Journal of Engineering Education Transformations,
Volume 30, No. 3, January 2017, ISSN 2349-2473, eISSN 2394-1707

OBE based Industry Academy Approach for Embedded System Design Course

M Rajendra Prasasd[1], B Santosh Pawan Kumar[2], A Swarnamani[3]
[1,2,3]Department of Electronics and Communication Engineering, Vidya Jyothi Institute of Technology, Hyderabad
[1]rajendraprasad@vjit.ac.in
[2]bspk96@gmail.com
[3]swarnamani13.1@gmail.com

Abstract: Outcome-Based Education (OBE) is a powerful framework which emphasizes on the outcomes of the course. OBE is the student-centred learning method that focuses on measuring the student performance. At the end of each course, student should fulfil the course outcomes.The purpose of this paper is to investigate and present an analysis report that gives the methodology to enhance the capabilities of a student from the existing courses by OBE based industry academy approach for embedded system design course. The objective for the Embedded Systems(ES) course enables the students to understand basics and program of an embedded system. It helps to learn and understand the method of designing, operating systems concepts, types and choosing an RTOS for an embedded system for any type of applications. It lets students design, implement and test an embedded system. The interaction between the Industry and Academia creates a path for the exchange of knowledge which is very crucial. Academia is the major source of knowledge for industry which provides required infrastructure and support to the Academia.

This interaction provides a platform for the students to foster research interests. Through this paper, we have implemented Industry-Academia Approach (IAA) to meet the outcomes of industry oriented course and also discuss the outcomes of the projects that we have undertaken during and after the training program through the collaboration with the industry.

Keywords: Embedded System, OBE Approach, Industry, Academy, Micro Processors, Course Outcomes

1. Introduction

OBE is the main focus to achieve the quality of education. For academy, collaborating with industry becomes an important factor [1]. The design of an embedded system requires customized hardware and optimized software. Therefore, there is a requirement of both hardware and software professionals. The biggest challenge is to induce both hardware and software concepts keeping multidisciplinary

M Rajendra Prasasd
Department of Electronics and Communication Engineering,
Vidya Jyothi Institute of Technology, Hyderabad
rajendraprasad@vjit.ac.in

undergraduates in mind. In order to overcome this challenge OBE proves to be a reliable and a very good learning method that focus on measuring student performance. ES is a part and parcel of our daily lives. The ever increasing dependence on the embedded systems compelled the industries to invest to develop such systems. Consequently, there is an increase in demand for skilled and knowledgeable professionals. The real scenarios such as in industry are difficult to reproduce in conventional academic environments [2]. The industries are not finding skilled engineering graduates to be employable. Henceforth, there is a requirement for the academia to collaborate with industry to enhance the skills of undergraduate engineers. The collaboration between academia and industry leads to innovation and improvement in industry. This becomes the basis for achieving sustainability and empirically evaluated results [3], [4]. Sometimes academia also states that in some instances it is difficult to collaborate with industry because it is not feasible or even easy to depend on a particular area of knowledge. [5]. Pablo Pavon-Marino stated in his discussions that it is difficult to collaborate with industries partially because of the absence of proper communication and being unaware of the industry and academia requirements [6]. It was rightly stated by Greg Peters in his discussions that for a successful partnership, clear communication and personal relationships are required. The ability of problem solving, innovative approaches, deep technical knowledge and other required skills are enhanced due to collaboration of academia with the industry [7]. This collaboration provides the students a valid alternative to expose them towards more realistic problems and situations than that which are prescribed in academic courses [8]. The important courses which form the foundation for the embedded systems are Computer Organisation and Operating System (COOS) and Microprocessors and Microcontrollers (MPMC). For an undergraduate professional who wants to study embedded systems/ processor design, these concepts are very important, as they form the basis of design strategy [9]. It is also a well-known fact that assembly coding is closest to the computer, and it is always most optimum, if written properly. This is very important for real-time or time-critical systems coding, as each millisecond is very important. Knowing the architecture completely helps in writing the assembly codes [10].

