e-Yantra Lab Setup Initiative:

Sustainable Knowledge Creation and Scalable Infrastructure Creation at Engineering Colleges

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***Abstract*—Embedded systems and Robotics are subjects that involve multi-disciplinary approaches to problem solving with an emphasis on hands-on experiments. Due to lack of infrastructure – robotics labs to execute projects, or trained teachers to mentor projects – engineering students in India do not get the benefits of hands-on experience. e-Yantra Lab Setup Initiative is designed as a scalable and sustainable approach that addresses infrastructure creation and teacher training to create an ecosystem at colleges to impart effective engineering education. In this paper, we discuss the three-pronged approach used in eLSI to: train a team of four teachers from each college and enable setting up of a robotics lab at each college. Analysis of feedback received from 64 teachers who participated in the pilot: (i) after the two-day workshop, (ii) at the end of e-Yantra Robotics Teacher Competition, (iii) during a visit to labs post lab inaugurations, and (iv) during a symposium held a year later for sharing and showcasing projects implemented in their robotics labs - shows that eLSI is effective in sustainable knowledge creation. The model used to establish robotics labs at 35 colleges across five regions of India in the current phase proves the scalability of the model.**

***Index Terms*—e-Yantra, Embedded Systems, Robotics, Engineering education, Scalability, Sustainability, e-Yantra Lab Setup Initiative (eLSI), Project-Based Learning (PBL),Robotics Competition**

I. Introduction

One of the major challenges faced by a rapidly growing economy like India is creating innovative engineers to solve problems unique to our environment and making them industry-ready [1]. Embedded systems as a subject is interdisciplinary, increasingly popular, and has a wide range of applications, making it an ideal subject for sparking innovation and creative thinking in young students.

Engineering curricula around the country include courses on embedded systems and/or robotics in the 3rd and 4th year of engineering studies across many disciplines including computer science, electronics, information technology, mechanical engineering. However, these courses are theory-oriented and do not encourage students to conduct any hands-on experiments. Many students are interested in executing their BE projects[1] in these subjects; however they are discouraged from doing so, as colleges lack infrastructure or teachers to mentor such projects. Thus, it is important to create an ecosystem at a college that includes: (i) teachers who can mentor students interested in projects in robotics and embedded systems and (ii) robotics lab infrastructure where students can execute projects.

Teacher training can happen through one of following ways of interaction with the teachers:

1. Face-to-face interaction: In this model, teachers physically attend lectures and seminars on a given subject on effectively delivering the subject matter to students[2], [3]. For example, in [4] teachers from different educational backgrounds who are interested in robotics are invited to attend a robotics festival where they are trained and given materials to impart training to their students.

2. Interaction through online teaching resources: This model focuses on creating and making available teaching materials such as practice workbooks, manuals, videos, etc. on the internet; teachers are expected to learn the content using these resources and deliver it to their students in classrooms[5][6].

3. Interaction through online web-conferencing: This model uses live streaming of lectures delivered by experts to classrooms distributed across a geographical area. Teachers come to centers at their local areas for attending these lectures. In this model limited interactions with the experts are available through web conferencing where local coordinators moderate peer-to-peer interactions in local classrooms. [7] is an example of such a model used to train thousands of teachers across the country.

Each of these models has its own advantages and disadvantages. Face to face interaction allows the deepest level of interactions between teachers and experts. But this model is not scalable. Training through online interactions is scalable but requires teachers to be self-motivated to learn the subject. Though web-conferencing training can be scaled to train a large number of teachers, this

[1] A mandatory requirement to qualify for a Bachelor of Engineering (BE) degree is a major project done in a group of 2-3 students for a duration of one year (fourth/final year).

model is difficult to implement for subjects which require hands-on lab component as in our case. [8] suggests that before teachers take up teaching a subject, he/she should first experience it themselves. This is especially true for embedded systems and robotics as hands-on experiments with micro-controllers constitutes a major part of the course. A model that combines face-to-face interactions followed by on-line training in the form of a competition, allows eLSI to achieve the objectives of the teacher training at scale while being cost-effective.

