Digital Device based Active Learning Approach using Virtual Community Classroom during the COVID-19 Pandemic

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Abstract

In India, traditional learning approaches in universities follow passive learning and instruction-based studies. The demand of evidence-based instructional and interactive active learning process increases with advancement in technology. To improve the quality of teaching and student performance, Laureate International University (LIU) network has taken a unique initiative by applying an iterative and evidence-based active learning process in small groups at University of Petroleum and Energy Studies, Dehradun for PGCAP program. In this work, active learning processes with digital devices (mobile devices) and digital technologies (modelling tools, simulation, and online-resources), having virtual small-to-medium strength classrooms are integrated in various scenarios with different levels of education. This has been found to be useful in improving student's performance during COVID-19 pandemic. The proposed process applies both traditional and active learning processes with the provision to use mobile devices for digital content. This process also involves teachers attending a Bootcamp, over a two-month period, consisting of four modules in which they learn about and use digital content that will then be applied in their courses. Results show that the active learning process is of great benefit to students over traditional learning, and it provides a 30% improvement in student's grades. Further, it is observed that the long-term learning average marks increase by 66.9% in two engineering subjects. The simulation-based experimentations are conducted to engage students and faculty members in active learning, and simulation learning processes. It shows that the proposed approach (active learning) improves students' learning abilities as compared to the traditional approach.

Keywords: Active Learning, Mobile Device, Digital Content, Performance Analysis, Student Community, COVID-19, PGCAP

1. Introduction

Active learning in small groups with digital devices expands the ways of teaching and learning in a virtual classroom and across multiple campuses. Further, it overcomes many learning barriers such as distances and uncontrollable situations such as the COVID-19 pandemic in recent times. According to Prince [1], active learning is an organizational dependent process with instructional methods to engage learners, improve learners' performance and perform a set of meaningful learning activities followed by their regular and continuous assessment and evaluation. In many scenarios, active learning is considered similar to engaged learning [1]-[4]. For example, when active learning involves creativity, intercultural collaboration, awareness of social responsibilities, ethical explanation, group formation, and teamwork assignments, and ability to innovate new ideas and products it is well known as engaged learning. In this form of active learning, students develop themselves and they are the stakeholders in the overall learning cycle. In other words, students are engaged in learning and create motivations or learning for others. The students' motivation to learn has been measured with their attendance in activities, outcomes or interactions. The major aims for any active learning with mobile devices are as follows [1]:

- Student engagement is the prime concern for any active learning process. In today's' digital world, students are actively using mobile devices in their learning. Thus, active learning with mobile applications encourages students to record the lectures and learn through digital content as and when interested.
- Student collaboration should be given preference to enable peer learning and support and to enhance the social side of learning online. Mobile applications are giving such quick collaborative solutions. They can have solutions available not just from within students' friend circle but from an anonymous mobile application user as well with or without disclosing their identities.
- Students should hold discussions, actively participate in debates, and conduct informal meetings for self-learning. Mobile devices are an add-on platform to encourage such debates and conduct formal or informal talks outside of other online delivery.

- Students should avoid unnecessary and long searches over the Internet for finding material; rather they should be enabled to make quick searches to find content that supports their arguments. This saves students time for open-book/notes assignments and discourages them from seeing answers in closed-book/notes exams. Domain-specific mobile applications provide them with quick solutions having efficient searches across the Internet in open-book/notes activities.
- The instructor should authenticate all concepts or material and this interaction should be active, timely, and preferably in team exercises. Government-approved study based mobile applications provides pre-authenticated (from renowned professors or government's education governing body such as the National Education Board) study material and digital content [5]-[7]. Thus, mobile devices are very useful in the active learning process.