There is a requirement of the best support from industry to gain the above mentioned skill sets which would reduce the gap between the industry and academia [6]. This paper provides a methodology for improving the skills of the students using industry-academia collaboration with the help of the powerful Outcome Based Education framework.

2. Literature Review and Related Work

A recent UK survey conducted by the industry and engineering students found that by having an industrial exposure, the academic performance and industry placements of the students improved [11].According to Tiago Gonclaves the embedded systems have a huge impact in our daily lives. There would be no progress in the day to day activities without the presence of the Embedded Systems. In order to meet these requirements, students have to be industry enabled and universities are trying to collaborate with the industry to make the ES course better [12]. As per Washington Accord, to achieve the quality of education OBE plays a vital role. With respect to this the collaboration of academia with industry becomes an important factor. When Academia collaboration with Industry increases, it facilitates research, online courses, internship, webinars, workshops, placements etc. The major source of knowledge for industry is the academia [13]. The aim of this paper is to focus on the implementation of the outcomes by industry-academia collaboration. The different kind of projects that were undertaken during the training facilitated students to explore the present trends in the ES by applying the concepts learnt in the prescribed courses like COOS, MPMC and ES.

3. Design Methodology for Industry-Academic Approach

Engineering is in every field these days. The pace at which the technology is changing is very rapid. Therefore, it is very important to improve the quality of learners by industry-academia interactions. OBE mainly focuses on abilities procured by the learners. It also assists by creating abilities and inculcating expertise [14]. OBE can be implemented by the Course Outcomes (COs) that are given by the instructor at the beginning of the semester [15], [16]. Students are given the COs at the beginning of each semester. The COOS is introduced in the 5th semester. The course outcomes are as follows:

Table 1: COOS Course Outcomes

Course Outcomes	Upon completion of course, students will have thorough knowledge about:
	1. Basic structure of a digital computer. 2. Arithmetic operations of binary number system. 3. The organisation of the Control unit, Arithmetic and logical Uni t, Memory unit and the I/O unit. 4. Operating system functions, types system calls. 5. Memory management techniques and deadlock avoidance. . Operating systems' file system implementation and its interface.

The course MPMC is followed by COOS prescribed in the 6th Semester The course outcomes are as follows:

Table 2: MPMC Course outcomes

Course Outcomes	Upon completion of course, students will have thorough knowledge about:
	1. The students learn the internal organization of popular 8086/8051 microprocessors/microcontrollers. 2. The students learn hardware and software interaction and integration 3. The students learn the design of microprocessors/microcontrollers-based systems

From the software perspective a student has the basic knowledge of COOS and from the hardware point of view the course on Micro Processors helps in software/firmware development. In the later stage the combination of these two courses was introduced in the course ESD in the 7th Semester. The course outcomes for the ESD course are as follows:

Table 3: ESD Course outcomes

Course Outcomes	Upon completion of course, students will have thorough knowledge about:
	1. Ability to design an embedded application on host system. 2. Ability to test 8051 based embedded systems. 3. Ability to design and develop ARM based embedded system. 4. Ability to apply the knowledge of Operating Systems for Embedded systems. 5. Transplant Linux RTOS of x86/ARM Processor boards.

To initiate with any action plan, a perfect base and foundation is required, it was the need of the hour to identify what the industry required and demanded for. Hence under the eminent guidance of the instructor, we identified the core sections of the ES course.

We identified our core domain of interest and got trained in the ARM University Program by the industry experts. We had trust in our intuitions and believed that we could be driven into the side of research with the help of the IAA [17].

The constant interaction with the Industry experts developed Work Integrated Learning (WIL) [18]. This helped us to learn concepts in a better way and also to foster research.