Training teachers would only do half the job as in order to have effective knowledge transfer from teachers to students, it is necessary to have infrastructure/resources to design experiments and implement projects. Thus it is imperative to create an ecosystem of trained teachers and lab infrastructure at each college. Given that there are thousands of engineering colleges across the country, how can we create such an ecosystem in a large number of colleges in a sustainable and scalable manner?

e-Yantra Lab Setup is an initiative of the e-Yantra project - sponsored by the National Mission for Education through Information and Communication Technology (NMEICT) of the Ministry of Human Resource Development (MHRD), Government of India to promote robot enhanced education at engineering colleges. eLSI attempts to achieve sustainable knowledge creation using a three-pronged approach which is discussed in Section II. We provide a case study of this approach implemented in the Pilot Phase of eLSI in Mumbai region in Section III. Effectiveness of our approach based on the performance of the teacher teams and feedback received from 64 teachers participated in the pilot phase is discussed in Section IV. The model used to address scalable infrastructure creation is explained in Section V. We summarize our findings in the concluding Section VI.

II. A three-pronged approach: Addressing Sustainable Knowledge Creation

"Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime"
– An English proverb attributed to Anne Isabella Thackeray Ritchie (1837-1919).

Sustainable impact in improving engineering education is achieved when instead of giving a piecemeal solution to colleges, an end-to-end solution is provided. In this case, we provide such a solution by enabling infrastructure creation at the colleges and imparting training to teachers on a continuous basis through Project Based Learning (PBL) mode. The eLSI model is designed keeping in mind that a trained and empowered teacher along with the necessary infrastructure can produce many batches of students who are enthusiastic learners and innovative thinkers.

Thus, in our model we concentrate on establishing infrastructure and transferring knowledge to teachers

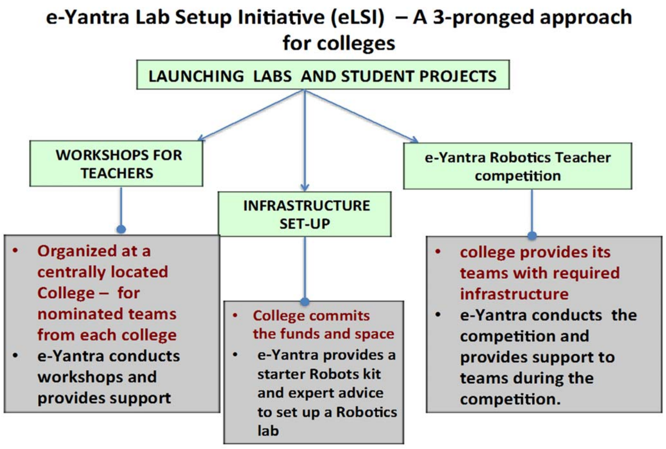

Figure 1: The three-pronged approach

simultaneously through the following steps:
1. Colleges from a region are invited to a Nodal Center (NC)[2] for participating in the initiative.
2. Colleges commit a team of teachers to be trained through a two-day workshop; this team then participates in the e-Yantra Robotics Teacher Competition (eYRTC). Each team is given a FireBird-V[3] Robot along with accessories required to implement a solution to an assigned "theme". This theme is a problem statement based on the abstraction of a real world problem, together with a rulebook for evaluating degree of success.
3. Through the competition teachers are trained in handling the robot and implementing a project over a period of 4 months - this prepares them with knowledge about a complete robotics project life cycle providing them with methodology to assign such projects to their students.
4. Colleges commit funds to procure robots and accessories to establish a robotics lab such that they have a robotics lab in place by the end of the competition. e-Yantra provides the necessary consultation.
5. Each team that successfully participates in the competition is awarded a set of robots to supplement the basic set up in their colleges.
6. At the end of the e-Yantra Robotics Teacher Competition, trained teachers are ready to educate their students and assign robotics projects to students using the equipment from their newly established robotics lab!

Figure 1, summarizes the three-pronged approach.

With reference to Figure 1, colleges invest in the infrastructure. This is a step taken considering the following:

[2]Nodal Center is a college identified as a coordinating institution for eLSI from a particular region. Responsibilities of a NC include: (i) Coordinating between the colleges and e-Yantra and (ii) Communicating details of workshops and events held at NC

[3]The FireBird series of robots was designed by the Embedded Real-Time Systems (ERTS) Lab, IIT Bombay as an educational robot for imparting hands-on project component of the embedded systems course taught in the Department of Computer Science and engineering, IIT Bombay.

