Optimizing Teaching-Learning process using Flexible and Integrated Software tool in Engineering Education

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Abstract
The aim of this research was to optimize the teaching-learning process using the Integrated and flexible software system which was built based on the problem centered approach stated by Dr. David Merrill's First Principle of Instruction, to teach C programming language for engineering students. The software assists the teachers and students encouraging interactive learning through the pedagogical module, exercise module and feedback module during the teaching-learning process. Survey findings and post intervention assessment outcomes were used to assess the student's and teacher's perception of their goals, satisfaction, motivation, and performance. Our findings suggest that the teachers and students had high level of satisfaction in attaining their goals, and the students who undertook learning with this methodology had much higher mean performance test scores.
Keywords: Teaching-learning process, First Principle of Instruction, interactive learning, motivation.

1. Introduction

Most of the Teachers in engineering colleges in India and many other countries are not properly trained to become effective instructors. Many of them never receive formal training in how students learn, what difficulties they encounter in learning, how to address student learning problems or even how to present material effectively to students. Teaching is broadly conceived as the dissemination of content knowledge to students. They use their personal learning experiences as the basis for selecting teaching methods, addressing only one learning style, mostly the preferred learning style of the teacher.

Teacher should seek to affect learning not simply by presenting information for student absorption, but rather by working as guide, motivator and participant with the students. It is important that students are aware of this. It works for the professors as a real class demonstration of the idea that "teaching is figuring out what students know and then helping them make connections between new information and prior knowledge" (Cross and Steadman, 1996). Class should develop a student's critical reading and thinking skills. While students can achieve content mastery through lectures and reading assignments, knowledge that is constructed by teacher and student through cooperative efforts, such as discussion groups and debate, is more likely to promote analytical skills. According to Bloom's Taxonomy teacher and student must have the shared goal of exploring material to enhance critical thinking (analytical skills). Improvement in organized writing indicates how well these skills are acquired. Students should have the ability to take in data (read), compare and contrast information in order to break into components (analyze), reorganize the components (synthesize), in order to express a new or individualized idea (formulate a thesis). They should then be able to compare and contrast various theses in order to find the best/most useful one (evaluation and application). When students master these skills they become effective learners in any field.

To match teaching style with learning style it is essential to know how college students learn. Though Bloom taxonomy is a useful tool, it is an outline not a detailed plan for the college classroom. Anthony Grasha's integrated model of teaching and learning (Grasha 1996), which was developed under the influence of William Perry (Perry, 1970). Grasha and Perry are more immediately useful tools than Bloom, because they are more adaptable and focus upon the learning of college level students in clear and practical terms.

Perry views the central experience of a college education as the student encounter with the multiplicity of ideas and opinions that constitute the body of knowledge. Perry empirically documents the process and demonstrates how the instructor can expect to encounter actual student learning. Understanding the cognitive skills of students is Perry's first principle in elevating them to a higher functioning level.

Students must be approached at their own levels. For example, Perry's college freshmen are in the discovery stage where each theory or its variance is a separate entity. It is the unequal value of each idea that differentiates between the bits of knowledge. Perry referred to this pitting of one idea against another as dualistic thinking, which seeks to discover the right answer (Culver and Hackos, 1982). Multiple choice questions or fill-in-the-blank answers satisfy students at this level.

Perry's second stage of student learning is multiplism. Students encounter a great deal of uncertainty at this phase. The normally attentive college student encounters multiple answers for every question, which tests previous notions about the certainty of knowledge and threatens long-standing beliefs. As a result, puzzled by the apparent lack of standards, students either see all ideas as equally valid or equally biased, becoming suspicious of the truth of any evidence or authority. Perry found that this could cause students to avoid a thorough consideration of alternative views and to develop opinions largely on the basis of whim or personal belief (Culver and Hackos, 1982).

Students can remain at the dualistic and multiplistic stages and survive in college by reading class material and by listening to lectures. But application skills are made possible only when students progress beyond the mere marshalling of facts to the third stage of learning, relativism. At the relativistic stage, the student perceives that all knowledge and value are relative and contextual, and he/she must differentiate between concepts by using the evidence of what, when and how. Teachers must know it means to guide their students to this stage.