The active learning process in University of Petroleum and Energy Studies (UPES), Dehradun, India concentrated on all the above-discussed objectives in performing an experimental study. This work started with recording student's classroom activities (attendance, performance in exams and/or internal evaluations and interactions with teachers) and their performance in classroom-based teacher-student Face-to-Face (F2F) and traditional learning. In the Uttrakhand state of India, Laureate Group introduces the Hybrid Blended based course learning in UPES. With this online learning process, active learning was introduced to certain courses as an experimental study. UPES constituted an international level council for reviewing and approving the courses. In a new certification program for faculty members, this council introduced a Bootcamp named Post Graduate Certificate in Academic Practice (PGCAP). The council give lectures to improve the quality of content in various courses regularly. PGCAP is kept as a pre-requisite activity for every registered teacher before starting active learning experimentation over students. In Mentor-Mentee PGCAP Bootcamp for faculty members, applications were collected through an open call before it began. Bootcamp is held annually (started from Jan 2019 onwards) and the performance of Bootcamp attendees is evaluated after each Bootcamp. Here, the mentee is a faculty member applying for training and a mentor is another faculty member that trains the mentees. The criteria for Mentee applying to this program include (i) a minimum of six months' experience at UPES, (ii) preference is given to candidates pursuing a higher degree, and (iii) having strong interest to make a career in academics. The criteria for selecting the Mentor include (i) A doctorate degree with a total teaching and/or industry experience of 20+ years, (ii) experience with middle to senior management, and (iii) a strong research profile. After Bootcamp, the Mentees' performance is evaluated in a simulated classroom experience with actual students. A comparative study of active learning implementation in different scenarios is conducted. Further, this comparative study includes comparisons of traditional and active learning approaches. The main contributions of this research work are:

- To design an iterative active learning process for continuous teaching and learning framework. In this iterative active-learning process, students are encouraged to maximize the use of digital devices (like mobile phones) and technologies (simulation, modelling, and learning management tools) and training is given to faculty members (in PGCAP program) to improve student performance.
- To design a contiguous student interactive learning strategy in a classroom and implement in actual engineering courses for improving student performance and their participation in real or virtual community classes through mobile devices. Students who adopt and develop an active instructional active learning should obtain higher qualitative and quantitative levels of academic performance as compared to those who adopt and develop a traditional methodology without mobile devices.
- To evaluate and observe the proposed active learning process in real-time class scenarios and simulate the learning for large classroom and long term evaluations.
- To increase the student's physical activities (working problems out alone and/or with other students, and taking lead in solving challenges) and active class participation through regular interactive subject events or digital mobile devices. Students should be satisfied with their performance and the methodology as compared to students who adopt the traditional methodology.
- To reduce students' preparation time for the exam without reducing their academic performance as compared to those students who adopt and develop a traditional methodology. To achieve this objective, the value of mobile devices in learning is explored.
- To develop a student habit of long-term iterative self and instructional learning from their theoretical and practical experiences compared to those students who adopt and develop a traditional strategy.
- To implement and simulate the proposed approach in small to large scale virtual community classes with small teacher-student group interactions (with and without mobile devices) and analyse the impact of active learning by varying the stimulation parameters and other digital contents.

This work aims to integrate iterative and evidence-based active learning practice through digital technology and mobile devices in Computer Science Engineering and Information Technology courses to improve student participation and performance. It is observed that traditional learning practices are monotonous in face-to-face Indian university class scenarios. With an average of 60 to 120 students in one classroom with 4 to 7 subjects per semester each subject carrying 2 to 3 hours of seminar per week, teachers are found interested in completing the course contents [8]-[10]. Further, some teachers teach to the test to enable as many students as possible to pass assessment. However, many other factors of student development are omitted, particularly around wider skills development for enhancing career prospects and transferable skills such as analytical skills, problem solving, teamwork, and technological skills. To try and enhance the incorporation of these elements, this work has designed an iterative and evidence-based active learning process using digital technology and mobile devices. A small virtual community team of students is selected in every course taken for experimentation. Initially, a group of 16 faculty members was divided into four community groups each consisting of four teachers. One additional experienced mentor (four in total) was assigned to each group. The role of the mentor was to plan the active learning practices, identify the goals, implement the active learning Boot-camp modules (as suggested by the University's management), monitor the progress of their group teachers, provide digital content, share knowledge of mobile devices based applications and collect the individual teachers' observations in their courses. Each community group teacher is trained under the guidance of a mentor and follows the active learning practices in their courses. Courses are then allocated to trained teachers with the admonition to apply active learning practices in their courses. During this process, care is taken to ensure that students enrolled in the experimental study courses have previously practised traditional learning rather than active. This exercise is necessary to observe the differences between traditional and active learning processes, and decide the future goals of the research. During the progress of active learning based teacher-student Bootcamp, iterative learning processes for both teachers and students are designed. These included teacher training followed by practising in classes with students, collecting the feedback, discussing the feedback with the mentor and an external instructor, reviewing and acting on any recommendations, maximizing the use of digital content, technology and devices, and incorporating the information gathered and lessons learned into the next phase of teacher-student learning. As there are records maintained by each mentor, teacher, and student in this complete process and multiple boot-camp cycles are applied over 6 to 12 months, this process is categorized as an iterative and evidence-based active learning process.

