# A VIRTUAL INDUSTRY PLATFORM FOR COURSE PROJECTS IN AUTOMOTIVE ELECTRONICS: A CASE STUDY

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*Abstract*

This paper presents the details of hands on course instruction attempted for the undergraduate programme for automotive electronics course in electrical sciences using virtual industry platform. The design of an Electronic Control Unit for an integrated engine and safety management system developed as part of course project on Automotive Electronics at the undergraduate level in Engineering in the multidisciplinary electrical sciences is proposed. The paper also proposes a course delivery mechanism model based on learn-by-doing approach to incorporate a practical hands-on on the design and validation of automotive control systems to enhance the specific learning outcome during the course delivery. The details of a virtual industry platform adopted for the course delivery to impart a team level project delivery and management experience to both the students and the faculty are presented.

*Keywords-* *Automotive electronics, course projects, integrated experience, project managers, requirement document, sub- module design.*

## I. INTRODUCTION

The automotive industry is today the sixth largest economy in the world, producing around 70 million cars every year and making an important contribution to government revenues all around the world. As for other industries, significant improvements in functionalities, performance, comfort, safety, etc. are provided by electronic and software technologies. In 2006, the cost of an electronic-embedded system represented at least 25%of the total cost of a car and more than 35%for a high-end model. This cost is equally shared between electronic and software components[1]. These general trends have led to introducing automotive electronics course to all branches of electrical science streams.

The design process of an electronic-embedded system for automotives relies on a tight cooperation between car manufacturers and suppliers under a specific concurrent engineering approach. To bring in this real feel among the students about the industrial project development scenario, the course projects were introduced for the course of Automotive Electronics. The main objective of the course projects is to give more hands on and an integrated experience, the way it exists in industry to the students in addition to that knowledge gained in the regular course. Typically, in automotive industries the carmakers provide the specification of the subsystems to suppliers, who are then in charge of the design and realization of these subsystems, including the software and hardware components. The results are furnished to the carmakers, who in turn integrate them into the car and test them. Similar virtual platform is created in a class; the entire class and faculty are mapped into automotive organization. The project managers were selected amongst the students and each manager was assigned to handle four project teams. Requirement document was sent across the project managers. The managers came with the specifications prepared by all the teams and subsequently the design aspects of it. The different teams came with sub module design and finally all the teams integrated their modules to arrive at final solution. The students worked on a real, working two wheeler engine and they could implement EGAS system, start stop system, safety systems to name a few. This activity helped the students to experience the industry environment, integration and interfacing of sub modules, and better understanding of engine management systems. Another main issue in automotive systems is to reduce the time to market. The reuse of components, or of subsystems, is one way to achieve this objective; which is also realized during the execution of the course project.

The course is highly multidisciplinary and application oriented requiring the knowledge of various engineering domains like mechanical, electronics and computers. The course deals with development of embedded systems to various domains of automotives. The main emphasis of this course is to develop the student's ability to analyze the electronic systems in present day automobiles and their specific requirements to become acquainted with the new applications that are being developed for future automobiles. To cater to these objectives, the course contents were framed by considering the inputs of various automotive industries like KPIT Cummins, RBEI and ARM limited. The course design teams mainly consisted of the industrial expertise from RBEI and KPIT , top management from the BVBCET and also the eminent faculties from the departments of Instrumentation Technology , Electronics & Communication Engineering , Electrical & Electronics Engineering and Automobile Engineering. The curriculum design also caters to societal requirements. The members of the committee have pedagogical and complex systems knowledge for being the paradigm on which the model is structured.

The course is introduced at the sixth semester level, for all the programs of the electrical science stream involving Instrumentation Technology, Electronics and Communication Engineering and Electrical and Electronics Engineering wherein the student has a sufficient background of embedded systems development, design of electronics systems and basics of mechanical systems.

Along with the conventional classroom teaching various other active learning methods are adapted to enhance the learning of the students. These methods include practical exposure to automotive mechanical systems, simulation of engine management systems, expert lectures to introduce students to the current technology related issues of industries, animations and video presentations to make the concepts clearer. These activities gave a required foundation for a student to frame a problem statement for their course project, wherein the student dealt with a real-world problem and suggested a optimized and novel solution.

