Blending ICT with Project based Learning for effective teaching and learning of Mechatronics

P.S.Jadhav[1], A.M. Mulla[2], P.M. Jadhav[3]

[1,2,3] Mechanical Engg, Rajarambapu Institute of Technology, Sangli, Maharashtra
[1] prashant.jadhav@ritindia.edu; [2] abid.mulla@ritindia.edu; [3] prakash.jadhav@ritindia.edu

Abstract: India is a rapidly growing country with its huge economy. As per the Vision 2020 India has a huge demand for product, services and automation. To fulfill this requirement, more number of engineers are required to build innovative solutions. It's a known fact that engineering graduates have a strategic and long-term impact on productivity, growth in industry and service sectors [8]. To produce sophisticated industrial products and services that are competitive in the global market and to realize the 'Make in India' dream, India needs a really high number of well trained and extremely qualified engineering graduates. Unfortunately the facts look a bit dismal. Institutions like the IITs, NITs and a few other public and private technical universities are admittedly performing well but the majority of institutes are affiliated to various universities and teach the curriculum developed by the affiliating university. As a result, they lack the incentive of continuous improvement of the quality of teaching and learning and are not geared to adapt to the changing qualification needs of the job market.

P.S.Jadhav

Mechanical Engg, Rajarambapu Institute of Technology, Sangli, Maharashtra
prashant.jadhav@ritindia.edu

So, in order to bridge the quality gap in engineering education there is a need of a platform where ICT is effectively used by premier institutes of India to develop and train teachers and students of private and public sector engineering institution through a combined methodology of Project Based Learning which is completely online.

Keywords: ICT, Project Based Learning, Make in India, Vision 2020

1. Introduction:

IIT's have always tried to improve the quality of engineering education through distance learning, NPTEL videos, online courses, workshops and by providing continuous support to teachers and students of tier II & III type institutions. This had some limitations since engineering education needs hands on training/experience for theoretical aspects. When theory is combined with practical sessions or after theory when some work is assigned to students, depending on classroom teaching it gives the effective result. With this, Quality of education can be maintained and students will have a platform to think upon and showcase their capabilities. IIT Bombay team has provided the perfect solution to remove the gap of quality in education with their project- e-Yantra. e-Yantra (Engineering a better tomorrow) is a

project of Department of Computer Science and Engineering, IIT Bombay, sponsored by MHRD through National Mission on Education through ICT (NMEICT). Mission of e-Yantra is to Enable Embedded systems education in engineering colleges across India in a scalable and sustainable manner. The workflow of e-Yantra is outlined in follwing figure[1].
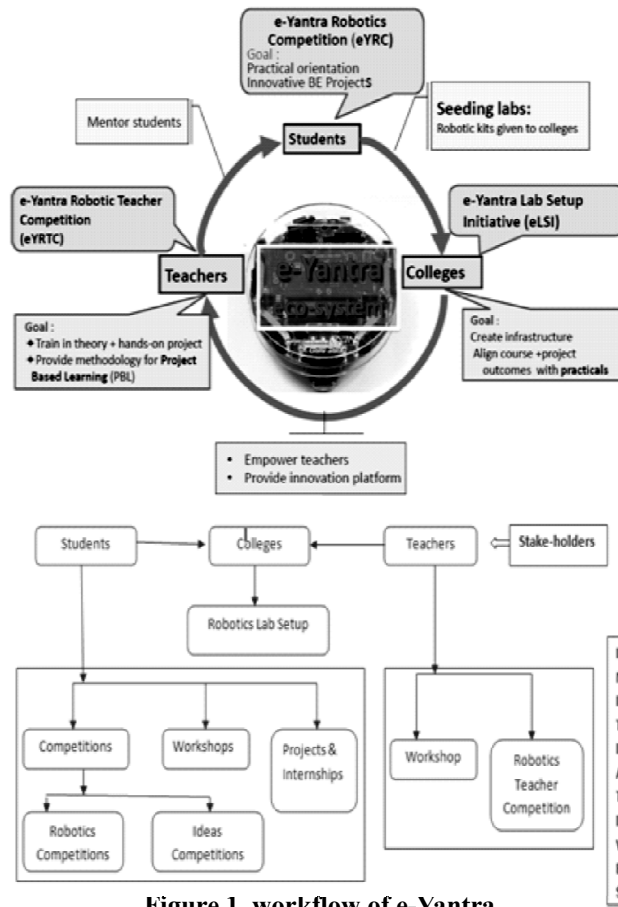

Figure 1. workflow of e-Yantra

2. Methodology:

Phase 1) e-Yantra Lab Setup Initiative (eLSI)

This phase focussed on hands on training for teachers across various regions of the country in a scalable manner through Nodal Centres (NCs) as shown in figure 2.