Perry noted that students do not advance through the dualistic to the multiplistic to the relativistic stages and achieve a real synthesis of knowledge until they can make a commitment to an idea or value that affirms their own identity. Commitment entails the realization that all ideas and dreams are fallible, changeable and eventually in need of reevaluation. In the end, a true commitment to knowledge results in the realization that all opinions and value may change. Furthermore, Perry clearly articulates, unlike Bloom, that knowing is an intimate engagement not a detached encounter. The well-prepared teacher must realize the intimacy of the teaching/learning experience and the fostering commitment in students entails changing student behavior. Another point of consideration is the importance of a strong theoretical knowledge of what learning is and how it manifests itself. Barbara Millis and Philip Cottell define learning as: "…an active, constructive process that…'provides opportunities for students to **talk** and **listen**, **read**, **write**, and **reflect** as they approach course content through exercises which require students to **apply** what they are learning' (Millis and Cottell, 1998)."

If students only master content, they have attained only the most rudimentary stage of learning, so teachers should learn to motivate students to improve their content acquisition, transforming the students from passive receptors of knowledge to active participants in the learning process. The key word is **active**. Learning that is active focuses on involving the students more directly in the learning process. It moves away from an emphasis upon the content to a focus upon developing student's skills to encounter the material. It shifts the responsibility for learning to the students and away from the teacher. The process can only be successful by modifying the preconception that the benefits of a college course accrue only within the walls of the classroom. Students must be made responsible for their learning at all times by making students accountable. Accountability is the vehicle that moves students to work to change their behavior outside of class, saving time for in class activities, which lead them to become more effective learners.

Larry K. Michaelsen, Arletta Bauman Knight and L. Dee Fink in their book, Team-Based Learning: A Transformative Use of Small Groups: 1. groups must be properly formed and managed; 2. students must be made accountable for their individual and group work; 3. group assignments must promote both learning and team development; 4. students must have frequent and timely performance feedback (Michaelsen, Knight, and Fink,2002) Michaelsen's team-based methods modify student behavior by employing a technique called the Readiness Assurance Process. The Readiness Assurance Process initiates student accountability by informing students in the very first moments of a class about the objectives and the organizational framework that is being used to achieve class goals. This information empowers students to adapt their personal learning strategies to the class plan, reinforcing the idea of personal responsibility for the work at hand. In a typical college course, extra-class readings are a part of the class plan. With the Readiness Assurance Process students are tested on the concepts introduced by the readings at the start of each new class segment or lesson. Individual students initially take a test (Michaelsen recommends multiple choice tests) on the assigned readings followed immediately by the team attempting the same test as a group. The theory is to add to the accountability students normally have to the instructor in their personal work by making each student responsible to the other members of the team as well. Students are also given formal opportunities to evaluate team members. The principle is that peers are more aware of the efforts of their fellow students and that social pressure is a significant and more pervasive motivating force for students than the threat of the professor's grade alone. The lesson learned from the Readiness Assurance Process is that strict accountability standards and peer review are powerful methods to modify stubborn student's behaviors. Frequent and timely feedback reinforces student responsibility and promotes effective learning. All assignments, such as essays or exams or the Readiness Assessment Tests, must be structured in a fashion compatible with student intellectual levels and student learning styles (Michaelsen, Knight and Fink, 2002). They must include clear instructions on how students are to perform. Recall the discussion regarding student assessment above. Again, this applies to whatever teaching style the instructor uses. A second type of reinforcement is the creation in students of the expectation that their accountability is constant, that their learning will progress when they are prepared to progress, and that they will be held accountable in every class. Team based learning works well in this regard because it requires the students to produce a measurable product for every activity, and the team format can be monitored at every stage.

According to Dr. M. David Merrill's First Principles of Instruction. a) Learning is promoted when learners are engaged in solving real world problems. b) Learning is promoted when existing knowledge is activated as a foundation for new knowledge. c) Learning is promoted when new knowledge is demonstrated to the learner. d) Learning is promoted when new knowledge is applied by the learner. e) Learning is promoted when new knowledge is integrated into the learner's world.

