Assessing and Monitoring Student Participation in Engineering Laboratory using Radio Frequency Identification (RFID) – Satisfying ABET EC2000 Outcome 3b

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***Abstract*—The Accreditation Board for Engineering and Technology (ABET) EC2000 Outcomes 3a–3k had spawn several healthy discussions in literature, thus causing a tectonic shift in the focus of quality of engineering education, taking the attention of educational institution away from the inputs (what material is taught) and creating a system that focuses more on the output of the students (what students learnt). The signature of EC2000 is on what the student is capable of with little or no intervention from the Instructors, especially in the Laboratory. The ABET EC2000 induced a revamp by creating an intense curricular which acts as a catalysis for improved Engineering Education. Some of these Outcomes (e.g., ability to apply knowledge of mathematics and science and solve engineering problems) do not require anything more than what most engineering faculties are already doing in their curriculum development, and for others, (e.g., ability to design and conduct experiments, as well as to analyze and interpret data) some departures from traditional way is needed to satisfy these criteria. Outcomes 3b, underscore the need for students to be able to design and conduct experiments, as well as to analyze and interpret data. This outcome requires little or no input from the instructor or Laboratory assistant during Laboratory experiments. Assessing and monitoring individual student–works during such an experiment becomes more difficult. This paper seeks to provide a way of assessing and monitoring students in laboratory through the use of Radio frequency identification (RFID). The paper discusses the use of RFID in Mechanical Engineering courses laboratory as a means of monitoring/assessing student(s) participation in Laboratory to satisfy the EC2000 Outcomes 3b. The paper also delved into EC2000 outcomes assessment and its impact on engineering graduates.**

***Index Terms*—ABET; EC2000; Engineering Laboratory; Radio frequency identification (RFID).**

I. Introduction

THERE are different opinions on the use of different technologies in the enhancement of engineering laboratory practices [1-3]. The different opinions are significant, as they state the benefits and short comings of these technologies. Many have argued that the era of virtual laboratories could change the economics of engineering education. The debate on the benefits of virtual laboratories versus hand-on laboratories in engineering education will spur an unending argument at least for this century. The bone of contention is whether the changing technology could change the effectiveness of engineering education. The ABET EC2000 criteria shifts the focus of institution evaluations from "taught materials" to "the student", the outcomes tend to measure the output of the student rather than the input from the institution's curriculum. These criteria have been proven right, and have made ABET a leading accreditation body not only in the USA but globally.

The students' output is more important in evaluating an engineering program, though not watering down the importance of other factors, like curriculum and the quality of instructor. The ABET EC2000 outcome 3b requires an ability to design and conduct experiments, as well as analyze and interpret data. This criterion underscores the need for little or no supervision during the period of laboratories, but the instructor still needs to assess students' capabilities in laboratory works. The difficulty experienced in fulfilling the demand of this criterion is what motivates the use of Radio Frequency Identification (RFID) in the Mechanical Engineering Laboratories. The use of this technology preserves the hand-on experiment, but allows the student(s) to fulfill the ABET EC2000 Outcome 3b criterion without the instructors' supervision and at the same time help the Instructor/laboratory Assistant to monitor the students' activities within the Laboratory period. The Radio Frequency Identification (RFID) was conceived in the 1948, but since then the technology has evolved into a proven technology. RFID is an automatic identification system that is gaining momentum and considered by many to emerge as one of the most pervasive computing technologies in history [4]. RFID is used for a wide variety of applications ranging from the familiar building access control proximity cards to supply chain tracking, toll collection, vehicle parking access control, retail stock management, ski lift access, tracking library books, theft prevention, vehicle immobilizer systems and railway rolling stock identification and movement tracking [5]. RFID is a generic term for technologies that use radio waves to automatically identify people or objects. It is this automatic people or object identification that brings its usefulness into Engineering Education Laboratory. It means with RFID the movements of students can be tracked without the physical presence of the instructor or the laboratory assistant. This technology becomes useful in fulfilling ABET

Manuscript received March 18, 2015.

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ISBN: 978-988-14047-0-1
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

EC2000 outcome 3b criterion. Assessing and monitoring becomes easy as the RFID technology becomes the eye of the Instructor in the Laboratory. The number of radio frequency identification (RFID) applications continues to expand, according to [7] cumulative sales of RFID tags at the beginning of 2006 stood at 2.4billion [7] a number believed to have doubled in 2012. The [7] put the sales of RFID tags in 2005 alone at 600 million tags. The expansion is moving beyond the initial RFID application areas like retail sector, supply chain management, warehouse management, logistics, manufacturing, military applications, and the service sector [8]. The application of FRID in health and Education sectors present a huge potential for RFID technology. The aim of this paper is to investigate the possibility of utilizing RFID in education, especially in fulfilling the EC2000 criterion 3b as prescribed by ABET in the laboratory.

