Effectiveness of "Learning by Doing" methodology in training programs - An evaluation of a teacher training program for information technology education

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Abstract— **To enhance the quality of IT education in Indian engineering colleges, we started a Teacher Training Program (TTP) in 2008. Through this TTP an effort was made to provide the faculty members hands-on experience in a myriad of skills/tools necessary to integrate technology into teaching and learning activities through the "Learning by Doing" (LBD) methodology. The focus of this paper is on the integration of these efforts into the TTP and to discuss our formative evaluation of our training process using Kirkpatrick's model. As this is an ongoing program, these results will be fed back to future training programs.**

Keywords- learning by doing, teacher training, evaluation, application based learning

I. INTRODUCTION

India produces about 500,000 engineering graduates every year. But, only about 25% of these engineering graduates are employable [1]. One reason is that engineering graduates are found to be lacking in problem solving skills and communication skills. The lack of experienced faculty in colleges is another point of great concern [2].

To enhance the quality of IT education in engineering colleges and to address the shortage of quality manpower in the IT industry, the **Certificate in Information Technology** (CIT) program was started as a joint initiative by the **Ministry of Communications and Information Technology** (MCIT), Government of India and International Institute of Information Technology, Hyderabad (IIIT-H). The goal of this program is to train 12,000 engineering graduates by 2013 [3].

A three phase process was adopted in delivering this program. First, the content was designed and developed (content development phase). Second, the faculty members from the participating engineering colleges were trained on the content (training phase). Finally, these faculty members implemented the CIT program i.e. training the students at their engineering colleges (implementation phase). In each phase, different approaches were adopted. The content was designed and developed to be amenable to being taught using the LBD methodology. A mentoring approach was employed during the training phase to train the faculty members on the content and LBD methodology. Remote mentoring and monitoring through the use of tools were employed during the implementation phase. This paper focuses on the effectiveness of using LBD methodology in the teacher training program.

II. TEACHER TRAINING PROGRAM

The LBD methodology is built on the constructionist approach and promotes a learner-oriented learning environment. It fosters skill development and the learning of factual information through hands-on implementation of the associated concepts [4]. It thus sensitizes people to the use of the knowledge rather than acquiring knowledge for its own sake. In this methodology, mentors assist the students in their course work by "providing hints and not solutions". Unlike the conventional (classroom) mode of teaching, the student to teacher ratio in this model is low (10:1), which allows for personalized mentoring and growth of the student (refer Table 1).

In this learning model, lesson/unit goals and expectations are set at the beginning, so learners understand what they are trying to achieve and the expected level of that achievement. Learners discuss multiple strategies of solving the problems with the mentor, allowing the learners to understand the various ways in which they can solve the problems that they encounter. Feedback is given by the mentors during learner interactions (through presentations and discussions) which allows the learners to revise their projects/artifacts. Also, an involvement with applications in the real world allows the learning process to take place in a more meaningful context.

While the LBD methodology is not new, we have combined it with personalization and customization in our training program, with effective results. In addition, we have explored multiple iterations of customization by including "toy problems" for each concept taught. The toy problems were designed by the mentors and were condensed versions of bigger problems. Additionally, each mentor was responsible for designing the "custom plan" for each faculty member. This "custom plan" (which was unique for each learner) included customizations like the number of toy problems to be done and the schedule for each module.

Conventional model	LBD & Mentoring model
Grading mostly done on knowledge and retention levels	Grading done on the application, analysis and the synthesis levels
Student to faculty ratio is high (usually 50:1)	Student to faculty ratio is 10:1
Students handle multiple courses simultaneously	Students work on one course at a time
Most of the learning is through lectures.	Most of the learning is through application.

Table 1. Comparison between the conventional and mentoring models

Another level of customization was done as we observed that several learners were advancing faster than their custom plans indicated. It has been observed that people who experienced customized instruction learned their information faster, showed greater improvement in their skill levels, and expressed greater satisfaction with the learning experience than those who were exposed to a learning experience without any customization [5].

These preliminary results encouraged us to extend this training methodology and thus the customization and personalization to our subsequent training programs. We later trained an additional 110 faculty members in two separate training batches and observed similar results.

In total, we trained 260 faculty members from 41 engineering colleges through 4 different teacher training programs. These trained teachers are teaching the same course content at their respective colleges to their students and using the same method that they were trained in.