Below is the methodology which we designed:

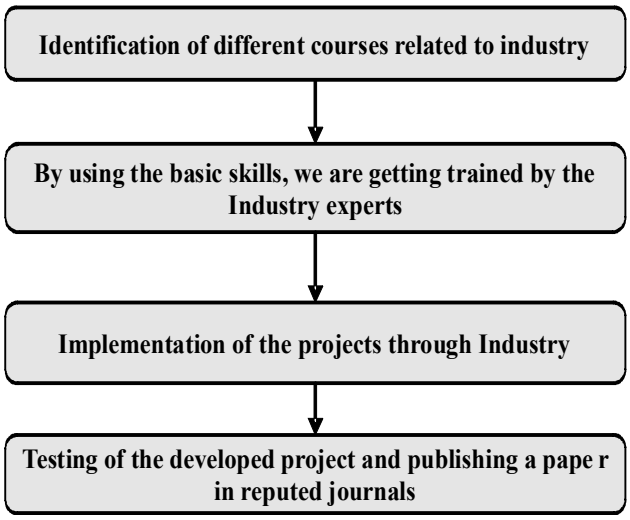

Fig. 1. : Industry Academia Approach (IAA)

As an example the industry training program was organized in our Institution:

The 5-day ARM training program for the final year students at the Vidya Jyothi Institute of Technology was enthralling. The trainers gave the best of their knowledge and shared their industrial experiences with the passionate students. The first day was an introductory session in which the students got introduced to ARM and its functioning. The students were given a brief description of the schedule for the next 4 days and were divided into groups of two.

After a detailed discussion on the theoretical concepts students were assigned with projects every day. Each team successfully accomplished many

projects at the end of the training program.

On the 5th day of the training program students were given 5 major challenging projects which were to be executed and shown to the trainers at the end of the day.

Students were given a list of major projects in which they were provided the flexibility to choose any one.

The projects were compiled on the mBed compiler, which is an online based compiler.

The best part of the training program for the students was a hands-on experience with the FRDM KL - 25Z boards, IoT shields, nRF modules.

4. Results and Discussions

The above methodology helped us implement the following projects which are related to the industry.

We have implemented wireless transmission and reception of data through RF frequency using SPI protocol. The ARM mBed compiler is shown in figure 2. The data transmission process is shown in the figure 3. The FRDM board with the IoT shield and nRF module is shown in figure 4.

Fig. 2.mBed Compiler

```
nRF24L10+ Frequency      : 2440 MHz
nRF24L10+ Output Power   : 0 dBm
nRF24L10+ Data Rate      : 1000 kbps
nRF24L10+ Tx Address     : 0xE7E7E7E7E7
RF24L10+ Rx Address     : 0xE7E7E7E7E7
imple Transmitter (0 - 9 Counter)Sending 2 - 57 83
pot = 0.89 LDR = 1.18
Sending 2 - 55 95
pot = 1.03 LDR = 1.38
Sending 2 - 60 106
pot = 1.24 LDR = 1.49
Sending 2 - 62 91
pot = 1.15 LDR = 1.31
Sending 2 - 57 84
pot = 1.04 LDR = 1.20
```

Fig. 3. The serial terminal window - the values captured from FRDM

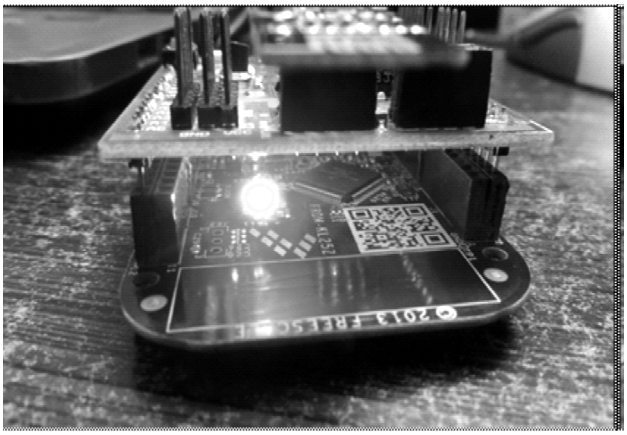

Fig. 4.FRDM KL-25Z board with IoT shield and nRF module

The projects that were undertaken are as follows:

1. WSN Multiple Nodes: This was the project assigned to our team during the ARM University training program. The idea behind the project is to create a wireless sensor network to acquire data from transmitters and upload the complete data to phant server. The figures below are the snapshots and screenshots while performing the project. We have used the concepts of microprocessors, embedded systems and computer organisation to properly organize the data and send it to the cloud. Figure 5 shows the source code of the embedded system. Figure 6 shows the sending of data from a wireless node to the receiver and figure 7 shows the data received at the receiver and this data is in turn uploaded to cloud which is shown in figure 8. We tested the embedded system and the project was

implemented and CO3 of ES course is attained successfully.