In this manner, first ABET EC 2000 criterion 3b will be reviewed and the difficulty encountered in Mechanical Engineering Department of Eastern Medıterranean Unıversıty wıll be explored. After a brief review of RFID technology, applications, future threats, and opportunities will be discussed. Finally, a case study of using RFID in Laboratory work in Mechanical Engineering (EMU) course computer integrated manufacturing will be presented with the different efforts employed to make it feasible.

II. ABET AND ACCREDITATION

A. ABET Accreditation in Eastern Mediterranean University

As Mechanical Engineering of King Saud University, Al-Muzamiyyah branch prepares for ABET accreditation, learning for successful applicants like Eastern Mediterranean University will be of benefit. Eastern Mediterranean University is one of the four universities (aside Turkish Universities with campus in North Cyprus) located in Northern part of Cyprus. It is the only University on the Island with ABET substantial equivalent accreditation for its engineering faculty. Two departments in 2005 secured the substantial equivalent accreditation by the ABET team, a status valid for 5 years. The 2010 visit of the ABET accreditation team gave the entire Engineering Faculty the substantial equivalent accreditation. The University's seriousness in meeting accreditation criteria was responsible for the accreditation of the entire engineering faculty. The Engineering faculty has attracted lots of international students from more than 25 countries at undergraduate, graduate and post graduate levels. The mechanical Engineering Department is one of the backbones of the Engineering faculty with students from the different cultural backgrounds. ABET is a non-profit, non-governmental accreditation body in the United States of America that accredits post-secondary education programs in Engineering. As at October 2011, ABET accredits over 3100 programs at more than 670 colleges and University in 24 countries [ABET]. Accreditation by ABET is voluntary, it provides accreditation to individual programs of study rather than institution evaluations as seen in most countries' national accreditation boards. The voluntary accreditation is achieved through a peer review process that guarantees quality standards in engineering programs. The ABET organization is the most recognized and sought after engineering accreditation body in the world, this is due to the evaluation process that assesses every aspect of the program thoroughly by using a team of expert from both Academia and Industries.

B. ABET EC 2000 Criteria

The Accreditation Board for Engineering and Technology (ABET) was established in 1932 in United States of America to advance the course of engineering education. ABET on a yearly basis makes revisions to the accreditation process and criteria. The most significant was in the 1990s, a paradigm shift was conceived by ABET to substantially revise their curriculum assessment criteria. In this respect the Accreditation Policy and Procedure Manual (ABET 2000) for the 2000–2001 accreditation cycle was released. This revision, which included a move to an outcomes-based program evaluation, is commonly referred to as Engineering Criteria 2000 (EC 2000). In order to ensure a proper measurement of an engineering program a new standard called Engineering Criteria (EC) 2000 was formulated. The criteria focuses on students' outcomes and performances rather than only obtaining grades [9]. Criterion 3 of EC2000 is a list of eleven technical and professional outcomes that accredited programs are required to ensure that their students attain. The Criterion 3 for Accrediting Engineering Programs demands that engineering programs must demonstrate that their graduates have:

a.) an ability to apply knowledge of mathematics, science, and engineering
b.) an ability to design and conduct experiments, as well as to analyze and interpret data
c.) an ability to design a system, component, or process to meet desired needs
d.) an ability to function on multi-disciplinary teams
e.) an ability to identify, formulate, and solve engineering problems
f.) an understanding of professional and ethical responsibility
g.) an ability to communicate effectively
h.) the broad education necessary to understand the Impact of engineering solutions in a global and Societal context
i.) recognition of the need for, and an ability to engage in life-long learning
j.) knowledge of contemporary issues
k.) an ability to use the techniques, skills, and modern Engineering tools necessary for engineering practice

A component of ABET EC 2000, Criterion 3.b (an ability to design and conduct experiments, as well as to analyze and interpret data), is one of the most difficult to fulfill. The criterion 03 of the EC 2000 program outcomes and assessment relates to students' acquisition of knowledge during their study period. This work focuses on achieving criterion 3b using RFID to assess and monitor students in the Laboratory as it is used in the Mechanical Department of Eastern Mediterranean University. This paper shares the experience of using RFID in satisfying Criterion 3b