The course is of three credits with two minor exams, semester end exam and course project. The questions of minor and semester end exams are framed to test the learning levels of students according to the blooms taxonomy. The course along with the delivery and evaluation methods addresses both the technical and professional outcomes of the program.

Organization of the paper is as follows section II deals with design of course of course projects, section III Implementation methods of course projects, section IV deals with evaluation methods , their effectiveness and discussion and section VI with Conclusion.
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## II. COURSE PROJECTS DESIGN

The course projects have been introduced with the following objectives,

- To introduce industry work environment to students.

- To develop industry specific skills among the students.

- To prepare new graduates well prepared before starting their career in automotive industry.

- To integrate and interface submodules including hardware and software.

- To develop team building environment.

- To provide effective reporting presentations.

One of the main challenges of the automotive industry is to come up with methods and tools to facilitate the integration of different electronic subsystems coming from various suppliers into the vehicle's global electronic architecture[2]. The introduction of course projects and practicing this activity by creating industry like environment helped the students to experience the industrial work culture.

The different phases of project realization are discussed below,

*A. Mapping of whole class and faculty to Automotive Organization*

This time we executed the case studies (course projects) with a unique approach. The purpose was to introduce the students the real industry work environment. We mapped the whole class and faculty to automotive organization. The Fig. 1 shows the structure of automotive organization which is in line with auto industry starting from president BVB worldwide, president BVB India, vice president, section head, group managers and project managers.
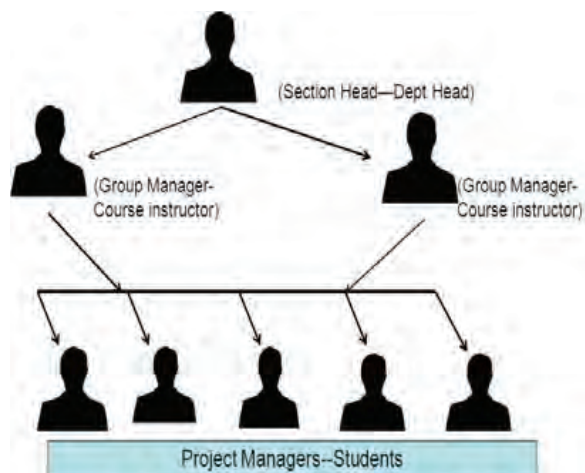
Fig 1. Course project organization structure (In line with auto industry)

### B. Brainstorming sessions for defining the Requirements

After the organization mapping next step was addressing the objectives of the course project by designing well defined requirements, the brainstorming sessions were conducted within faculty (group managers). These sessions discussed about providing a comprehensive overview about existing and future automotive electronic systems through course projects. The distinctive features of the automotive world in terms of requirements, technologies, and business models were highlighted and state-of-the-art methodological and technical solutions were expected in the following areas [3]:

- In-vehicle architectures: Selection of sensors, associated electronics, microcontrollers etc.

- Multi partner development processes: (subsystem integration, product line management, etc.)

- Software engineering methods: Use of modular programming approach

- Embedded communications: Selection of communication protocols

- Safety and dependability assessment: validation, verification, and testing

The requirement document consisted of plain language description of what the user wants and expects to get in the different domains of automotives. The domains like power train, safety and body.

## III. COURSE PROJECT IMPLEMENTATION METHODS

This section deals with the course project implementation and execution details at various stages; the whole process was planned for 10 weeks. There were weekly scheduled reviews with section managers along with unscheduled reviews too.

### A. Implementation stages:

The details of various stages such as project manager selection, requirement analysis, specification finalization, implementation details with software and hardware integration along with validation and testing are discussed below.

### III.A.1. Project Manager Selection

The whole class was briefed about the course projects and their implementation methods .Few students volunteered to act as project managers. Five project managers were selected and each project manager was asked choose four project teams, each team consisting of four students. Project managers to co-ordinate between the teams and manage the teams. The course instructors were assigned the role of group manager and department head was playing the role of section head.