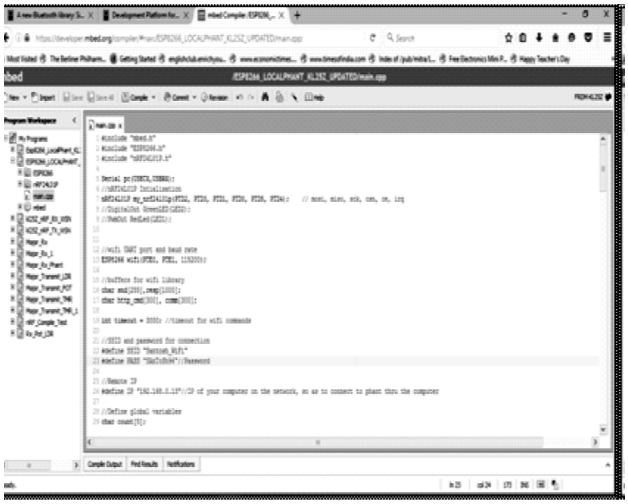

Fig. 5.Part of the source code for the WSN multiple nodes

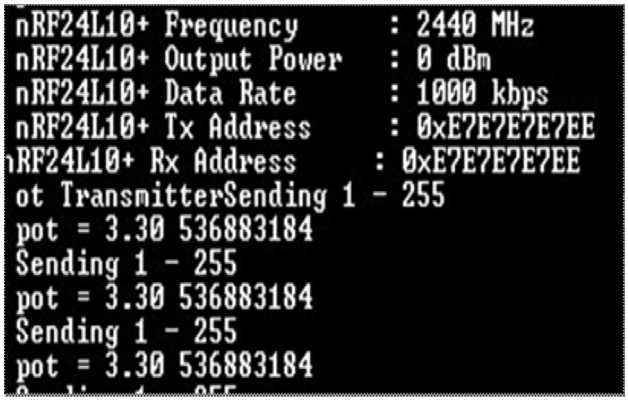

Fig. 6.Fig 6: Wireless nodes sending the data

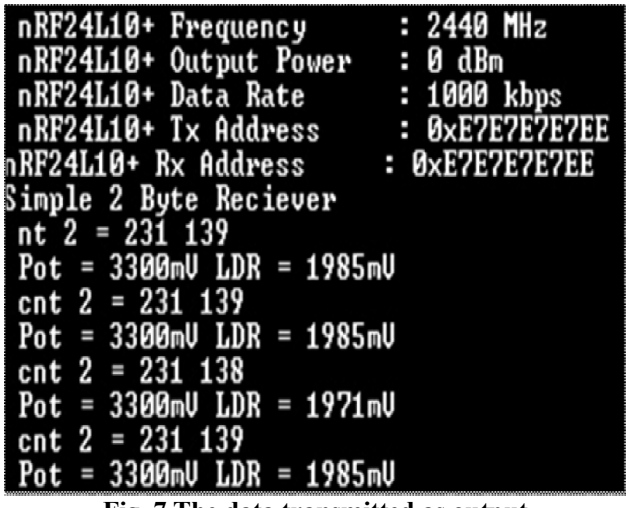

Fig. 7.The data transmitted as output at the receiver end

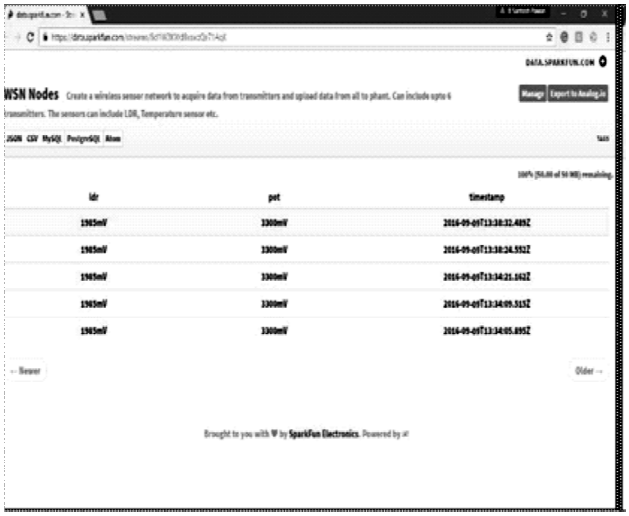

Fig. 8.Data stored on cloud

2. Linux Kernel Source Image: This project was accomplished under the guidance of our professor. The aim of the project is to develop a Linux kernel source image for the Raspberry Pi 3, which is a credit card size computing system. The Raspberry Pi 3 (RPi 3) has a 1.2GHz 64-bit quad-core ARMv8 