1. Embedded systems and robotics lab is seen as a mandatory facility in an engineering college and gives a competitive advantage to the college. For this reason, most colleges are ready to invest, especially given that e-Yantra provides guidance, training, and initial consultation.
2. When a college invests its own money in infrastructure creation, it is likely that lab activities are seriously taken up by the faculty than when equipment is given free of cost. This is important in ensuring the sustainability of the project. The desired outcome is to have each college continue with activities on their own even after the end of the e-Yantra project.

III. eLSI-Pilot Phase

To test the three-pronged approach of eLSI and to fine-tune the processes involved, e-Yantra piloted eLSI in the Mumbai region. We explain the steps involved in our approach below:
1. **Addressing infrastructure creation with colleges:** Principals of colleges affiliated with Mumbai University (MU) were called for a meeting at Indian Institute of Technology Bombay (IITB). Twenty-one colleges expressed interest to participate and sixteen eventually completed the formalities to participate in the pilot phase of eLSI. Each of these colleges nominated a team of four teachers to be trained and committed funds (around $7500) to buy the basic set of equipment for a robotics lab.
2. **Training team of teachers:** In eLSI, teacher's training happens through the following steps of engagement: (i) a face-to-face two-day workshop familiarizing them with micro-controller programming knowledge and basic concepts in embedded systems and robotics (ii) the e-Yantra Robotics Teacher Competition (eYRTC) that imparts knowledge through hands-on project implementation, conducted completely online and (iii) finals of eYRTC where the teachers present their solutions and interact with their peers. In this event, each team makes a presentation on the challenges they faced in solving the problem and their algorithm. Figure 2, illustrates these steps. We explain the competition model and methodology used in eYRTC in the next section.
3. **Simultaneous lab inaugurations:** At the valedictory function of eYRTC Finals, all the newly established labs at the colleges are virtually inaugurated.
4. **e-Yantra Robotics Teacher Competition:** eYRTC is designed to impart PBL where all participating teams are given a FireBird-V Robot along with accessories required to implement a solution to the theme assigned to them. [9] elaborates upon several reasons for considering PBL as a successful approach for quality teacher education. While this paper is more general and applied to both formal and informal education, it is seen that projects are a welcoming and enjoyable experience for both students and teachers. An European project [10] is developing a framework for teacher education courses in

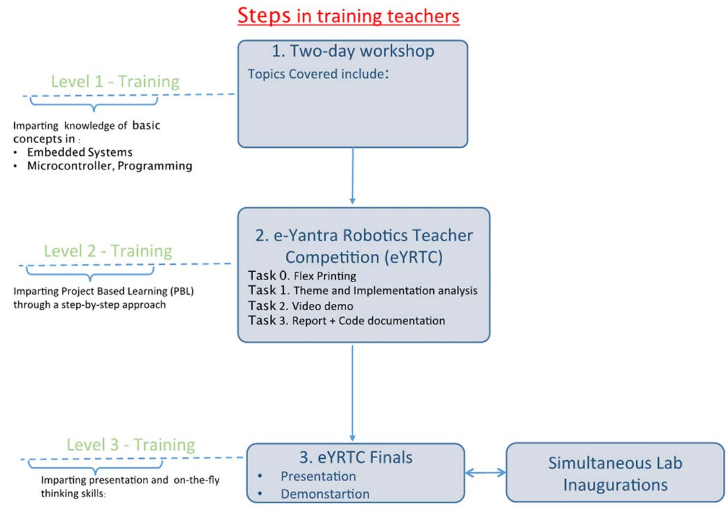

Figure 2: Steps in engagement with teacher teams

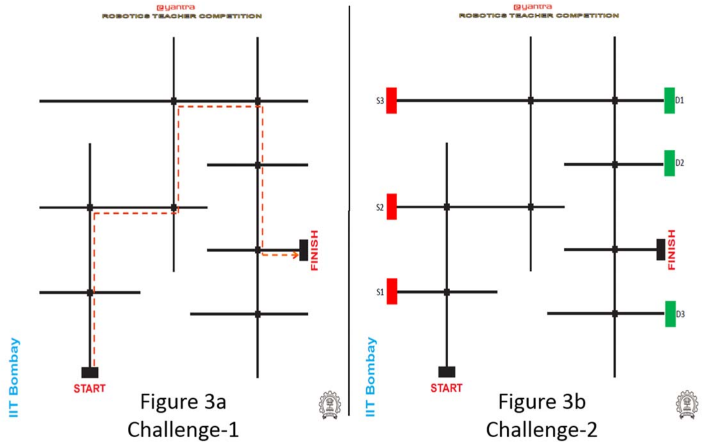

Figure 3: Theme Assigned in eYRTC

order to enable teachers to implement robotics-enhanced constructivist learning in schools.