III. Evaluating the Teacher Training Program

When we measure the results of learning through LBD, do we have to evaluate learning through LBD differently from traditional training methods? Horton points out that current training evaluation techniques and processes can be expanded to include learning through LBD as a method of delivery [6]. Indeed, he states that the techniques to evaluate learning through LBD are the same as evaluating other training solutions.

How do we measure the results of learning through LBD, whatever the delivery method? Using Kirkpatrick's classic model [7], any training – traditional or learning through LBD – can be evaluated at four progressive levels (refer Figure 1).

Level I: Reaction is a measure of learners' reactions to the course.

Level II: Learning is a measure of what they learned.

Level III: Transfer is a measure of changes in their behavior when they return to the job after the training program.

Level IV: Results is a measure of the business outcomes that occur because they are doing their jobs differently.

Phillips [8] recommends the addition of a fifth level to Kirkpatrick's model where appropriate. The new Level V is a measure of the Return on Investment (ROI), the cost-benefit ratio of training. In this level, the Level IV data are converted to monetary values and then compared with the cost of the training program.

While it is still early to draw solid conclusions about measuring the effectiveness of actual learning that takes place as a result of learning through LBD –we can analyze some results that we have observed and measured using Kirkpatrick's Four Levels of Evaluation.

A. Level I – Reaction

The course design and delivery for this training program was done in the LBD instructional model instead of the lecture model because this training program was more focused on combining theoretical knowledge with its application (problem-centric approach) [4][9]. Since this pedagogy is different from the conventional courses run in the participating engineering colleges, we knew we had an uphill task in the program's acceptance and implementation at the colleges.

1) How do Learners Feel?

It is not hard to find learner enthusiasm for learning through LBD. 98% of the faculty members we trained said that they were very comfortable adjusting to the learning methodology. One faculty member commented that: "Through this methodology I have learnt how to apply concepts to real world problems; something I haven't done in my 17 years of teaching experience" [10].

Reaction was measured by surveys given after the course was completed. Though in the first two weeks of training the faculty members found it difficult to adjust to the learning methodology, 98% of them comfortably adjusted to the methodology as the training progressed. Moreover, they indicated that students would easily adjust to this type of training methodology.
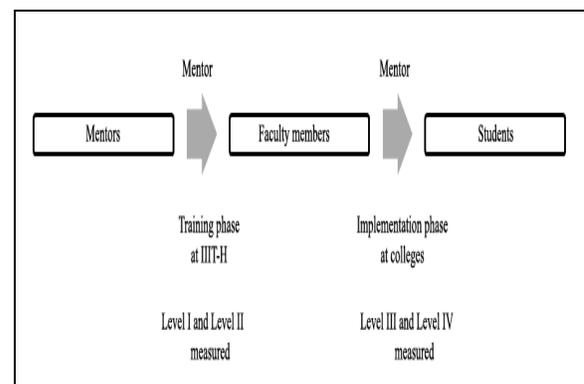

Figure 1: Phases involved and measurement levels

We gathered additional data on how faculty members feel about the use of LBD methodology to teach IT. The questions measured how the participants in the training program felt about their experience. Are they satisfied with what they learned? Do they regard the material as relevant to their work? Do they believe the material will be useful to them on the job? These questions, therefore, do not measure learning; they measure how well the learners liked the training session. Out of the 260 faculty members that we surveyed:

- 89 percent would take a similar course if offered again
- 86 percent would refer this course to their colleagues
- 92 percent said this course would benefit the student community at large

2) What do the mentors feel?

The mentors, who were customizing the experience on the go, initially observed that pure LBD was not giving the desired effects. A blended learning approach, using more than one method of delivery (e.g., LBD plus traditional classroom delivery of content, to increase training effectiveness) was employed even though it took time and effort. By having a mix of classroom lectures (20 percent) and task based learning (80 percent) the desired effects were obtained resulting in increased satisfaction levels of the faculty members and thus the mentors.

B. Level II – Learning

According to Kirkpatrick, learning is defined as the principles, facts, and techniques that are understood and absorbed by the learners. When we measure the learning, we find out how much of the skills, knowledge, or attitudes of the faculty members have changed. We have instituted a rigorous process to observe the learning from the beginning to the end by mentors observing and evaluating the faculty members' deliverables from the start. Through this model we completely track the learning process of the faculty members and observe the rate of learning and validate their competency gains.