CPU. The RPi 3 is shown in figure 9. We have downloaded the latest kernel version 4.4.9 and the source tree is as shown in figure 10. We have cross compiled the code and build Linux kernel image and booted successfully on the target system, i.e., Raspberry Pi 3. By implementing this project, CO4 and CO5 are attained. The figures 11, 12 and 13 are the screenshots from the target system. The project was successfully implemented and the results and screenshots are as shown in the figures below:

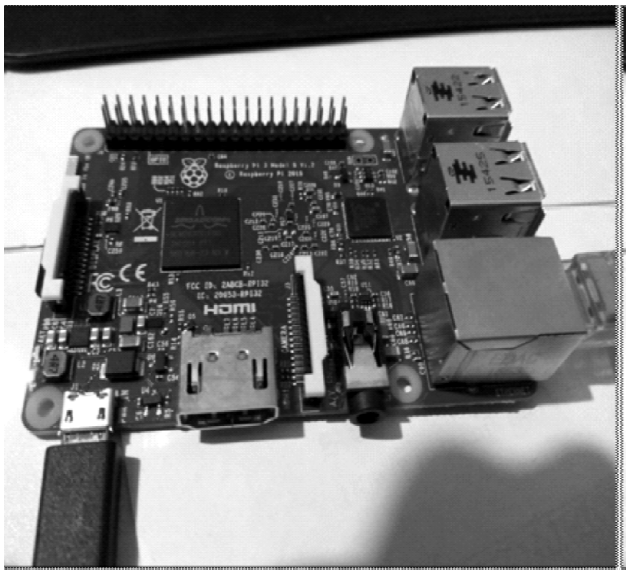

Fig. 9. The Raspberry Pi 3

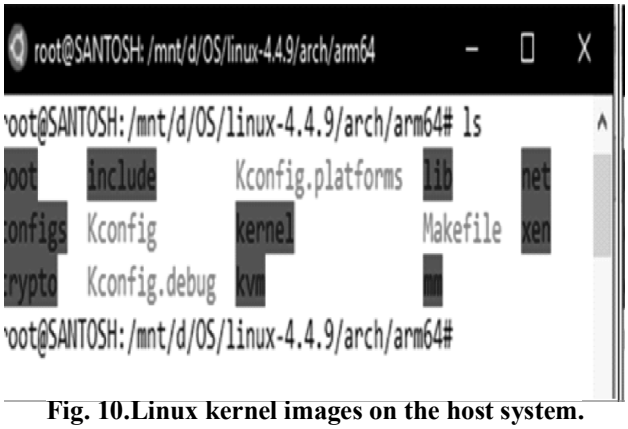

Fig. 10.Linux kernel images on the host system.