The rest of the paper is organized as follows: a literature review of active, face-to-face, and other traditional learning processes is set out in Section 2. Section 3 presents the proposed active learning approach and a comparative study of traditional and proposed active learning processes considered for experimentation. Section 4 presents the experimental setup, class design, and integration of active learning, assessment and evaluation criteria, and feedback mechanism. This section shows the results and analysis of the comparative study between traditional and proposed active learning processes as well. Finally, section 5 concludes the work.

2. State-of-the-art

This section explores the importance of active learning in recent studies. We focus on those studies which apply digital active learning and compared with traditional approaches, to discuss the challenges, and suggest possible solutions for implementation of this approach. We explore solutions from the literature that integrates a hybrid (quantitative and qualitative) learning and active learning process in engineering studies. In hybrid learning, quantitative learning is related to how much explore should be given to students in any course whereas qualitative learning includes quality and content's relevance.

Shekhar et al. [2] identified the importance of a hybrid learning process to enhance digital active learning. In the hybrid approach, quantitative and qualitative learning with the use of digital mobile devices is preferred over quantitative and qualitative learning without the use of digital mobile devices in the engineering domain. In the quantitative learning process, students gain knowledge from generalized evaluation and assessment. Further, qualitative methods are useful for the rich and in-depth understanding of any topic. This work observed that most of the engineering studies prefer a mixed (both qualitative and quantitative) learning process. The proposed learning process in this work applied a mixed approach and found that an iterative process of qualitative followed by a quantitative approach improves student performance, and develops student study skills and ability to learn as well. The study observed that the integration of qualitative and quantitative learning processes is challenging faculty.

Bartholomew et al. [3] conducted a study to assess the impact of digital devices-based active learning on the physical activities of school children and socioeconomic status. A study of over 2493 students shows a significant increase in physical activity. Daily recommendations and supplement opportunities concerning physical activity are found to be important for students. Thus, this study helped recommend that schools adopt a policy change and apply active learning for increasing physical activity across students. Tomkin et. al. [11] realized that digital devices-based active learning practices with evidence-based instructional practices are much more helpful as compared to traditional face-to-face active learning practices like conferences, class discussions, workshops, guest lectures, and seminars. In this study, it is observed that both students and instructors are interested in those classes where there are student-centric active learning practices rather than a lecturing mode that is instructor centred. Further, student learning and retention is enhanced with these best practices and digital content [12]. In the results, it is also observed that such practices are more fruitful in small and disciplinary teams linked with individuals or groups having evidence-based instructional and active learning processes in execution.

Mehrotra and Wagner [13] acknowledged the importance of understanding the features, characteristics, potentials and population requirements with digital technology in the learning process. They observed that age, gender, religious affiliation, and social contacts are necessary to understand before teaching someone "how to live in a pluralistic society". Here, active learning takes an important role in emphasizing population knowledge and skills. Active learning is used to broaden students' thinking abilities and demonstrate them the person's values and attitudes [14] [15]. The authors have studied the importance of active learning process in various important domains like health beliefs, behaviours and services, information and formal care of elder persons, life during work, retirement and leisure, religious affiliations, individual preferences in habits, foods, and services. In summary, active learning has been found to be important not just for students or teachers but for every population in any geographical region.