In the pilot, the theme comprised of two challenges as shown in figure 3,
a. The problem of "Maze solver" was assigned as the first challenge, illustrated in Figure 3(a). The challenge is for the robot to start at the START point and reach the FINISH point without any human intervention. This problem requires programming the robot using a traversal algorithm – teams did not have to build any additional structure on the robot. Solving this problem was a mandatory requirement for the teacher teams to qualify for the award of robotic kits to their college and individual certificates.
b. The second challenge was designed as a bonus challenge as illustrated in Figure 3(b). In this challenge the teams had to build a gripper mechanism to move 3 blocks from source locations S1, S2, and S3 to the corresponding destination locations D1, D2, and D3 while traversing the path from START to FINISH. Teams that implemented this challenge competed for cash prizes in the finals of the

competition.

Our goal for having the first challenge as a compulsory component of the competition was to ensure that each teacher is trained such that she/he is confident to guide a student project in embedded systems and robotics; every teacher was awarded a certificate at the end of the competition. The bonus challenge was designed to encourage teachers to take the additional step of building a structure on the robot. We discuss the methodology used in the first challenge for imparting PBL below.

The first challenge consists of several tasks, which the teacher teams complete over a period of three months – the time taken by the college to procure the equipment to set up a robotics lab. Each task is a milestone in the project life cycle as illustrated in Table 1. The methodology followed is similar to the one used in the e-Yantra Robotics Competition (eYRC) [11]. For each task, a template is provided which is filled by the team members. The methodology used provides:

a. A step-by-step approach to implementing a project: teachers are given time to complete each task and are provided on-line help with any problems they faced. This instills confidence and encourages teamwork.

b. Complete know-how on guiding a student project in embedded systems and robotics: the templates given for each task can be used by the teachers in their own classes for mentoring student projects.

A total of 64 teachers, four from each of the 16 colleges, participated in eYRTC. The Finals of eYRTC were held on April 5th 2013 along with the simultaneous inauguration of sixteen labs. We provide a detailed analysis of the effectiveness of eLSI in the next section. Note that we are interested in measuring the sustained use of (i) knowledge imparted to the teachers and (ii) the robotics labs created at the colleges.

IV. Impact Analysis: Sustainable Knowledge Creation

As discussed in the introduction section, eLSI is motivated by the desire to create an eco-system at the colleges that includes:

(i) teachers who can mentor the students interested in projects in robotics and embedded systems and

(ii) robotics lab infrastructure where students can execute these projects.

Given these goals, impact of eLSI should be measured along two dimensions:

1. Effectiveness of teachers' training through:

a. *Two-day workshop*: We present our findings based on the feedback received from teachers after the workshops.

b. *e-Yantra Robotics Teacher Competition (eYRTC)*: We analyze the outcome of the two challenges posed to the teams and the feedback received at the end of the competition.

2. Effective use of lab infrastructure created at the colleges: To assess the impact of the project in terms of lab usage and student projects which measure the sustainability aspect of eLSI, we devised two activities:

a. *Visit to the colleges*: Given that the colleges inaugurated the labs in April (at the end of the first semester in 2013), we visited the colleges five months later at the end of September 2013. We collected feedback from the teachers, reviewed student projects, and provided them with an update on eLSI follow-up activities.

b. *e-Yantra Symposium (eYS)*: As a follow up activity for eLSI, we conducted the e-Yantra Symposium (eYS-2014) on April 10-11, 2014. This symposium provides a platform for eLSI colleges to share best practices, discuss research ideas and student projects in the area of embedded systems and robotics. Teacher teams from 12 of the 16 colleges participated in a panel discussion and 21 student teams from these colleges showcased their projects which were judged for awards and certificates.

We analyze effective use of the lab infrastructure based on the feedback collected from the teachers during our visits to their labs and the feedback collected from teachers and students during the e-Yantra Symposium. We discuss the impact along these dimensions below.