2. Implementation

The effective learning tool with the above described characteristics is being implemented using the Knowledge based systems; an integrated and flexible concept processing system is developed. The contents of the course and the number of sessions will be prescribed by the University, and accordingly the lesson-plan will be designed by the instructor by taking into considerations of all the recommendations done based on the work of the Educational psychologists and the academicians, (Dr. David Merrill's First Principle of Instruction) which is then approved by the authorities of the institution, the knowledge based system helps the instructor in designing the lesson plan, pedagogy materials, course objectives, monitors the process of teaching- learning. The effort of building such a system is being done taking due care that the teachers and the students will have a smooth sail throughout the process with more interest without any extra work in achieving their goals in using this system.

Studies have shown benefits in the temporal association of visual and verbal information, where presenting visual and verbal sources at the same time leads to better learning than presenting them at different times (Mayer & Anderson, 1992; Mayer, Moreno, Boire, & Vagge, 1999). Benefits have also been found for spatial association, where learning is supported by placing visual and verbal materials in close physical proximity or integrating them into a single, combined representation (Hegarty & Just, 1993 Moreno & Mayer, 1999). One proposed rationale for these benefits is that temporal/spatial coordination reduces cognitive load demands associated with working memory maintenance and visual search (Mayer, 2001). The reduction in cognitive effort needed to find and maintain multiple sources of information allows students to engage in deeper processing. Visual-Verbal knowledge Integration (Multimedia) class sessions compared to the 19th century methodology of black-board classroom sessions have critical and powerful effects on learning.

The software aids in building an effective learning tool for both the teachers and students in accomplishing their goals, it facilitates the on-going sessions to all the students enrolled, it monitors the students session, It interacts with the students during session exercises individually/group, If a particular student fails in answering the question, instead of giving an immediate feedback on errors uses the model of desired performance. The model of desired performance refers to the behaviours or performance we desire students to achieve. In cognitive Tutors the model of desired performance is implemented as a set of production rules representing target skills in a specific domain. The model of desired performance plays a diagnostic role in intelligent tutor systems. When student behaviour is consistent with the model of desired performance, the system does not intervene. However, if student behaviour is inconsistent with the model of desired performance, the system intervenes with feedback so as to guide students toward performance that is consistent with the model. Currently, feedback in Cognitive Tutors is based on what is broadly referred to as an expert model. An expert model feedback is structured so as to lead students toward expert-like performance. The tutor intervenes as soon as students deviate from a solution path. An alternative model that could serve as the basis for feedback is the assumption that someone with general skills facing a novel problem is still likely to make errors. Recognizing this possibility, the software incorporates error detection and error correction activities as part of the task. Feedback based on such a model would support the student in both the generative and evaluative aspects of a skill, while preventing unproductive floundering, goes a step further by providing the necessary contents, definitions, explanations so that the student understands all the related concepts and then helps the students in correcting their mistakes. It evaluates the students, monitors, motivates, encourages, reminds, if necessary for the stubborn students warns about the negative consequences of not attaining the long term goals which was agreed upon before/during the registration of the course. It provides feedbacks, maintains the results database of each session, it does the result analysis session-by-session helping in continuous evaluation.

A knowledge-based system is a computer system that is programmed to imitate human problem-solving by means of artificial intelligence and reference to a database of knowledge on a particular subject. To be more specific, knowledge based system also called as expert systems are generally conceptualized as depicted in

Figure 1.

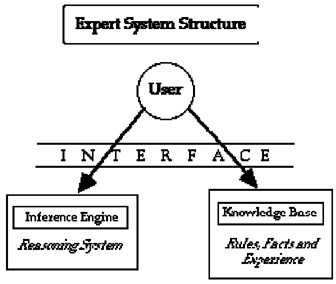

Figure 1: Knowledge based System

The user makes a consultation through the interface system (the communication hardware and also the software which defines the types of queries and formal language to be used) and the system questions the user through this same interface in order to obtain the essential information upon which a judgment is to be made. Behind this interface are two other sub-systems: - the knowledge base, made up of all the domain-specific knowledge that human experts use when solving that category of problems and - the inference engine, or system that performs the necessary reasoning and uses knowledge from the knowledge base in order to come to a decision with respect to the problem posed. The knowledge based system here interacts with the management, Higher Officials, Supervisors, Teachers, Agents in fulfilling the vision and mission of the institution, and in attaining the desired goal of providing an efficient teaching-learning environment.- the knowledge base of the system. The adaptive rule-based procedures or modules guides the teachers in preparing the course content, Identify key concepts, terms, and skills to be taught and learned based on the recommendations done by the Educational psychologists as mentioned earlier in making the teaching learning process more effective.

