Observation

For this study, the researchers visited the FTK of MTUN 1, MTUN 2 and MTUN 3 in order to observe the laboratory facilities, as well as the process of teaching and learning in the laboratories. However, due to time constraint and budget, only three laboratories at each MTUN were observed.

Three laboratories were observed at the FTK of MTUN 1, namely Electrical and Electronic Lab (Figure 1), Pneumatics and Hydraulics Lab (Figure 2) and Fundamental Control System Lab (Figure 3). The Electrical and Electronic Lab were divided into 2 sections. The first section (i.e. Electrical and Electronic Lab I) is equipped with 32 desktop computers for students to perform simulation work. During the simulation practices, it was observed that every student was allocated with one desktop computer. The practical hands-on work was conducted in the second section (i.e. Electrical and Electronic Lab II). In this laboratory, the students worked in a group of two and were assigned to one workstation. In another laboratory (Pneumatic and Hydraulics), ten desktop computers were provided for the simulation work. Thus, two to three students need to share one desktop computer to conduct the simulation. However, for the practical hands-on work, five to six students shared the equipment and tools at one workstation. Another laboratory observed was Fundamental Control System Lab. There were fourteen workstations in this laboratory. Each workstation is equipped with 14 desktop computers and 14 sets of equipment. During the observation, students did not perform any practical work in this laboratory.

(a)

(b)

Figure 1. Electrical and Electronic Lab (a) simulation, (b) hands-on

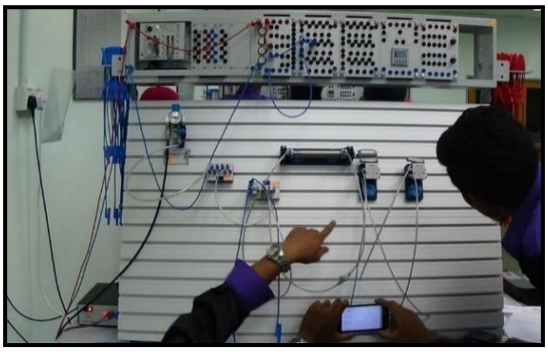

Figure 2. Pneumatic and Hydraulics Lab

Figure 3. Fundamental Control System Lab

At the FTK of MTUN 2, the researchers have the opportunity to observe three laboratories. These were the Electronic Lab, Electrical Technology Lab and Rapid Prototyping Lab. Both Electronic Lab and Electrical Technology Lab which could be categorised as general laboratories, comprise 30 workstations. Each workstation was well equipped with the necessary equipment and tools such as oscilloscope, analogues and digitals meters for students to perform the practical hands-on work. In these laboratories, it was observed that two students shared one workstation to conduct the laboratory work.

Another laboratory observed was Rapid Prototyping Lab which consists of ten workstations for students to conduct their laboratory work. This is a specialised laboratory where students produce prototypes of their designed project.

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Figure 4. Electrical Technology Lab

Figure 5. Electronic Lab

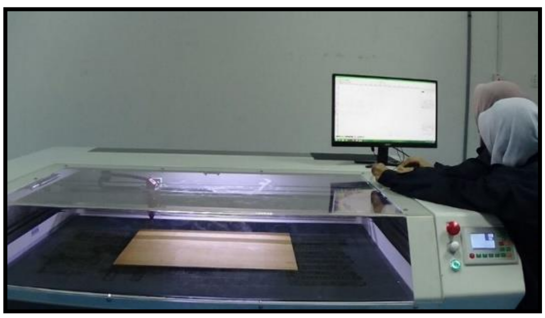

Figure 6. Rapid Prototyping Lab

At MTUN 3, the researchers managed to observe Machining Workshop, Biodiesel Lab and Industrial Robotic Lab. Machining Workshop is for 1st year students where they learned the basic cutting and machining process. There were 26 workstations in Machining Workshop. Each workstation was occupied by two students working as a group. Biodiesel Lab is a specialised laboratory where the setting of the laboratory is similar to a process plant. This laboratory is used by 3rd year students, where they work in a group of four students. Industrial Robotic Lab was divided into two sections. The first section was equipped with Programmable Logic Controller (PLC). It can be observed that two to three students were conducting their practical hands-on work at one workstation. Among the equipment in the second section of Industrial Robotic Lab was pneumatics robot.