Lee et al. [16] investigated the application of the active learning process in a large classroom to improve student learning and student success. Among recent research works on active learning, this work designed a model and investigated the use of spatial and technological features of bigger classrooms based on the Pedagogy-Space-Technology framework. In active learning, large classroom is handled by creation of small groups, individual group teaching and evaluation, and an interactive question/answer and feedback process. This is preferred over passive listening in large classrooms. In observations, it is found that a small lecture followed by small group discussion is the backbone of active learning. Further, technology should be laid down in a way activities are planned. Active learning applies collaborative, student-centric, and active pedagogy for enhancing class performance. Active learning could be related to one or more of the following activities: cooperative learning, team-based learning, collaborative assignment, project contribution, and group discussions. All of these activities are given preferences since they actively engage students in a classroom rather passively receiving the information. Studies show that the qualitative active learning process for undergraduate students facilitates small group activities while pointing towards overcoming the challenges of large class discussions.

Brewer and Smith [17] realized the need to change the teaching and learning methodology in undergraduate biology courses. This change is necessary to remove the gaps of theoretical and experimental biological teachings. This work recommends good status, recognition, and rewards for faculty members and departments involved in biology and other science-related disciplines. Further, there is a need to improve students' classroom activities, and all stakeholders should support them. Likewise, various other frameworks have been proposed to improve teaching and learning in recent times [18]-[23]. Gonzalez [18] discussed the importance of hands-on and student centric activities that can be performed at home, and/or explored in local communities. Smith et al. [19] developed Bio-MAPS (Biology-Measuring Achievement and Progression in Science) tool to measure learning in biology courses. This tool improves conceptual understanding and accordingly guides the students to make necessary modifications in the curriculum for enhanced learning. Similarly, Couch et al. [23] presented the General Biology-Measuring Achievement and Progression in Science (GenBio-MAPS) tool to measure the understanding of core concepts in biological courses. This tool helps students and departments to coordinate and remove challenges faced in teaching/learning core concepts. Jardine et al. [20] discussed the use of Group Active Engagement (GAE)-based exercises in biology courses. In GAE exercises implementation, data was collected from surveys, interviews, and in-class videos. The data analysis shows that GAE exercises should be adopted in curriculum and instructional practices for improving knowledge. Gray et al. [21] discussed the importance of toxicology learning framework that encompasses multiple disciplines. This multilevel framework suggests how contents should be taught in biology courses. Further, the framework enables integration of various disciplines and evidence-based teaching to the educators in allied disciplines. Tripp and Shortlidge [22] discussed the interdisciplinary aspects using an interdisciplinary science framework that develops learning outcomes, activities and self-assessments in students. Various challenges in interdisciplinary studies are summarized that fosters students' ability to excel in interdisciplinary science.

A comparative analysis of other recent active-learning processes for engineering, mathematics, and social science courses is shown in Table 1.