A. *Effectiveness of the teachers' training*

a. Two-day workshop

Teacher teams each having four members from the sixteen participating colleges attended the two-day workshop. We collected feedback from each of the team members. Each teacher filled a questionnaire having 6 questions, 3 questions pertaining to content delivery, 2 questions pertaining to the usefulness of the workshop and 1 to the duration of the workshop.[4]

In Figure 4(a) we have presented the outcome related to effectiveness of content delivery. Responses of teachers on each question about the effectiveness are presented in a bar chart and the response of each teacher (measured as the average score of a teacher across the 3 questions) is presented as a pie chart. Seventy percent of the teachers rated content delivery as very effective and rest 30% as effective. In Figure 4(b) outcome related to usefulness of the workshop is presented. Here again, we present the responses of the teachers on each question about the usefulness of the workshop in a bar chart and the response of each teacher (measured as the average score of a teacher across the 2 questions) is presented as a pie chart. Ninety percent of the teachers felt that the material covered in the workshop is very useful to them, with 7% rating it as useful. Three percent were not sure about how useful it would be.

From the feedback collected about duration of workshop, we infer that over 70% of the teachers wanted more time to practice their hands-on exercises. This

[4]Note that while we had 64 teachers from the participating eLSI teams, 6 teachers from the hosting college participated in the workshop. Thus we have a total of 70 responses to our feedback questionnaire.

Table I: Details of Tasks assigned in e-Yantra Robotics Teacher Competition

Assigned Task:	**Outcomes Imparted/Tested:**	**e-Yantra provides:**	**Responsibility of Teacher's Team**
Task 0: Flex Printing	• Following given Instructions	• Flex-design Instructions	• Printing Flex Design • Uploading an image of the flex design.
Task 1 & 2: Theme Analysis & Implementation Analysis	Understanding of • Concepts • Working of Robot • Theme Assigned • Algorithm Analysis	• Video Tutorials • Robotic kit with accessories • Manuals • Rule Book with the Problem Specification • Template for Theme Analysis and Algorithm analysis	• Critically Examining the Problem. • Answering Questions Based on the Concepts Learnt. • placement of sensors, actuators • Considering different options for solving the problem, listing the pros and cons of each option, justifying selection of a particular algorithm.
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 for reuse by providing: Comments in code, "read me" file with versions of software used and instructions for execution of code.

feedback is consistent with the eLSI model, where in order to provide time to work with the robot, eYRTC is launched soon after the workshop to train the teachers to implement a solution in the PBL mode.

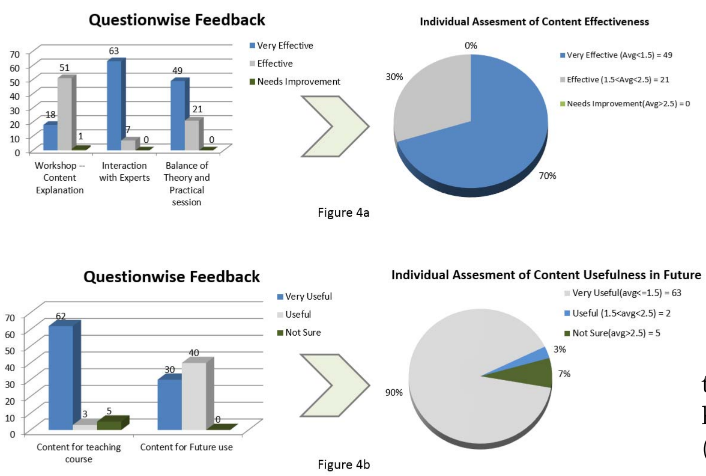

Figure 4: Impact Analysis of the two-day workshop

b. e-Yantra Robotics Teacher Competition (eYRTC)
All the 16 teams (each with 4 members) that participated in eYRTC completed the first challenge of the theme (Refer to Section III for details) assigned to them. As listed in Table 1, the first challenge 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, completely on-line through