Needs of this phase:

a) Colleges as a nodal centre

b) e-Yantra labs in Colleges

In order to make student projects successful, it requires trained teachers and infrastructure. Two days workshops were conducted at the nodal centres to train the teachers on a platform i.e. Fire Bird educational robot and e-Yantra which helped to set up robotic labs in colleges. Along with this, a competition and symposium for teachers was also organised to make a strong bonding between e- Yantra team and teachers from different regions of the country.
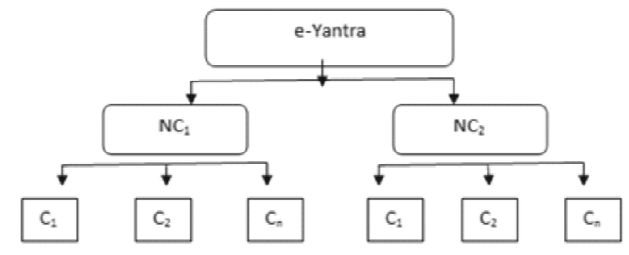

Figure 2. Nodal centre flow

This made colleges self sufficient. In the pilot phase of e-Yantra, to create awareness and to train students in the basic concepts of embedded systems and robotics, e-Yantra had conducted face-to-face two-day workshops at various venues (NC's). Team e-Yantra provided a starter robotic kit to colleges to encourage student projects in robotics and embedded systems. This turned out to be ineffective as the robots ended up locked in cabinets and students did not have access to therobots. These experiences prompted e-Yantra to look for other ways to engage with students.

Phase 2) e-Yantra Robotics Competition (eYRC)

In the e-Yantra Robotics Competition, the course material covered in face-to-face two-day workshop was converted into video tutorials. These tutorials were given to student participants in eYRC to learn concepts at their own pace. Support was provided through an on-line discussion forum where students posted their queries. All teams participating in eYRC were given a FireBird-V Robot along with accessories required to implement the solution to a problem assigned to them [7]. Students did not incur any cost to participate in the competition. The interesting part of the competition was the model and methodology used to engage with students even from the rural area of the country. Robotic competition is an effective way to impart Project Based Learning (PBL). It is considered here that there are three different models of PBL:

a) PBL through a stand-alone competition,

b) PBL through a classroom course incorporating the competition as a course project

c) PBL through an online course.

e-Yantra team has taken all the positive aspects of these three models where a competition with a step by step methodology is provided to students completely online[1].
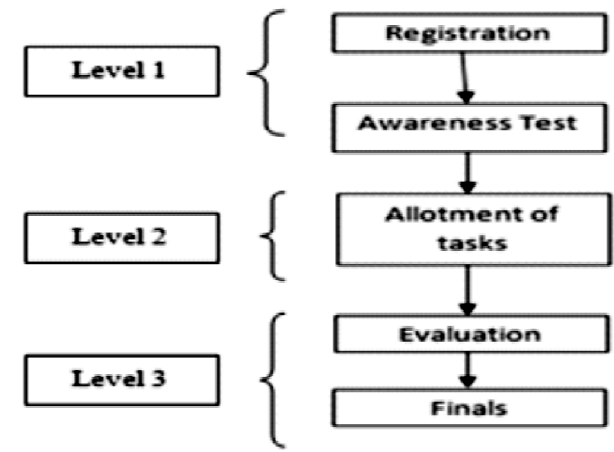
3. Levels of e-YRC:

Figure: 3. Levels of e-YRC

Level 1: At this level, students were encouraged to form a multidisciplinary team to take part in competition and register online through e-Yantra website. Plenty of students registered for the competition e-YRC 2012. the number of students registered was over 4000. Then an online test was conducted to check the basic knowledge of students in robotics and programming which is a need to participate and solve the problem allotted to them. The test conducted comprised of multiple choice questions related to basic electronics and C language for programming. Out of 4000 students, 500 were selected on the basis of online test.

Level 2: a robotic kit - a Firebird-V robot along with accessories, video tutorials, detailed hardware and software manuals, instruction sheets, and necessary software - was given to each team. e-Yantra proposed four themes: Pothole filler, Pick and placer, Line follower, and Room cleaner. One out of these four was assigned to each team. The span for competition was 3 months; during this, every team had to perform different tasks within stipulated time [1].