Figure 7. Machining Workshop

Figure 8. Biodiesel Lab

(a)

(b)

Figure 9. Industrial Robotic Lab (a) PLC, (b) Pneumatics Robot

In general, the researcher found that the number of workstations in the laboratories used by the 1st first year and 2nd year students (i.e. general laboratories) are higher compared to the number of workstations in the specialised laboratories. This will ensure that every student will have the opportunity to use the equipment and tools, and thus develop the required practical hands-on skills. It is worth noting that the equipment and tools in the general laboratories are cheaper compared to the specialised equipment and tools. Nevertheless, all MTUN institutions should try to provide more equipment in the specialised laboratories such that the maximum number of student per group is four students. Thus, more students will have the opportunity to use the modern and standard technical equipment.

4.3 Facilities as per Interviews

The focus group interviews were also carried out on the teaching staff at the FTK of MTUN 1, MTUN 2 and MTUN 3. These interviews were carried out aimed to scope on their satisfaction on the number of laboratories provided and the corresponding equipment and tools in the laboratories.

At MTUN 1, the teaching staff are satisfied with the laboratory facilities provided by the university, for students to develop and enhance their hands-on skills. This is evident as they expressed the concern that more practical sessions would be better to support students' learning and development of hands-on skills. At MTUN 2, the teaching staff interviewed stated that even though the laboratory facilities are adequate for the students, they also expected the equipment and tools in the laboratories to be upgraded as soon as the upgrading work of the laboratories is completed.

The teaching staff at MTUN 3 admitted that students at the FTK are still sharing the laboratory facilities with students from conventional engineering programs. However, this does not limit the students from performing the required practical laboratory work specified in the ET programs. According to them, the development of the new campus in the near future will allow the ET programs to have their own laboratory facilities.

4.4 Facilities as per Questionnaires

In this study, students' perceptions on the laboratory facilities offered by ET programs at the three MTUN institutions were determined through survey questionnaires. This is an important indication whether the MTUN institutions fullfiled the expected outcomes of students' learning with respect to the laboratory facilities provided.

As shown in Figure 10, 100% of students from MTUN 1 were satisfied with their experience at the university as compared to MTUN 2 (96%) and MTUN 3 (88%). The students' satisfaction in the university experience includes the satisfaction regarding library and classroom facilities, as well as technology and computer laboratories. All required software to perform the simulation work was also installed.

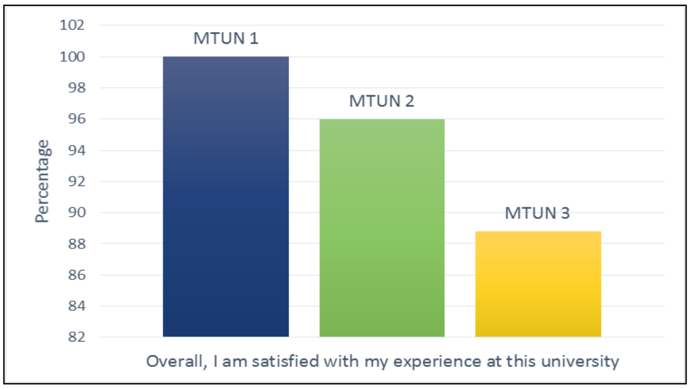

Figure 10. Students' experience at MTUN

Students also agree that the universities have provided enough technology laboratories for them to practice their hands-on skills, as shown in Figure 11. The result of the survey indicated that 97% of students from the FTK of MTUN 1 agreed that the number of technology laboratories is adequate for them to practice their hands-on skill, followed by the FTK of MTUN 2 (93%) and FTK of MTUN 3 (87%).