Another way to obtain meaningful results is to design more effective assessment methods. Data from such assessments should help drive the development of solid content and advanced instructional practices. We have enhanced the LBD methodology by employing the popular pedagogical concepts of formative and summative assessment to design rubrics for learning as well as grading phases. The rubrics map the learning objectives of the module and measure them on various parameters. These rubrics benefit in that the faculty evaluating the deliverables can justify the marks given and the learner can know how he/she will be assessed. Using these rubrics, faculty can give better feedback to the learner. Most importantly, the use of rubrics provides a standardized way of reducing biased judgment and human errors while evaluation.

Moore [11] describes the three key features of a good training program as follows:

1. The preliminary specification of good learning objectives, with this crucial question at the heart: Did each student produce evidence of having learned what was required as specified in the learning objectives? If not, why not?

2. The construction and handling of assignments, which are the students' evidence of learning and an important source of feedback for the program.

3. A good data gathering and reporting system and a solid review of all of the data by both instructors and program administrators.

Research and Observations

Through strict deadlines/milestones we ensured that the learning happened in a timely manner. Personalized mentoring augmented the learning rates and task based learning, the retention rates. We observed learning outcomes in favor of LBD methodology delivered through the mentoring mode (refer Figure 2). 80% of the faculty members have expressed that they were able to relate to real world problems much better and were confident of explaining such examples in class immediately after the training program (refer Figure 3).

In another angle to the learning aspect, Jonassen [12] stressed the need to foster critical thinking and other higher order skills among students. Serrano and Alford [13] discovered that including technology across the curriculum acted as a catalyst for all learners and as a result students were empowered to engage actively and to develop higher-order critical thinking, visualization, and literacy skills.

We have faculty feedback that the application based learning has helped in improving critical thinking and other higher order skills of students though this needs to be measured.

C. Level III—Transfer

Bregman and Jacobson [14] summarize that a training program succeeds, by definition, when the training changes employees' behaviors in ways that matter to their customers. We can relate this to our case and consider our training program successful when the faculty members' behaviors change in ways that matter to their students.
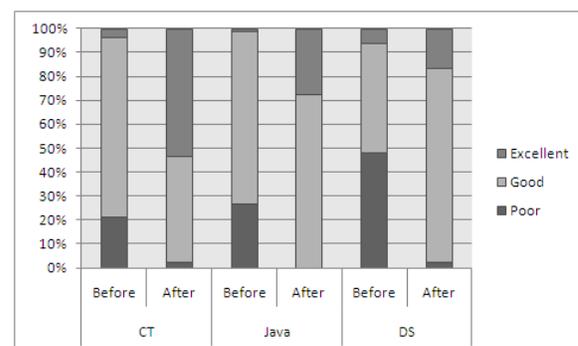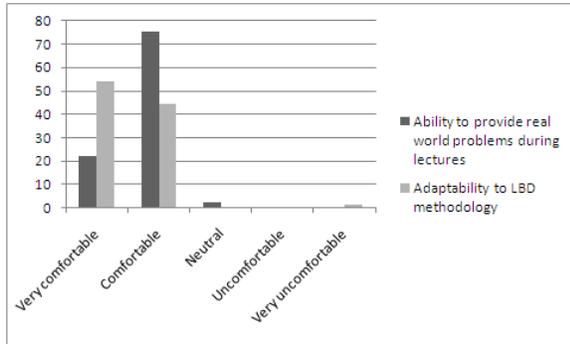

Figure 2. Faculty members competency gain

Figure 3. Comfort levels of faculty members

Once faculty members undergo training they are now ready for the implementation phase. We have a strong process to measure transfer because we are including the support of the process as part of our responsibility as trainers and content developers. To understand and assess how the transfer is taking place, we have instituted a parameter based measurement process with specific milestones. One such parameter for the college management is to "allocate appropriate workload for the faculty members". Another is to "integrate the training program as part of their academic calendar". We had come up with these parameters so as to ensure that the transfer happens. We categorize the colleges based on how well these parameters are met and assign color codes accordingly (Green, Yellow and Red). This process measurement is the "Start Green Stay Green" process [15].