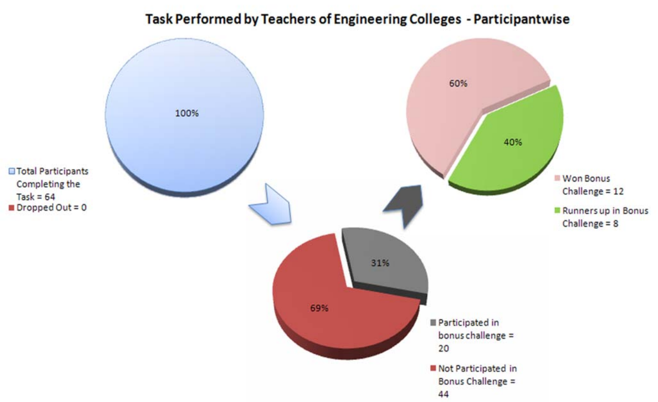

Figure 5: Participant-wise break-up of performance in the challenges

this competition. These include: (i) understanding the hardware (ii) algorithm design (iii) report writing and (iv) code documentation, in addition to soft skills such as presentation skills and video recording skills.

Five of the 16 teams worked on challenge 2, Three teams successfully implemented the gripper mechanism. These teams worked on constructing a gripper mechanism applying hardware analysis and mechanical engineering concepts. We present these statistics in Figure 5. We have given the percentage break-up as a pie chart with the actual number of participants given as legend.

From Figure 5, we find that all the 64 teachers were trained in the basics of embedded systems and robotics and all of them could program the robot. To gauge the effectiveness of the competition and to understand the attitude of teachers toward participating in a competition, we analyze the feedback received from the teacher teams at the end of the competition. Here we asked each team to list up to three points they liked the most about the competition and up to three suggestions for what can be improved. These were open-ended questions to which respondents provided answers in their own words. Four major categories emerged in the positive responses: (i) knowledge gained (ii) teamwork (iii) motivation and (iv) support from e-Yantra team. Similarly, we categorized the responses for suggestions for improvement into the following three categories: (i) workshop: time/frequency (ii) competition format and (iii) comprehensiveness. Figure 6, illustrates our findings:

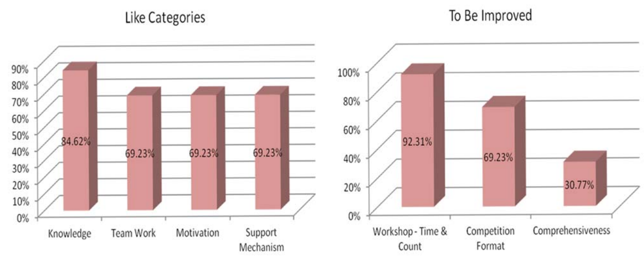

Figure 6: Impact Analysis of eYRTC

From Figure 6, we find that knowledge imparted through the competition emerges as the most liked thing with almost 85% percent stating this, while teamwork, motivation, and the support provided by the e-Yantra team are equally liked by the teams each having about 70% of the people mention it in their feedback.

In terms of things to be improved, most teams suggested having more time (3 days instead of 2 days) and/or more number of workshops. Some suggestions on the competition format include having the competition between semesters, and including students along with teachers in the competition. Suggestions to improve comprehensiveness of the competition included exposure to other micro-controllers and platforms.

B. Effective use of lab infrastructure

a. Visit to the colleges: Two senior e-Yantra members visited fourteen of the sixteen colleges that established robotics labs in their colleges to assess the impact of eLSI. The other two colleges posted their feedback online. To assess the effective use of the robotics lab, a survey of current and planned student projects in embedded systems and robotics was conducted. In fourteen colleges student projects are already in progress and the other two colleges have short-listed projects to be assigned to students in the spring 2014 semester. To understand the impact of eLSI, teachers were asked for their feedback to 3 questions − Question 1 pertains to knowledge gained through participating in eLSI training which included the workshop and competition, Questions 2 and 3 pertain to the usefulness of the eLSI training in preparing the teachers for mentoring student projects. We present our findings in Figure 7.

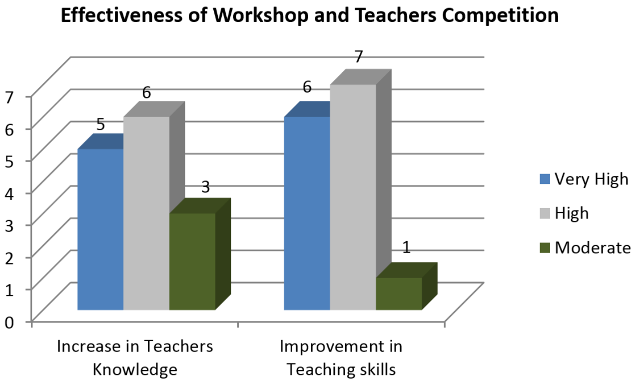

Figure 7: Post Competition Feedback

From Figure 7, we infer that over 78% of the teachers felt that knowledge gained participating in eLSI training was very high or high while 21% felt that their gain in knowledge was moderate. Note that no one had selected the options − Very little and Nothing − given in the feedback form. Similarly, over 92% felt that the training through eLSI would contribute to their better teaching skills of courses in embedded systems and robotics. Here again no one had selected the options − Very little and Nothing − indicating the usefulness of the training imparted over a period of 4 months.