Different tasks are enlisted below and detailed in Table 1:

i) Task 0 : Flex Printing
ii) Task 1 : Theme Analysis
iii) Task 2 : Implementation Analysis
iv) Task 3 : Video demo
v) Task 4 : Report and Code Documentation

Table 1: Detailed Task

Allotted work	Outcomes	Support	Duties of student team
Task 0: Flex Printing	Following given Instructions	Flex-design Instructions	Printing Flex Design, Uploading an image of the flex design.
Task 1: Theme Analysis	Understanding of Concepts, Working of Robot Theme Assigned	Video Tutorials, Robotic kit with accessories, Manuals, Rule Book with the Problem Specification, Template for Theme Analysis	Critically Examining the Problem, Answering Questions Based on the Concepts Learnt
Task 2: Implementation Analysis	Design Analysis Algorithm Analysis	Template to test Design Analysis and Algorithm Analysis	Designing mechanical structure on the Robot, Placement of Sensors, Actuators, Considering different options for solving the problem, listing the pros and cons of each option, justifying selection of a particular.
Task 3: Video Demonstration	Working Prototype for the Theme Assigned, Video Shooting, Presentation Skills	Instructions	Setting up the Demonstration, Video Recording as per Specifications, Providing an introductory presentation
Task 4: Report and Code documentation	Report Writing Following Software Documentation Standards	Instructions to follow Software Engineering Principles, Template for Report	Specifying Implementation Idea, Design Constraints, Challenges faced Modular design of code

Level 3: Each task was evaluated and the total score of the team was used to select the finalists. Five teams from each theme were selected as finalists. Evaluation consists of a set of tasks designed to impart PBL, along with awareness of basic concepts in embedded systems and micro-controller programming. Several other skills that are honed through PBL were also evaluated on-line. This skill includes hardware design, algorithm design, report writing and code documentation, in addition to soft skills such as presentation skills and video recording skills. 20 finalist teams - 5 teams from each of the 4 themes - travelled to IIT Bombay to participate in the grand finals.

4. Analysis of PBL through e-YRC:

a) Total number of teams participated = 131
b) Number of teams submitted at least one task = 127 (i.e. 97% of a)
c) Number of teams submitted all the tasks = 79 (i.e. 62% of b)
d) Number of teams completed all the tasks = 41 (i.e. 52% of c)

e) Number of teams selected as finalists = 20

(i.e. 49% of d)

This event provided the Level-3 evaluation which authenticates the project implemented by the students in

(i) Design quality
(ii) Generality/optimality of the algorithm implemented
(iii) Modularity of the code written and
(iv) Validating authorship of the project.

Teams were asked to demonstrate their solution in an arena that was slightly modified to ensure the originality of the work done and generality of the algorithm used. Expert judges conducted an oral questioning during the demonstration, to evaluate the contribution from each of the team members and their understanding of the solution provided. Design aspects of the solution provided were also given due consideration.

Above statistics show, according to b, 97% of teams acquired at least basic knowledge. From c, 62% of these teams were exposed to all the tasks through the PBL mode. From d, 52% of students were trained to implement a project independently. From e, 49% of these teams not only successfully completed all the tasks but also have shown the potential to be innovators.

Table 2: Level description of task

Cognitive Level	Level Description	Task	Task Description
Knowledge	Recite a policy, Quote prices Know the safety rules, Define a term.	Task 0: Flex Printing	Registration, downloading file, printing it with give dimensions, uploading photos.
Comprehension	Understand the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words.	Task 1: Theme Analysis	Critically examining the problem. Answering questions based on the material learnt.
Application	Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place.	Task 2: Implementation Analysis	Considering different options for solving the problem, listing the pros and cons of each option, justifying selection of a particular algorithm.
Analysis	Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	Task 3: Video demo	Making a working prototype. Evaluating the prototype to make the solution more efficient.
Synthesis	Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	Task 4: Report and Code Documentation	Specifying implementation idea, design constraints, challenges faced. Coming up with a sleek design and/or an efficient algorithm.

i. No Knowledge Gained: Students who did not complete even one task. These students did not learn anything from the e-Yantra Robotics Competition.

ii. Basic Knowledge Gained: Students who submitted at least one task but could not solve the assigned problem and dropped out of the competition. These students learnt the basic concepts related to robots through video tutorials and completed the first or second task.

iii. Application of Knowledge: Students who tried to solve the assigned theme but could not complete the theme as desired. These students were able to make the robot perform part of the solution but could not integrate all modules required to solve the theme completely.

iv. Incorporated Critical Analysis: Students who successfully completed all the tasks and solved the problem as specified. These teams learnt the basic concepts and applied those to design the robot by understanding and analysing the problem statements.

v. Showcased Creativity: These students were the members of the top five teams from each theme. These students not only demonstrated a working solution but also showcased their creativity in designing an efficient [7]. Attainment of program outcomes with task involved is mapped in the following table:

Table 3: Attainment of PO with tasks.