Issues like interfacing of modules and technical help, resource management all was handled by the project managers and reporting the status of the project to the group managers. The group manages monitored the status of the complete project, and provided the needed technical help as well. Section head was not only providing the technical help but also resource management as well.

### III.A.2. Requirements to project managers

After designing the requirements, the requirement document was sent to the project managers, like how in real time the requirements from OEMs such as Mercedes Benz reach the suppliers. Managers had discussions among themselves and also with team members and divided the requirements. The sample requirement sheet is shown in Fig. 2 below,

**Highly confidential document**

Customer Requirements for zx class vehicle.

$ Two cylinder 4 stroke SI engine.

$ Electronic ignition system.

$ EGAS over CAN.

$ Auto start-stop system.

$ oxygen sensor1 over CAN.

$ oxygen sensor2 Hard wired.

$ seat-belt warning.

$ send gear info over CAN

$ Sensors for CAM and Crank position sensing.

$ MAF implementation required.

Fig 2. Requirement document

*III.A.3. Development of specifications*

All the project teams explored and surveyed independently about the requirements given. The teams then with discussion between all the teams and managers came with the more precise description of the system. The specifications were carefully written so that they accurately reflected the customer's requirement and served as the contract between the customer and the architects [4]. The specifications also included functional and non-functional elements.

*III.A.4.Brainstorming sessions with managers and group managers for implementation aspects.*

The Managers came with specifications prepared by all the teams and subsequently design aspects of it. At the start of the project, there was big confusion among students how to start and from where to start , how to integrate , how to communicate, how to develop code independently, and what tool to use and so on many things. The discussions with the section head, group managers and project managers resulted in a methodology to be adapted to initiate the project execution which addressed the below issues,

- Faster Hardware or cleverer software?
- How much hardware do we need?
- How big is the CPU? Memory?
- How do we meet our deadlines?
- How do we minimize power?
- Turn off unnecessary logic? etc.

*III.A.5. Development of software, hardware and integration*

Slowly things became clearer and clearer. It all started with bunch of team came with live engine of two wheeler, all other teams started mounting the components onto it and dissecting it, making their way easy to develop their hardware and implementing their requirements. Many sensors

have been integrated into the conventional engine to sense various parameters such as exhaust particles, Mass air flow, accelerator pedal position, throttle position and so on. Parallelly all the teams developed software for controlling engine parameters gave the conventional engine an "Aatma". Next challenge for the students was how to integrate the modules they have developed and what interface they need to have. Yes they indeed use the widely used automotive communication protocols to interface between different modules.

Finally students could integrate the all the modules and demonstrated the compliance of the new renovated conventional engine for the customer requirements. Some of the sub modules associated with engine management are,

- EGAS system
- Start stop system
- Electronic ignition system
- Exhaust gas sensing using Oxygen sensors
- seat belt warning system
- Gear indication over CAN protocol.
- Air conditioning using CAN
- MATLAB/ SIMULINK modelling of ABS,ACC and suspension system
- Air bag module
- Wheel speed sensor realization

The model based simulation is the latest trend in automotive industries. The students carried out modelling and simulation of the sub-module they are developing in the first phase. Later the sub-modules prototype was developed. The Fig. 3 shows some of the model based simulation of Anti-lock braking system (ABS) and suspension system.
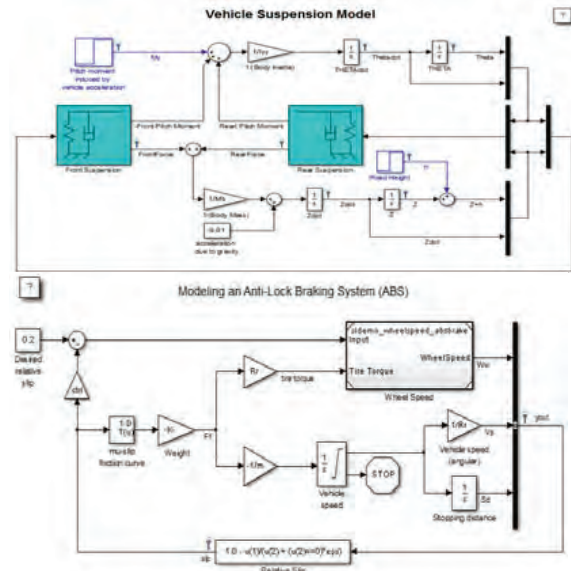