C. ABET EC 2000 Criterion 3b Experience in Mechanical Engineering Department, Eastern Mediterranean University

This outcome is one of the most difficult outcomes to achieve in the criterion 3 of EC2000 "The student ability to design and conduct experiments, as well as to analyze and interpret data". The emphasis here is on the ability of the student(s) to carry out experiment with little input from the Instructor within the Laboratory procedure. The department (Mechanical Engineering Department of Eastern Mediterranean University) likes most other Mechanical Engineering departments, design experiments for student and through the help of laboratory assistant procedures for the experiments carried out. The part of data collection and analysis is the sole responsibility of the Student. The submitted results will be used to judge the student performance in the experiment. In our quest for an efficient laboratory for Student and the Laboratory assistant we encountered numerous challenges and drawbacks. The major issues we faced were:

- Access to laboratories is restricted to the staff and laboratory assistants, therefore students need at least one laboratory assistant to be around (mainly to take responsibility of the laboratory equipment's and also to supervise the experiment)
- Due to Laboratory schedule, which is according to working hour of the staff, time limitations for experiments are enforced.
- The Laboratory require entrance key by an authorize staff or laboratory assistant.
- Students are restricted to working in the laboratory within working hours of lab operator.
- The laboratory assistant has to measure the student's group performance and individual contribution(s) during an experiment, in order to prepare an assessment report.

The department has engaged more MS/PhD students as laboratory assistants, since they work more on their research in the Laboratory, thus more financial commitment from the University. This method falls short of EC2000 criterion 3, outcome 'b', as the outcome intends the student to design their own experiments and conduct such experiments on their own. This is a challenge in most of our courses as they have readymade experiments to be carried out with the help of the Laboratory Assistant. The introduction of RFID technology was in order to solve this problem. We have tested the use of RFID in some of our courses within the laboratory, although we are still experimenting, the anticipated improvement in fulfilling EC2000 outcome b is significant. Yet, there are few problems we are still working on, to perfect the use of this technology in our Laboratory.

III. The Radio Frequency Identification (RFID) Technology

RFID is not a new technology; as its application can be seen in day to day life [10-18]. Recently, Radio Frequency Identification (RFID) technology has been widely used in many applications as seen in Table 1. The RFID system utilizes radio waves to transmit information from an integrated circuit tag through a wireless communication to a host computer [16]. These systems consist of three components: chip/tag, an antenna and a reader.

TABLE I. Identifier-based application cases examples [19]

No	Application area	Application case
1	Manufacturing	Inventory management, Tracking management, Quality control management, Resource management
2	Warehousing	Picking management, Receiving management, Shipping management
3	Transportation, traffic	Distribution management, Material processing management, Safety management, Public transport ticket, Toll collection, Smart car key, Parcels, mailbags, Luggage handling, Automatic vehicle location
4	Retailing	Inventory management, Shelf–stock management, Checkout management,
5	Digital documents	Access control and monitoring and revision control and monitoring of files, Digital signature
6	Agriculture	Animal tracking, Animal diagnostics, Crop identification,
7	Environment	Waste haulage, Recycling
8	Perishables	Recipe control, Load processing, Auction
9	Fuel, chemicals	Dispensing control
10	Clothing	Cleaning control, Laundry ID
11	Healthcare	Pharmaceutics, Hospital equipment and personnel, Patient medical history, Implant and prostheses, Elderly care
12	Sports and games	Sports event timing, Tracking golf balls, Gaming chips,
13	Human identification	Digital ID, Electronic passport, Facility access, Punishment system,
14	Finance	Smart card, Banknote identification
15	Government and military	Military logistics

The reader communicates with the tags in its wireless range and collects information about the objects to which tags are attached. Aside these three primary components is the database for information storage. The chip/tag is a very tiny electronic device comprised mostly of silicon; it stores information about the carrier which can be an item/product or a person. The RFID tags (passive or active) consist of a small coil that serves as an antenna and the small chip that holds the identification number of the tag (this number called EPC is unique to every tag). This device is small enough to be embedded in smart cards, capsules or any other forms [20]. The RFID reader emits radio waves at the tags frequency in other to read the tags information. Thus the RFID tag relies on the power drawn from the radio waves in order to activate its internal circuitry. By doing so, the tag circuitry sends out the data stored inside it which is the Electronic Product Code (EPC) number [21]. In addition, to emitting radio waves, the reader captures and decodes the generated data from the tag integrated circuit. The passive tags rely on the reader radio waves for its power supply while the active tags generate their own power supply.