Program Outcome*	Task	Task Description
a, d, g	Task 0: Flex Printing	Registration, forming team, downloading file, printing it with give dimensions, uploading photos.
c, d	Task 1: Theme Analysis	Critically examining the problem. Answering questions based on the material learnt.
d, e	Task 2: Implementation Analysis	Considering different options for solving the problem, listing the pros and cons of each option, justifying selection of a particular algorithm.
d, k	Task 3: Video demo	Making a working prototype. Evaluating the prototype to make the solution more efficient.
e, g	Task 4: Report and Code Documentation	Specifying implementation idea, design constraints, challenges faced. Coming up with a sleek design and/or an efficient algorithm.

*List of program outcomes for Mechanical engineering, RIT, Sakharale, taken from [12]

5. Conclusion:

e-Yantra was initiated with the aim of reducing the gap in engineering education in India. Two days face to face workshop for teachers was very effective in terms of making them self sufficient to mentor student projects with the e-LSI. eYRTC is launched soon after the workshop to train the teachers to implement a solution in the PBL mode. e-Yantra Symposium brought together colleges which have established e-Yantra labs through eLSI for discussions and seminars on how to turn these labs into innovation hubs. Then e-YRC provided students a platform to showcase their abilities and ideas. In all projects, e-Yantra used as a very effective way to reduce the gap in education

quality and opportunities offered to students. e-Yantra team has taken all the positive aspects of three models of PBL where a competition with a step by step methodology is provided to students completely on-line. eLSI adds value to teachers in preparing them to mentor students in embedded systems and robotics and also gives a path for colleges to set up an embedded systems facility along with the training to sustain it.

References:

[1] Krithivasan S., Shandilya S., Lala K., Arya K, "Massive Project Based Learning through a Competition Impact of and Insights from the e-Yantra Robotics Competition", IEEE Sixth International Conference on Technology for Education,2014

[2] Das, Anup Kumar, "Open Educational Resources (OER): Policy Perspectives and National Initiatives. In: CSIR-NISTADS", India - Science and Technology, volume 3. Delhi: Cambridge University Press India, ISBN 9789384463045, pp.16-21

[3] Prof. Kavitha T C, Dr. D Ashok, " ICT: An Enabler and a Catalyst to Nurture Service Quality in Higher Education- A Review", International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-4, Issue-2), February 2015.

[4] "Homepage of e-yantra project." [Online]. Available: http://www.e-yantra.org/ [Accessed: 14th July,2016]

[5] R. R. Murphy, "A strategy for integrating robot design competitions into courses in order to maximize learning experience and promote intellectual development," In IEEE Robotics &Automation Magazine, vol. 8, pp. 44-55, 2001.

[6] M. S. Raghav, S. Jain, and S. K. Saha, "Robotic competition based education in engineering (roc-bee)," In National Conference on Mechanism Science and Technology: from Theory to Application, Proceedings of NCMSTA'08 Conference, pp. 1-11, 13-14 November 2008.

[7] S. Krithivasan, S. Shandilya, K. Arya, K. Lala, P. Manavar, S. Patil, and S. Jain, "Learning by competing and competing by learning:experience from the e-yantra robotics competition," In IEEE Frontier In Education Conference, 2014.

[8] "Homepage of Department of Higher Education, Ministry of Human Resource Development, Government of India,AnnualReport,2013-14, [Accessed: 12th July,2016]

    http://www.mhrd.gov.in/documents_reports"

[9] J. Strobel and A. van Barneveld, "When is PBL more effective? a meta-synthesis of meta-analyses comparing PBL to conventional classrooms," Interdisciplinary Journal of Problem-based Learning, vol. 3, pp. 44-58, March 2009.

[10] E. Trudell and C. Chung, "Development of methodologies to assess the impact of autonomous robotics competitions in science, technology, engineering, and math education," In Proceedings of the International Technology, Education and Development Conference (INTED 2009), 9-11 March 2009.

[11] Godleski, E.S., "Learning Style Compatibility of Engineering Students and Faculty," Proceedings, Annual Frontiers in Education Conference, ASEE/IEEE, Philadelphia, 1984, p. 362.

[12] List of Program Educational Objectives (PEO) for Mechanical Engineering in Rajarambapu Instituteof Technology, Sakharale, Maharashtra, (India).

    Available online at http://www.ritindia.edu /images / B.Tech-Mech/peo-mech.pdf.