Fig. 3 Model based simulation of ABS and suspension system

The integration of different sub modules developed is shown in Fig. 4. It illustrates the demonstration of major features of engine management system. The students worked on two wheeler engine, they placed the sensors and actuators on engine. They placed exhaust gas oxygen sensor, wheel speed sensor and the operation of throttle was controlled. The information was communicated on CAN protocol. The ARM Cortex M3 processor was used in the electronic control unit they built. The students were actually controlling the engine operation using code.



Fig. 4. Students working on engine.

*III.A.6.Validation, verification, and testing*

After integration of different modules the following things were in the minds of the project teams, like

- Does it really work?
- Is the specification correct?
- Does the implementation meet the specifications?
- How do we test for real-time characteristics and test on real data?
- How do we work on the system?
- Observability, controllability?

Hence the integration phase is followed by a validation, verification, and testing of a software and hardware modules at unit level, module level and product level.

*B. Highlights of the activity*

The major outcomes achieved out of this activity are,

- Realization and implementation of feedback control
- Modular software and hardware development
- Ability to work with larger team
- Handling multiple files during software development
- In depth learning of engine management systems,
- Industry experience
- Deadline management
- Project Management
- Communication skills
- Working with Multi-disciplinary teams

IV. **EVALUATION METHODS, THEIR EFFECTIVENESS AND DISCUSSION**

This section discusses about the various evaluation methods adapted for the course and the discussion about the effectiveness of the activities realized and their mapping towards program outcomes. Equal weightage has been given to continuous internal evaluation (CIE) and semester end evaluation (SEE).

**Assessment of CIE and SEE:** The course projects were part of continuous internal evaluation. The weightage of 20% was assigned to this activity. The activity also helped in enhancing the question paper levels according to the Blooms taxonomy [6][7]. The question papers of minor exams and semester end exams included higher levels of questions addressing application, analyzing levels of Blooms taxonomy.

**Assessment of Course Project:** The effectiveness of the course project as part of a core subject is mapped to the learning outcomes 'a'to 'k'defined according Accreditation Board for Engineering and Technology (ABET) [5]. The Table 1 represents the outcomes 'a' to 'e' belong to technical outcomes and 'f' to 'k' belong to professional outcomes. It can be seen that the course project addresses both technical and professional outcomes defined by the program.

Tab le 1.Activity outcomes mapping to program outcomes

| Activity Phases | Performance Indicators | ABET Program outcomes |
|---|---|---|
| Literature survey and problem definition | *An ability to identify needs. *An ability to formulate problem *An ability to find alternate solutions and choose the best one. *Ability to work effectively in project teams, both as a member and leader, with different skills. | c, d, i, j |
| Concept level design | *Understand environmental, political, economical, and social impacts of engineering work. *An ability to use established method to design a system/process. *Knowledge of contemporary issues in the field of Instrumentation Technology | c, j |
| Implementation | *An ability to use modern engineering tools for modeling and simulation *Ability to engage in independent and life-long learning. | i,k |
| Demonstration & report writing | *Oral and visual communication skills appropriate to the profession of engineering | g |

*IV.3    Reflections    of    course    project    with continuous monitoring and feedback*