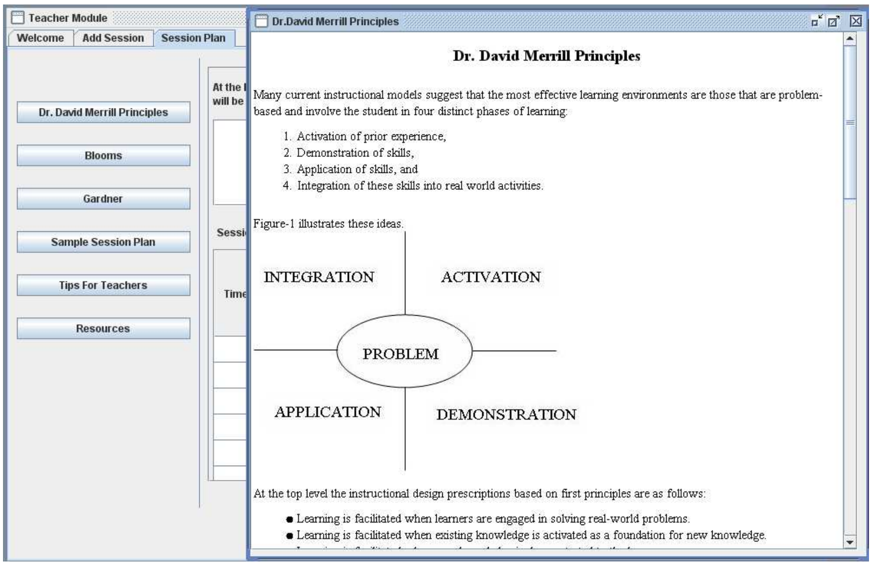

Figure 2: Assists the teacher while preparing the course content.

The teachers before and after preparing for each session will fulfill the criteria's by answering the queries such as: i) the course goal clearly mentioned to the teachers and the students. ii) Role of the teachers and students clearly mentioned. iii) Whether graphical representations (e.g. Graphs, figures) that illustrate key process and procedures used sufficiently where ever required. iv) Whenever possible, present the verbal description in an audio format rather than as written text. Whether the integration of audio and video pedagogy prepared which helps in understanding the subject more deeply. v) Whether pre-questions are prepared before the introduction of the new topic for knowing the readiness assessment test of the students. vi) Whether quizzes, multiple choice questions, exercises are prepared for each session and evaluated. vi) Encourage students to "think aloud" in speaking or writing their explanations as they study. vii) Encourage teachers to ask deep questions when teaching, and provide students with opportunities to answer deep questions to stimulate thought. viii) Feed backs at every stage are being monitored and corrective measures being taken at every stage by providing corrective feedback to the students and the teachers. – the inference engine of the system. The result analysis is done with respect to the pre-mentioned goals at every stage and recommends the management for external motivation and corrective measures of each teacher and students of the institution. The results can be compared with other conventional teaching methodologies being used and analyzed of the effectiveness of the learning tool.

3. Procedure and Discussion

As a case study, we chose C programming subject, which is a common subject for all Engineering students irrespective of which department the student belongs to (Students from Computer Science & Engineering, Information Science & Engineering, Electronics & Communication, Electrical & Electronics, Telecommunication Engineering, Mechanical Engineering, Civil Engineering were selected). Set of 60 students were taken in Experimental group and 60 students in Control group were chosen from the same Engineering stream, so as both the groups were divided only on the basis of their role numbers. The Teachers in the Experimental group used the software which aided them in preparing their lesson plan, and to construct each and every session based on Dr. David Merrill's First principle of Instruction, After each session, the students attended the assignment/exercises which was posted by the teacher which was then monitored and supervised by the software on behalf of the teacher guiding the students in completing their assignment. The students were reminded about their assignments by sending messages to their mobile phones which were registered at the beginning of the course by the software on behalf of the teacher, so that the students would feel that, teacher is monitoring and supervising their assignments online. The survey assessment showed that the 92% of students from the experimental group felt motivated and continued in doing their end-of-session exercises more regularly compared to only 37% of the students from the control group did their end-of-sessions regularly because students felt lack of supervision and motivation.