b. e-Yantra Symposium (eYS-2014): Objectives of the e-Yantra Symposium are: (i) to bring together colleges which have established e-Yantra labs through eLSI for discussions and seminars on how to turn these labs into innovation hubs, (ii) to provide a platform for showcasing student/research projects that were executed in the e-Yantra labs at these colleges, and (iii) to discuss with stakeholders about e-Yantra's plans to engage with the e-Yantra family of colleges in the future. By providing a platform for the teachers from all the participating regions of the country, to meet and share ideas/best practices, we have created one more avenue to ensure sustainable use of the labs. We found that the symposium served the purpose of both facilitating peer-to-peer interactions among teachers and seeding healthy competition amongst colleges for producing good quality student projects in embedded systems and robotics. Feedback received from 20 teachers representing 16 colleges in Mumbai is presented in Figure 8. Analysis of feedback from the teachers show that eLSI has imparted effective teacher training in terms of improving teachers' knowledge and teaching skills in addition to training teachers to deploy PBL in their classrooms making them effective teachers. These results corroborate our findings from the feedback received during the lab visit discussed in Section III.

To understand the experience of students who were the first batch of students from these colleges to have used the robotics lab facility, we had collected feedback. The results of feedback received from 47 students representing 10 colleges is presented in Figure 9. Students' feedback indicate that the experience of implementing a project mentored by teachers from their colleges have helped them to learn the concepts and to appreciate the subject better.

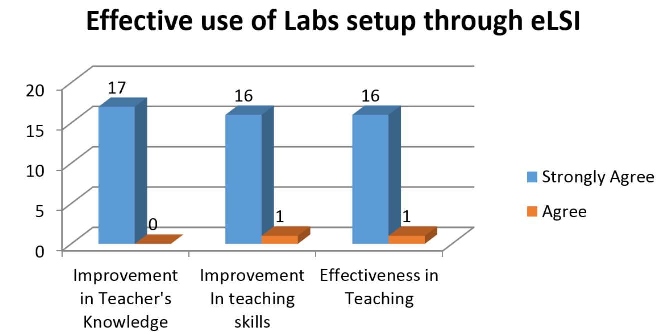

Figure 8: Post Symposium Teachers' Feedback

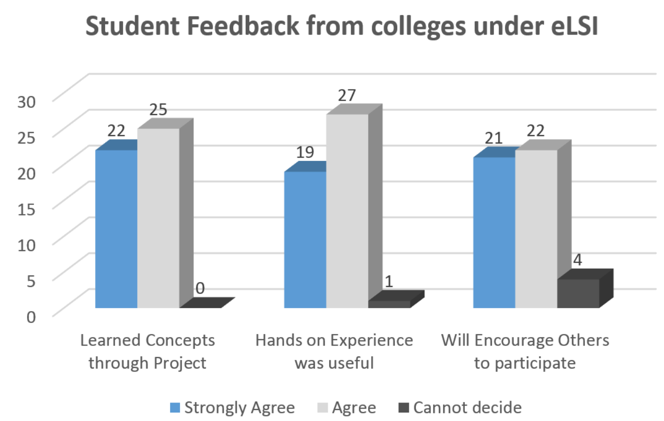

Figure 9: Post Symposium Students' Feedback

V. eLSI The Expansion Phase: Scalable Infrastructure Creation

In this section we present the model that is currently being deployed to scale up eLSI. The challenge is to quickly replicate the three-pronged approach at engineering colleges across the country. We do this through the following steps:

1. Leading engineering colleges are identified from different regions of the country.
2. These are designated as "Nodal Centers" (NCs) which coordinate and host events such as principals' meet, workshops for teacher teams, demonstrations of prototype by teacher teams and finals of eYRTC and inauguration of labs.
3. The e-Yantra team conducts workshops at each NC for teacher teams from colleges in that region.
4. The model and methodology explained in the previous sections for the eYRTC are deployed across regions and managed completely online.
5. The finals of the competitions are held at each NC and labs are inaugurated at each region simultaneously.