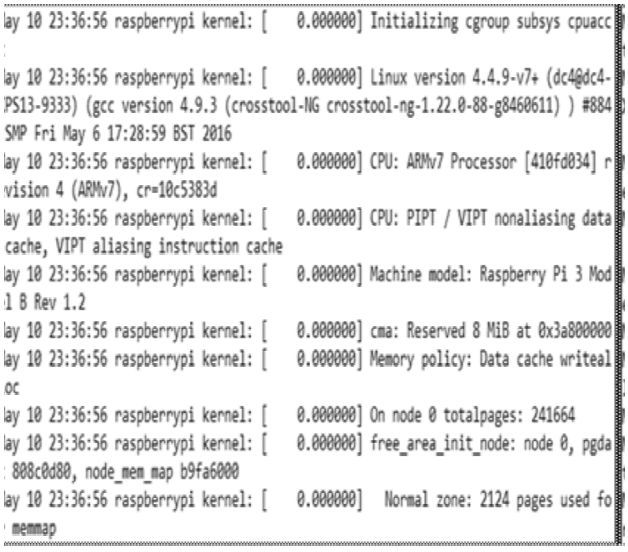

Fig. 11. Linux Boot log

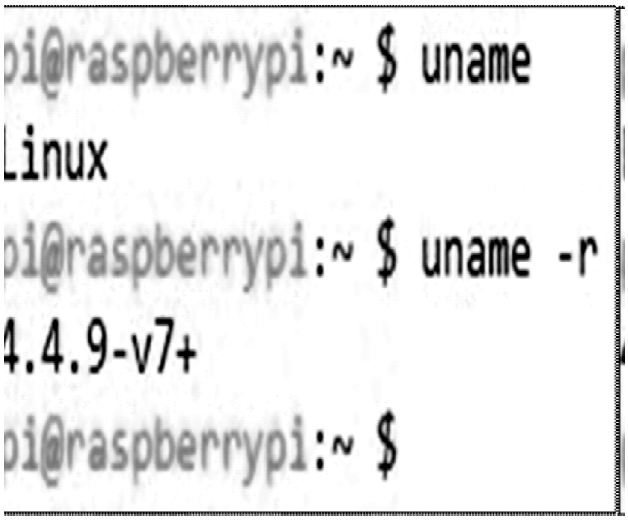

Fig. 12.Linux kernel flashed on top of the target system, in this case Raspberry Pi 3.

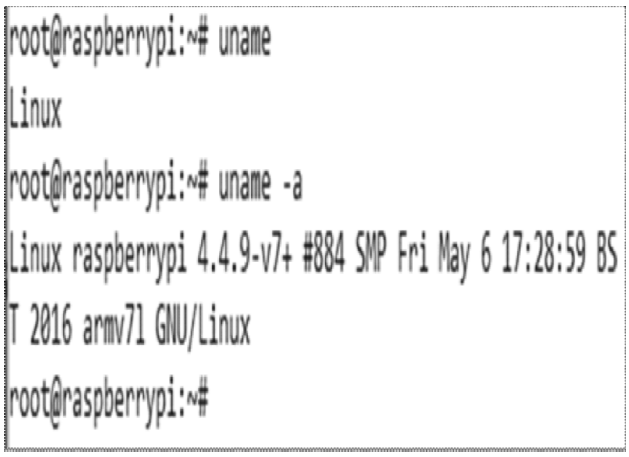

Fig. 13. Details about the Linux kernel version

5. Conclusions

The process of teaching the critical subjects which are commonly used by everyone in the world should be done in a meaningful and right manner where students learn the concepts properly. The assembly level programming or embedded C programming must be taught to students where they find fun in learning than feeling it a burden. Henceforth, with the help of OBE and the support of industry we could successfully establish a link between the subjects taught in regular academics and the industrial standards. We understood the industrial expectations from students. The industry provided their tools and the software which they use thereby empowering us to set the industry standards. With the help of such training programs the interaction between industry and academia can be enhanced and the gap between these could be reduced to a larger extent and enabled the students to make their foundation strong. To conclude our discussion in this paper, the above-mentioned methodology helped us implement the projects entitled: WSN multiple nodes and transplanting Linux Kernel Image for ARM 11 processor board successfully.

6. Future work

After the implementation of the project, we would like to publish our findings in reputed international journals.