Table 1: Comparison of recent active-learning approaches

Authors	Year	Methodology	A	B	C	D	E	Strengths	Weaknesses
Roden et al. [12]	2018	Two-days active learning workshop based experimentation to prepare graduate students to engage undergraduates	×	×	×	√	√	• Scientific teaching practiced. • Statistical evaluations conducted. • Graduate students to engage undergraduates experimented.	• The statistical evaluation time is very short. • No long-term evaluation conducted • The experiment scale is small.
Auerbach et al. [13]	2018	Instructional active-learning using expert-novice experiences	√	×	×	√	×	• Knowledge learning and outcomes are discussed in detail • Reflection practices integrated biological courses have experimented	• Real-scenario based experiments are required. • Brain grasping power need to be integrated for enhancing the overall learning experiences
Virtanen et al. [14]	2017	Multiple active-learning processes integrated model for knowledge enhancement and self-learning	×	×	×	√	×	• Multiple active-learning methods including goal-specific competencies, motivations, and self-regulated learning are practiced. • Validate the self-learning, active-learning, and autonomous learning processes.	• The larger sample size is necessary to validate the proposed process. • Brain learning and knowledge levels should be taken into consideration. • A computerized simulation model with variable inputs expected
Cole et al. [15]	2019	Online active-learning practices and predictions for online course engagements	×	×	×	√	×	• It is observed that online active-learning is more ambiguous for students as compared to classroom teaching. • In minority student cases active online-learning process deteriorates students' academic and health outcomes.	• The proposed hierarchical processes are not validated. • Student knowledge level after proposed process implementation is measured from GPA rather than feedback or deep evaluations.
Wright et al. [16]	2019	Intended and enacted active-learning and teaching strategies for small and large class instructor's active learning pedagogical practices	√	√	×	√	×	• A comparative study of active learning processes in small and large class size is drawn. • Reducing class size to small can lead to more active and engaged learning. Case-studies, group discussions and simulation studies are easily applicable in smaller scenarios.	• Knowledge affecting parameters and students' capabilities could result in much more weightage to small scale classes. • A computerized model can predict the indirect parameters necessary to analyze for universities with mandatory larger class strengths.
Wiltbank et al. [17]	2019	Student's self-reported active learning process for undergraduate students in large strength biology subject	√	√	×	√	×	• Unique student's self-reported engagement and evaluations are designed. • One to one student handling and problem-solving skills is possible. • Beneficial especially for biology education because of impactful education experiences and outcomes.	• This study does not experiment with non-biological education. • It would be very difficult to apply the proposed approach over a large class strength. • Long term student learnings are not evaluated.
Proposed Approach	2020	Hybrid Mode-based active learning process	√	√	√	√	√	• Hybrid blended in a unique approach. • The experiment extended for larger and long-term learnings. • A simulation conducted for small and large scale implementation	NA

A: active learning workshop/Bootcamp/training conducted for experimentation, B: results evaluated using statistical tests, C: Self-regulated learning practiced, D: provide additional digital contents on student's request, E: Hybrid blended experimentation conducted, NA: Not available.

Critical Analysis: In the literature [24]-[33], it is observed that most of the existing Indian university learning technique is traditional which follows passive listening and instructional studies. With the evolvement of technology and advancement in engineering studies, evidence-based instructional and iterative active learning processes are needed for the internationally competing universities of India. Thus, a unique initiative is taken by Laureate International University (LIU) network to improve the quality of teaching and performance of students by applying an iterative and evidence-based active learning process in small groups at UPES. After conducting extensive studies, LIU network's instructors created small groups (both teachers and students) having equally likely probability of weak, moderate and strong students in each group, assigned courses to teachers, and recommended that the teachers apply the active learning process in their courses. This complete process draws on the various active learning practices identified in the literature such as physical activities (working problems out alone and/or with other students, and taking lead in solving challenges), active classroom discussions, debate sessions, participation in webinars, seminars, and conferences, applying one-to-one problem-solving methodology. Further, the aim of applying such learning processes is to remove the disadvantages of traditional learning practices as identified by various authors in their research.

3. Proposed Active Learning Approach

This section compares the traditional learning processes which were applied earlier with an iterative teacher-student Bootcamp based active learning process. Algorithm 1 explains the steps that teachers used to consider while teaching a course before the utilization of the active learning process. Figure 1 shows the flow of Algorithm 1 in detail. Algorithm 1 and Figure 1 reflect a passive learning model in which students come to class, punch their attendance, take their respective seats, listen to teacher's teachings, make classroom notes, ask questions (sometimes), give classroom tests, assignments, and quizzes, prepare home assignments, collects results from the teacher and give teacher's feedback. Algorithm 2 explains the proposed active learning process that was applied (i) to small groups within a large class using simulation, and (ii) small groups in the real class scenario. Figure 2 shows the Algorithm 2 flow in detail. In Algorithm 2 and Figure 2, there are four modules (reflection, learning architecture, digital academician, and academic-practitioner) which are first used as a training exercise for teachers in order to help them roll out active learning techniques to students. In the reflection module, the teachers were trained, boot-camps were executed, teachers taught the students, students interacted actively with the teacher using different activities, teachers interacted with the mentor and introduce another set of activities, and the feedback process was executed. In the learning architecture module, the courses are planned using digital content based delivery system (both online and offline lectures), and mapping the course material with Course Objectives (COs), Program Objectives (POs) and Program-Specific Objectives (PSOs), and courses are re-planned by making the modifications in course content. In the digital academician module, convergence techniques are used in the learning management system, a hybrid mode of course content delivery and distribution is implemented, and evaluation and assessment for small group-based learning activities and feedback system are undertaken. Finally, the academic-practitioner module involves action research, academic management, and leadership.