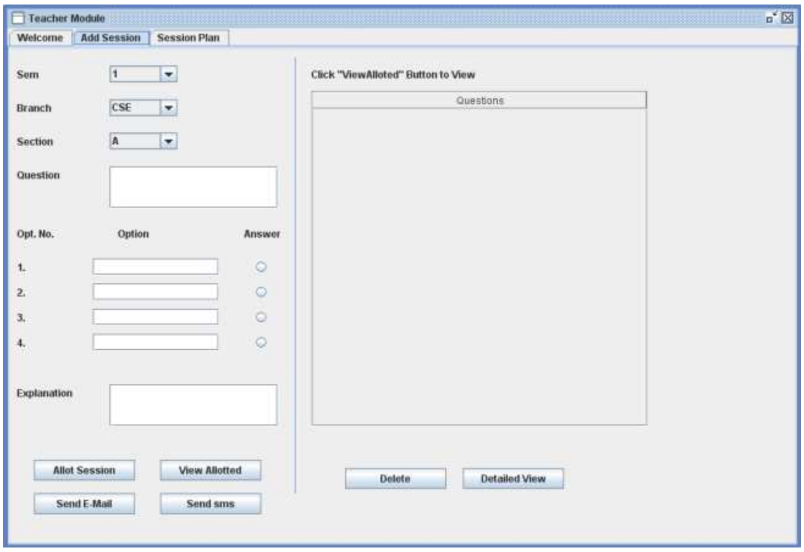

Figure 3: Assist both teachers and students in end-of-session exercises.

As every programs explained were demonstrated, compiled and executed in the experimental group, the students were able to understand much better unlike the black board teaching done in the control group. The students in the experimental group were able to develop and execute most of the programs assigned in the laboratories compared to the students in the control group, their motivation level while applying their knowledge to the problems assigned were also higher among the students in the experimental group.

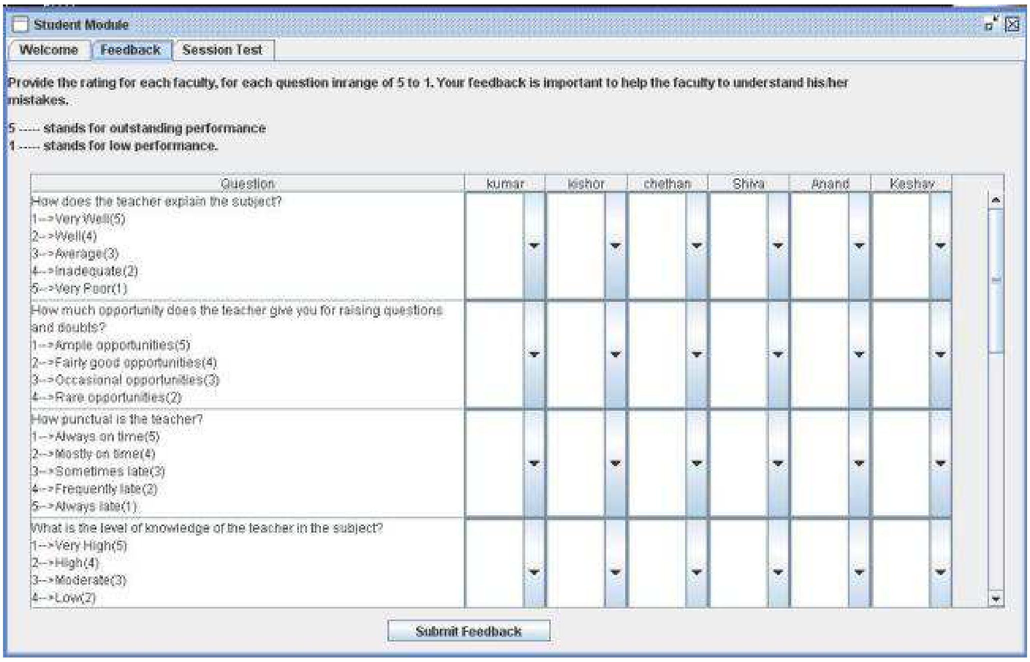

Fig 4. Assist in conducting and generating detailed report of the student's feedback.

The result analysis is done with respect to the pre-mentioned goals at every stage and recommends the management for external motivation and corrective measures of each teacher and students of the institution. The results can be compared with other conventional teaching methodologies being used and analyzed of the effectiveness of the learning tool.