Since, performance of any technology is important to its success/applications, in order to optimize the performance of RFID, performance testing has been carried out extensively in the supply chain environment with [22] rating RFID performance 100% based on the ratio of tag responses per request. Other researchers, like [23] have rated RFID within 80-90%. These assessments only reiterate the potential of RFID in other sector like Education. One area of Education that is currently engaging RFID is the Library

[24-27]. Other applications of RFID are in college registration and class attendance in some Schools. Applications of RFID technology in laboratory have not yet been rigorously studied, attention in Laboratory is shifting from the traditional laboratory to online/virtual reality laboratory; the debate is still open for discussion. There are few works On RFID applications in traditional laboratories [28-30].

The successful application of RFID in Laboratories will help many University seeking ABET accreditation to solve one of the bottle neck of approval, as when it comes down to fulfilling the EC2000 outcome 3b.

IV. RFID APPLICATION IN MECHANICAL ENGINEERING LABORATORY OF EASTERN MEDITERRANEAN UNIVERSITY

The introduction of RFID in Laboratory of Mechanical Engineering Department, Eastern Mediterranean University started in the Computer Integrated Manufacturing (CIM) Laboratory, the RFID application is still in its experimental phase and with successful application other Laboratory will be equipped with devices to enable them utilize RFID systems.

A. The Computer Integrated Manufacturing (CIM) Laboratory

The CIM Laboratory is equipped with computers, CNC machines, Conveyors, Robots etc. The RFID system designed for this laboratory is to help facilitate the achievement of EC2000 Outcome 3b and to allow more time for students to conduct experiments at any time without the presence of the Laboratory assistant. Figure 1 and Figure 2 show the layout of a task by a student working with the conveyor and the robots in CIM laboratory.

When a tag carrier (currently we use passive tag, given to students in the CIM course) enters the Laboratory, the RFID reader assesses the tag and confirms entry. The equipment's in the Laboratory are tagged for the equipment movements and each equipment is designated a station. The system stores all information of all activities performed by the tag carried on equipment (corresponding with the tag on the carrier and the equipment's) up till the time the tag carrier leaves the Laboratory. All data were stored in the University database. The tag carrier information can be called using analyzer software (See Figure 3) at any point of the activities at the convenience of the Laboratory Assistant. The analyzer software (we have written a visual basic code for this task) is pass-worded for security. The detailed carrier information (raw data) as seen in Figure 4 shows the reading of the reader as the tag carrier moves from one station to the other. The tasks activities are shown in Figure 5 using the analyzer software, the analyzer organizes the data in usher friendly interface. The student design what they want to experiments based on the available equipment in the Laboratory. Each Student in a group carries a tag that distinguishes him/her from other students; the RFID reader reads the movement and location information of the carrier throughout the experiment period and stores the time spent at each equipment's station, and also the time spent on each operation of the equipment is stored. Device vicinity check is performed by the RFID antennas placed in each station where the equipment's are located. The read range of each antenna is limited to the station, once a tag carrier is located in the vicinity of the device, the reader store the time spent in the station by the tag carrier. This enables the RFID system to record information of individual tag carrier, though the carrier is a part of a group, taking part in group activity through the device vicinity check.