The activity was practised by all the students of Instrumentation Technology,

Electronics and communication engineering and electrical and electronics engineering students. With this activity, different teams were able carry out course projects addressing different themes. Around 50 different projects with different themes were carried out. This activity resulted in building strong knowledge of fundamentals, realizing the various aspects engineering analysis and hence the problem solving ability of the student enhanced [5]. The students' exposure to industry like environment is expected to help them in their carrier endeavours. Finally the assessment based on student feedback has been collected by each team as detailed in the appendix and the statistics shows that the objectives of the course project were satisfactorily met as mentioned in Fig. 5. Question 1 and 3 related to understanding of concepts and applying the same to the application has made an impact on learning. Question 2 relating to scope of understanding beyond curriculum is satisfactory. Suggestions by review committee and participation in technical events reflected in question 4 and 5   needs a scope for improvement.
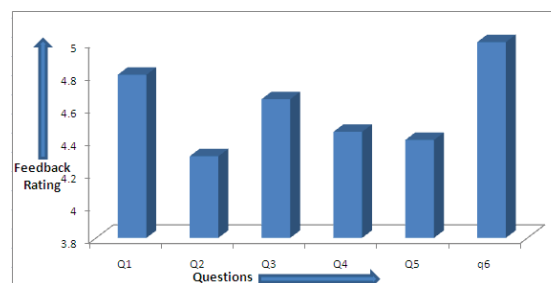


Fig 5.  Feedback questionnaire response

*IV.4    Reflections of activity in participation in technical events and placement activities*

Finally to encourage students the course project competion  named as " Drive by Code" was conducted . The competition  included the course projects from all the brances where automotive electronics course was taught. The industry experts evaluated the projects and they expressed an overhelming response towards the activity.

Fig. 6. Students exhibiting their projects

The students also participaed in different project competitions conducted by automotive industries and five batches have won the top prizes. The projects have been appreciated by industry personnel and few ideas were having research attributes in them. The number of automotive and embedded industries visiting the college campus has been increased and number students placed in those industries are also increased considerably. The college also initiated a strong industry-institute relationship; the KPIT and Robert Bosch Engineering Solutions (RBEI) being the major industries.

## V. **CONCLUSION**

The case studies as a part of automotive electronics course developed and executed by creating a virtual industry platform. The activity contributed in enhancing the various skills related to an automotive engineer. The metrics and the techniques adopted for the assessment of the learning outcome have been listed and the results are presented.

The overall outcome as seen from the result analysis clearly indicates that the approach adopted has significantly been encouraging in terms students overall growth. The students' participation in technical events, the placement and students pursuing carrier in automotive and embedded domain has been significantly increased. The activity helped in establishing a strong industry-institute relationship.

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## *References*

1. Lehtovuori, A. ; Honkala, M. ; Kettunen,H. ; Leppavirta, Interactive Engagement Methods In Teaching Electrical Engineering Basic Courses. Global Engineering Education Conference (Educon), 2013 IEEE Digital Object Identifier: 10.1109/Educon.2013.6530089 Publication Year: 2013, Page(S): 75 – 84

2. O. B. Adamo, Student Member, IEEE, P. Guturu, Senior Member, IEEE and M. R. Varanasi, Life Fellow, IEEE Department of Electrical Engineering University of North Texas, Denton, TX 76207, USA An Innovative Method of Teaching Digital System Design in an Undergraduate Electrical and Computer Engineering Curriculum .

3. Jennifer M. Case, Gregory Light, 'Emerging Methodologies in Engineering Education Research' Journal of Engineering Education January 2011, Vol. 100, No. 1, pp. 186–210

4. Edward F. Redish, Karl A. Smithg 'Looking Beyond Content: Skill Development For Engineers' unpublished

5. Motoei Azuma, François Coallier, Juan Garbajosa, 'How to Apply the Bloom Taxonomy to Software Engineering', Proceedings of the Eleventh Annual International Workshop on Software Technology and Engineering Practice, 2004

6. The University of Wisconsin-Madison http://teachingacademy.wisc.edu/archive/Assistance/course/blooms.htm

7. http://www.abet.org/special-reports/

**Appendix**

The questionnaire consists of five questions, the students are asked rate on a scale of 1-5.
1. Does the course project helped in understanding the automotive systems better?
2. Did the course project boost your knowledge in the area of Automotive Domain?
3. Are you able to apply your knowledge of Instrumentation and control in Real time Embedded Automotive applications?
4. Did the Review committee give you the right feedback to guide you for the implementation course project?
5. Did the course project help you to participate in technical events and placements?

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