Survey was conducted for both the teachers and the students with both the groups to explore the satisfaction, motivation, and learning orientation on a five point scale from strongly disagree to strongly agree, (from one to five), for item scoring. By the survey at the end of the session and throughout, the teachers following this integrated approach using this software scored very well compared to their counterparts who followed the conventional way of teaching.

Common test papers were given for both the groups set by a teacher (domain expert) not belonging to any of these experimental or Control group and the identity of the students were withheld to avoid bias while valuating the scripts. All the test scores were for Maximum of 25 marks.

Student's *t*-Test: Results

Group A (Experimental Group): Number of students= 57

16.0 16.0 17.0 17.0 17.0 17.0 17.0 18.0 18.0 18.0 19.0 19.0 19.0 19.0 20.0 20.0 20.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 22.0 22.0 22.0 22.0 22.0 23.0 23.0 23.0 23.0 23.0 23.0 23.0 23.0 23.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 24.0 25.0 25.0 25.0 25.0 25.0 25.0

Mean = 21.6

95% confidence interval for Mean: 20.66 thru 22.61

Standard Deviation = 2.70

Hi = 25.0 Low = 16.0

Median = 22.0

Average Absolute Deviation from Median = 2.23

Group B (Control Group): Number of students= 53

7.00 7.00 9.00 9.00 10.0 11.0 11.0 11.0 11.0 12.0 12.0 12.0 12.0 12.0 13.0 13.0 14.0 14.0 14.0 15.0 15.0 16.0 16.0 16.0 16.0 16.0 16.0 17.0 17.0 17.0 17.0 17.0 18.0 18.0 18.0 19.0 20.0 20.0 20.0 20.0 20.0 21.0 21.0 21.0 21.0 21.0 21.0 23.0 23.0 23.0 23.0 24.0 24.0

Mean = 16.3

95% confidence interval for Mean: 15.29 thru 17.31

Standard Deviation = 4.56

Hi = 24.0 Low = 7.00

Median = 16.0

Average Absolute Deviation from Median = 3.77

The results of an unpaired t-test performed showed
t= 7.52
sdev= 3.71
degrees of freedom =108
The probability of this result, assuming the null hypothesis, is less than .0001The probability of this result, assuming the null hypothesis, is less than .0001 by conventional criteria, this difference is considered to be extremely statistically significant.(These results done internally was mentioned in the previous paper Brahmananda S.H., Dr. V. Cyril Raj / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 1,Jan-Feb 2012, pp.1065-1070).
At the end of the semester, the student's performances at the university examination by both the groups are as mentioned below:
Group A (Experimental Group): Number of students= 60
69,38,50,52,40,47,51,67,40,49,35,50,48,75,55,80,51,50,64,53,45,52,68,47,64,35,48,50,60,54,63,49,74,35,58,62,67,39,81,47,49,70,75,71,78,71,45,66,56,49,65,63,57,53,49,70,48,58,70,49
Group B (Control Group): Number of students=60
56,29,55,56,35,13,52,54,63,85,35,38,48,41,19,63,47,57,44,20,25,46,48,70,60,56,49,44,54,42,40,28,58,55,61,35,49,71,69,35,52,43,54,46,36,19,38,22,40,44,12,23,41,23,51,10,20,29,56,18
Unpaired t test results
P value and statistical significance:
The two-tailed P value is less than 0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 13.20
95% confidence interval of this difference: From 8.01 to 18.39
Intermediate values used in calculations:
t = 5.0377
df = 118
standard error of difference = 2.620

Group	Group One	Group Two
Mean	56.23	43.03
SD	11.97	16.39
SEM	1.55	2.12
N	60	60

4. Conclusion

Our work showed that both Teachers and Students were highly motivated and encouraged while using this integrated and flexible software system which consistently held them in following the agreed upon goals throughout the course unlike where after going through a workshop or seminars the teachers motivation gets drained off slowly. This is of significance to engineering educators which helps in taking the students from passive receptors of knowledge to active participants in the learning process without much burden on the teachers, though this approach showed significant results in both motivation and remarkable performance of the students in programming subjects. This approach is to be extended for other engineering subjects also and investigated for more conclusive results.

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