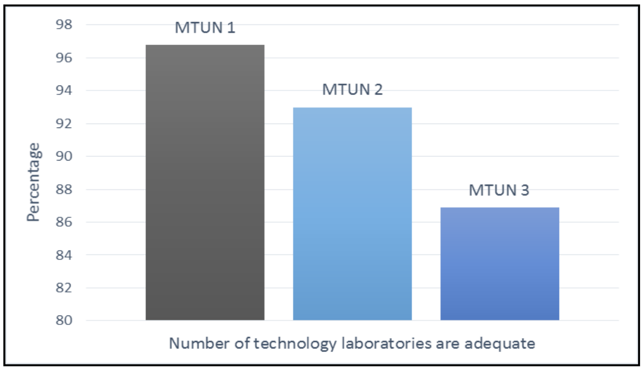

Figure 11. Students' satisfaction – number of laboratories at MTUN

Referring to Figure 12, almost 100% of students from the FTK of MTUN 1 agree that the university has furnished them with well-equipped laboratories, followed by MTUN 2 (94%) and MTUN 3 (91%). In other words, from the students' point of view, the universities have provided enough equipment and tools in the laboratories for them to conduct the practical hands-on work.

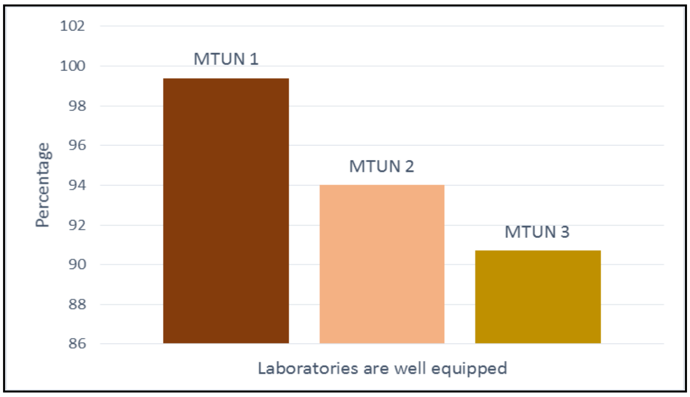

Figure 12. Students' satisfaction – facilities in the laboratories at MTUN

From Figures 10, 11 and 12, it can be seen that the FTK of MTUN 3 has the lowest percentages of students' satisfaction compared to the FTK of MTUN 1 and FTK of MTUN 2. This may be due to the fact that students at the FTK of MTUN 3 are still sharing the laboratory facilities with the students from conventional engineering programs.

5. Conclusion

An engineering technologist is a specialist dedicated to the development, improvement, and implementation of engineering and technology. Its education is more of a broad specialised and applied engineering education. Thus, engineering technology programs are different from conventional engineering programs because the focus is on practice-oriented and hands-on learning so that graduates acquire a variety of technical skills. The institutions that offer Engineering Technology programs should appraise their laboratory facilities as these will influence and affect the quality of teaching and learning.

From the observations on the three FTK of MTUN laboratory facilities, interviews conducted and questionnaires distributed to the students, it can be concluded that the laboratory facilities provided by these MTUN institutions are satisfactory. The researchers believed that the present laboratory facilities are up to standards and hoped that these be constantly improved and upgraded as the educational system expands and advances. These universities must attempt to furnish their laboratories with equipment and facilities that are current and modern to ensure that their graduates are familiar with the types of equipment and tools that they may encounter in the industry. Extensive laboratory work for engineering technology curricula with sufficient equipment and tools is important so that all students will have an opportunity to develop and enhance their practical hands-on skills. Consideration of these recommendations by MTUN institutions is a step forward in meeting the demands of engineering technology education in supplying the needed engineering technologists.

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