Figure 1. The Antenna

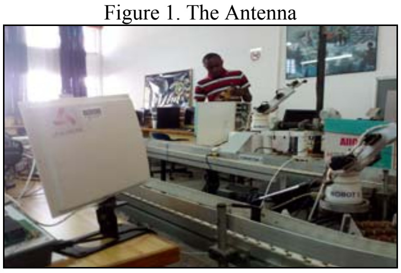


Figure 2. A student in the Laboratory

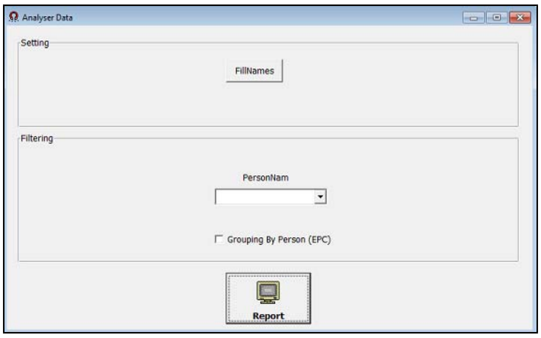


Figure 3. Visual Basic Program

EPC	Seen Time	Date	Antenna	RSSI	Channel in	PC	CRC
200563000000000000000B46	06:01:01:5625	Nov-09-2012	1	-61	0	3000	E423
200563000000000000000B46	06:01:01:9687	Nov-09-2012	1	-63	0	3000	E423
200563000000000000000B46	06:01:02:3750	Nov-09-2012	1	-62	0	3000	E423
200563000000000000000B46	06:01:02:5781	Nov-09-2012	1	-63	0	3000	E423
200563000000000000000B46	06:01:02:9687	Nov-09-2012	1	-59	0	3000	E423
200563000000000000000B46	06:01:03:3750	Nov-09-2012	1	-61	0	3000	E423
200563000000000000000B46	06:01:03:7812	Nov-09-2012	1	-61	0	3000	E423
200563000000000000000B46	06:01:03:9843	Nov-09-2012	1	-62	0	3000	E423
200563000000000000000B46	06:01:04:3906	Nov-09-2012	1	-63	0	3000	E423
200563000000000000000B46	06:01:04:8906	Nov-09-2012	1	-59	0	3000	E423
200563000000000000000B46	06:01:05:1250	Nov-09-2012	1	-61	0	3000	E423
200563000000000000000B46	06:01:05:6875	Nov-09-2012	1	-63	0	3000	E423
200563000000000000000B46	06:01:05:8906	Nov-09-2012	1	-61	0	3000	E423
200563000000000000000B46	06:01:06:2968	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:06:7031	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:07:1093	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:07:5000	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:07:9062	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:08:1093	Nov-09-2012	1	-64	0	3000	E423
200563000000000000000B46	06:01:08:5000	Nov-09-2012	1	-63	0	3000	E423

Figure 4. Data Captured by Antenna

Person Name Vatankhah **EPC** 2005630000000000000007E1

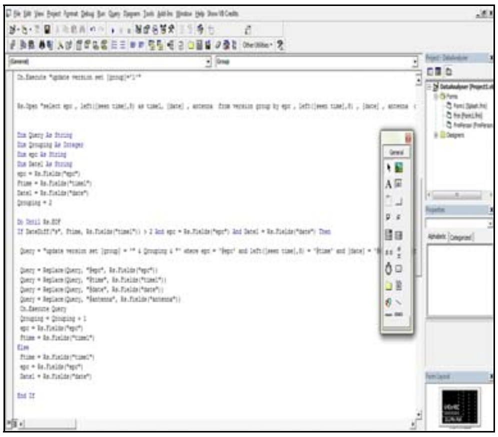
Date	STme	ETime	Lenght	ANT
11/26/2012	00:42:14	00:42:28	0:00:14	1
11/26/2012	00:43:25	00:43:39	0:00:14	2
11/26/2012	00:42:48	00:43:12	0:00:24	3
11/26/2012	00:43:52	00:44:04	0:00:12	4

Person Name Afzali **EPC** 200563000000000000000807

Date	STme	ETime	Lenght	ANT
11/26/2012	00:39:03	00:39:07	0:00:04	1
11/26/2012	00:39:17	00:39:25	0:00:08	2
11/26/2012	00:39:31	00:39:41	0:00:10	3
11/26/2012	00:39:51	00:40:25	0:00:34	4

(a)

ISBN: 978-988-14047-0-1
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)



(b)
Figure 5a&b. Data Analyzer interface

V. DISCUSSION & CONCLUSION

Our experience so far with the use of RFID in Laboratory experiments shows that the technology's potential can provide an edge for institutions willing to further in accomplishing EC2000 outcome b criterion. The students now designs experiments in the CIM laboratory and carry out the experiments without the presence of the Laboratory assistant and the Instructor is not worried about the integrity of the submitted reports. The RFID provides minimum information required by the Instructor to assess the contribution of each student in the Laboratory by checking their movements in the Laboratory against the stations and the equipment's movement within the time the student was at the station. Students now run more experimental tasks than ever before in the CIM laboratory due to the use of the RFID systems in place. Although the cost of the system is still high, but the advantages far outweigh the cost. We are in the second phase of the RFID experimentation which involves installation of cameras that can monitor the operation of each equipment in the Laboratory to aid the performance of the RFID systems. The non-contact, non-line-of-sight characteristics of the technology is the required advantage and edge provided for the fulfillment of EC2000 outcome 3b. Although challenges may still be experienced with the use of RFID in our Laboratory, such as the interferences of station reading (Since the equipment's in the Laboratory are not so distant from each other, two stations may read a tag carrier position at the same time) measures (such as the creation of signal barrier from one station to another) are in place to counter such challenges.

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