A schematic of the model is presented in Figure 10.

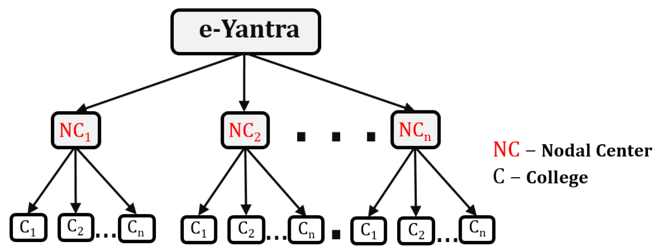

Figure 10: A scalable model

Thirty-five colleges from five regions across the country participated in eLSI in the current phase. The 35 teacher teams (160 teachers) participated in eYRTC. Finals of eYRTC and simultaneous inaugurations of the 35 labs were conducted as part of the e-Yantra Symposium (eYS-2014) on April 10-11, 2014. In eYRTC, tasks from the pilot phase, such as theme analysis, implementation analysis, etc. were used again; these templates designed for imparting PBL produced desirable outcomes demonstrating the scalability of the model. Another 25-30 colleges from various regions of the country have already expressed interest in participating in the next phase of eLSI, commencing end of May 2014.

Face-to-face interactions with the colleges and teachers happen three times during the six month period of initiation to inauguration of labs in the following manner:
1. Initiation: One or two senior members of the team address the principals of colleges from a region at a meeting organized at the prospective NC.
2. Teacher's workshop: Two-day workshop is conducted by the members of e-Yantra team, robotic kits are carried by the team and distributed to the teacher teams at the end of the workshop.
3. eYRTC Finals: e-Yantra has proposed to conduct regional finals of the eYRTC at each NC, providing a platform for teachers to present their solution and interact with their peers.
All other interactions happen through e-Yantra's discussion forums. Note that with minimal resources allocated for travelling, we utilize the project funds effectively to reach out to maximum number of colleges. Our goal is to establish labs at 500 colleges in three years. With over 50 colleges that have already established labs through eLSI and another 25-30 colleges waiting for the start of next phase, we are well poised to meet our target.

VI. Conclusion

As discussed in the introduction, project e-Yantra, addresses a major gap in engineering education in India - that of too much theory and not enough practical exposure to solve real problems. e-Yantra Lab Setup Initiative (eLSI), is motivated to create an ecosystem at engineering colleges throughout the country to initiate students in Project Based Learning. In order to do so, we have had to address two key problems:
(i) Training teachers to mentor students interested in projects in robotics and embedded systems and
(ii) Setting up of robotics lab infrastructure where students can execute these projects.

Creating a solution for a national level problem is challenging; to ensure that the solution is sustainable and scalable is even a harder challenge. The true assessment of the impact of eLSI can be (and should be) measured 4-5 years from now after the project is complete. In this paper we have presented the model and modalities used in eLSI, keeping in mind the impact to be created at these colleges in terms of sustainable knowledge creation and scalable infrastructure creation. Our model ensures sustainable knowledge creation by:
(i) training teachers both in basic concepts and micro-controller programming
(ii) encouraging them to implement a project honing their implementation skills
(iii) providing them support to conduct workshops for other teachers and students in their colleges, and
(iv) giving them contents in open-source and providing them a platform through the e-Yantra Symposium (eYS) to share their best practices.

Scalable infrastructure creation is supported by our model by:
(i) identifying and nurturing colleges who lead and mentor other colleges from the region as Nodal Centers
(ii) creating robust web based infrastructure for conducting the competition online and
(iii) providing necessary know-how to colleges for investing and creating robotics labs.

From our experience so far, we have demonstrated that eLSI adds value to teachers in preparing them to mentor students in embedded systems and robotics and gives a path for colleges to set up an embedded systems facility along with the training to sustain it. Given that with little additional manpower we have grown from 16 colleges to over 50 colleges within a year, we look forward to taking this Nation building initiative to many more colleges across the country in the next couple of years.

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