On having successfully implemented the concept of OBE into real time projects and having come to

know its importance in effective learning we would like to implement the same on a regular basis for all the upcoming batches.

We would also collect feedback from the academia and industry to continuously improve the methodology of implementation to suit the required standards.

Acknowledgement

We are immensely grateful to Correspondent, Director, Principal, Head of the Department-ECE and faculty of ECE department of Vidya Jyothi Institute of Technology, an autonomous institution, for teaching us the importance of Outcome Based Education and the essence of keeping up with emerging technology. We would like to extend our sincere gratitude towards the industry experts for their kind support.

References

[1] SaeidNooshabadi and Jim Garside, "Modernization of teaching in embedded systems design-an international collaborative project", IEEE Transactions on Education, Vol. 49, November 2006.

[2] Juýrez-Ramýrez, Jimýnez and Carlos Huertas "Developing software engineering competences in undergraduate students: a project-based learning approach in academy-industry collaboration", Software Engineering Research and Innovation (CONISOFT), 2016 4th International Conference.

[3] Nadia Alshahwan, Michael Felderer and Rudolf Ramler, "Industry-academia collaboration in software testing: An overview of TAIC PART 2015", Software Testing, Verification and Validation Workshops (ICSTW), 2015 IEEE Eighth International Conference.

[4] JoelmaChoma, Luciana A.M. Zaina and Tiago Silva Da Silva, "Towards an approach matching CMD and DSR to improve the academia-industry software development partnership: a case of agile and UX integration", Software Engineering (SBES), 2015 29th Brazilian Symposium.

[5] Francisco Falcone, Pablo Sanchís, Antonio López-Martín, Ana Alejos and Raúl Rodriguez Rubio, "Fostering Industry-Academia synergies in the curricular development of engineering education", TecnologiasAplicadas a la Ensenanza de la Electronica (Technologies Applied to Electronics Teaching) (TAEE), 2014 XI.

[6] Pablo Pavon-Marino and Jose-Luis Izquierdo-Zaragoza, "Net2plan: an open source network planning tool for bridging the gap between academia and industry", IEEE Network (Volume: 29, Issue: 5, September-October 2015).

[7] Greg Peters, Jack Wenstrand, Roger Stancliff and Tim Wu, "An industry view of industry/academic research collaboration", icrowave Symposium Digest (MTT), 2012 IEEE MTT-S International.

[8] Jorge Rodriguez and AlamgirChoudhurry, "Opportunities and challenges for collaboration industry-academia via sponsored design competitions", Interactive Collaborative Learning (ICL), 2014 International Conference.

[9] RajeshwariHegde, "Implementing outcome based education for microcontrollers", MOOC, Innovation and Technology in Education (MITE), 2014 IEEE International Conference.

[10] P R Kolhe, M H Tharkar, R M Dharskar and P P. Kolhe, "Impact of embedded system in modern life", IPASJ International Journal of Computer Science, October 2014.

[11] Aaron Simon Blicblau, Tracey Louise Nelson and Kurosh Dini, "The role of work placement in engineering students' academic performance", Asia-Pacific Journal of Cooperative Education, 2016, 17(1), 31-43.

[12] Dr. M Indiramma, et. al, "Role of Industry to improve outcome based education in engineering", JEET, Jan. 2015.

[13] Tiago Gonçalves, A. Espírito-Santo, B.J.F. Ribeiro, P. D. Gaspar, "Design of a learning environment for embedded system", World Congress on Engineering 2010.

[14] S. Viswanadha Raju, M.S.V.S. Bhadri Raju, G. Abbaiah and MadhaviGudavalli, "Role of ICT in outcome based education", Advanced Computing (IACC), 2016 IEEE 6th International Conference.

[15] M MShahidul Hassan, "Challenges of implementing outcome based engineering education in universities in Bangladesh", Electrical & Computer Engineering (ICECE), 2012 7th International Conference.

[16] ShivakumarRamchandra, Samita Maitra and K MallikarjunaBabu, "Method for estimation of