We have a number of instances wherein a connection between measures of behavioral change and the hoped for consequence: solid business results (Level IV), is evident. Our partner colleges claim that our training program has produced a significant change in faculty-student relations. To quote the director of a reputed institution "All of our faculty members who have undergone the TTP have shown a remarkable improvement in their ratings from students. Some faculty members have even received upwards of 95% rating from the students".

We have conducted a study on a group of 58 students undergoing this course at one participating college. 95% of the students reported a significant gain in their programming skills (refer Figure 4). We will extend this research to the remaining students who are taking this course at different colleges and measure their learning. A good strategy for the colleges is to focus on Level III to find out what is really effective within the training programs.

D. Level IV – Results

Level IV evaluation attempts to measure the results of training as it directly affects a college's productivity– a challenging task for many reasons. Kirkpatrick noted that the number of variables and complicating factors make it difficult, if not impossible, to evaluate the direct impact of training on a business' (in our case colleges)

bottom line – and this is just as true for learning through LBD as for traditional training programs.

We can measure results by considering parameters like students placed, improved grades of students, higher satisfaction levels of students, colleges interested in sending more teacher for training programs, improved brand image of colleges, etc., We have direct data from a participating college on some of these parameters (refer figure 4).

Another participating college applied this training for students who were lagging in their course-work and have recorded an improvement in grades of the students who underwent the training.

In a different approach to prove the effectiveness of this course, we have instances of faculty members getting offers from IT companies after taking this course. Interestingly, of the 260 faculty members that we trained, 48 have been placed in IT companies. This is a direct measure of employability of those attending our training program as most of these faculty members have an average of less than one year of experience.

We have evaluated our training program at the 4 levels as described below:

• Level 1: Reaction was measured by surveys given after the course was completed

• Level 2: Learning was measured at both formative and the summative stages through tasks uploads and periodic assessments

• Level 3: Behavioral changes were measured through regular interaction through phone calls, Skype or mails, through regular visits to colleges and through periodic surveys conducted for the faculty members and students

• Level 4: Business results were measured through improvements in faculty-class interactions, and through enhanced students' employability

E. Level V – ROI

To use Phillips' ROI calculation as an added level to Kirkpatrick's model requires a lengthy and complex evaluation and calculation process. Using Level IV evaluation data, ROI is calculated by converting productivity and quality improvements to monetary values and then compare those with the cost of the training program to obtain a return on investment.
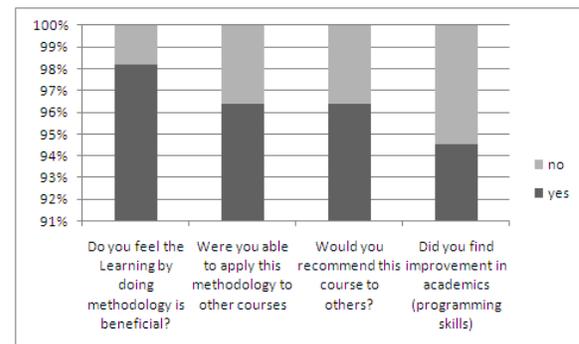

Figure 4. Student feedback on the training program

The cost of the training program to the colleges is close to zero as this cost is borne by funds from MCIT, Government of India. Thus, even if minimal monetary values are assigned to the result parameters the ROI is very high. We have instances of several colleges who have signed up to send more faculty members for the next training programs..

As the training progresses to its natural conclusion for the students at other colleges, we also expect the same results from them. Our goal is to see an increase in the number of students trained at the colleges so that the ROI is higher. Also our focus is on building different employability abilities - guiding students on hands-on projects, guiding faculty members in helping students on projects.

IV. FUTURE WORK AND RESEARCH

We are continuing to conduct further training programs for more faculty members across the country and to do detailed impact studies on how this translates to the students' learning. We will continue to further refine our evaluation methods and refine the training program based on feedback. We also plan to conduct awareness building to make LBD more understood and used throughout the country.

V. CONCLUSION

While few people debate the obvious advantages of the LBD methodology, systematic research is needed to confirm that learners are actually acquiring and using the skills that are being taught, and that LBD methodology is the best way to achieve these outcomes. We propose that the content developed in the LBD methodology and the mentoring model complement the faculty (as faculty now act as mentors and they are more refined) and are not a substitute for them. Our results demonstrate that the LBD methodology is a win-win proposition for all – the faculty members, the students, and the colleges.

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