Algorithm 1: Traditional learning process used by the teachers (same teachers were taken for active learning practice) for their course delivery

Goal: To design and complete the course contents within a specified time (usually).

1. **For** each class and course
2. The teacher learns through study material provided by an industry partner, online sources and library material.
3. The teacher teaches their learning to students in medium to large sized (number of students) classrooms.
4. Students mark their attendance, listen to teaching and some teachers allow them to ask questions during lectures otherwise students are free to ask questions at the end of every class.
5. The teacher gives classroom assignments, quizzes, puzzles, and home assignments to students.
6. Two examinations (mid-semester and end-semester) are conducted over a period of six months.
7. The teacher evaluates every assignment, exam or any other internal evaluation and gives back the result to the students within one week.
8. The teacher prepares the results and submits to the student records and evaluation department for record-keeping. Results are displayed on the result board and website followed by grade calculation and certificate preparation.

9. Students give feedback online for every course and every teacher.
10. **End**

Algorithm 2: An iterative assessment and evidence-based active learning process for engineering courses maximizing the use of digital technology and mobile devices.

Goal: To improve the teaching practice of teachers and develop students' learning ability using active learning processes supported by University management.

1. **For** each module
2. **Repeat**
3. The teacher (Mentee) learns through Reflection (Module-1)
4. In Reflection, each teacher (Mentee) attends 6 classes of every other faculty members (Mentees) in a group.
5. Teacher (Mentee) fills a pre-observation form and circulates it among peer members (Mentees) of the same group.
6. The attending teacher (Mentee) fills a post-observation form in a prescribed format and gives reflection/feedback to the Mentor and shares with the class teacher (Mentee) as well.
7. Teachers (Mentees) use their learning from the Bootcamp and online modules while teaching in class to students.
8. Peer group members (Mentees) are invited to these classes to analyse and give feedback.
9. Mentor also invites all his group members (Mentees) to his class so that they can learn from his teaching in a Hybrid Blended Online (HBO) course. This is a digital content based teaching-learning style.
10. Feedback on the active learning process, usage of mobile devices, and digital contents is collected from the students.
11. **Until** (all teacher groups are covered)
12. **Repeat**
13. Teachers (Mentees) are provided the necessary support to develop their teaching through Learning Architecture (Module-2)
14. Teachers (Mentees) redefine course modules (at least one) including re-writing of course outcomes, program outcomes, program-specific outcomes, course content, and assessment methodology using Bloom's taxonomy and evaluation.
15. A panel of exam paper checkers examines the course material, digital contents, and question papers.
16. Feedback is collected from students on the revised digital content.
17. **Until** (all teacher groups are covered)
18. **Repeat**
19. Teachers (Mentees) are supported to develop their teaching through the Digital Academician Module and taught to maximize the use of digital devices (Module-3).
20. An industry professional or expert is invited to give training session on the Learning Management System (LMS) to teachers with and without mobile devices.
21. An international faculty member is invited to give a webinar (using digital devices and contents) to improve teaching style using positive thinking and communication in a class.
22. After the above training, a module and video session are prepared by each teacher (Mentee) and presented to all the group members.
23. **Until** (all teacher groups are covered)
24. **Repeat**
25. A process of writing a technical paper is executed by each teacher (Module-4).
26. Contents of writings is verified by mentors in proof-reading as well as through mobile device-supported tools (grammar checking, plagiarism score verification, and equation verification).
27. Under academic management and leadership, quality improvement of entire education eco-system (faculties and students) is accessed from the feedback of students and peers.
28. Mentor conducts regular sessions with and without mobile devices for each teacher and motivates them to apply similar practices in classes.
29. **Until** (all teacher groups are covered)
30. An active learning project report is prepared by each faculty member in each group. This report is a comprehensive report on all exercises, learnings, and observations.

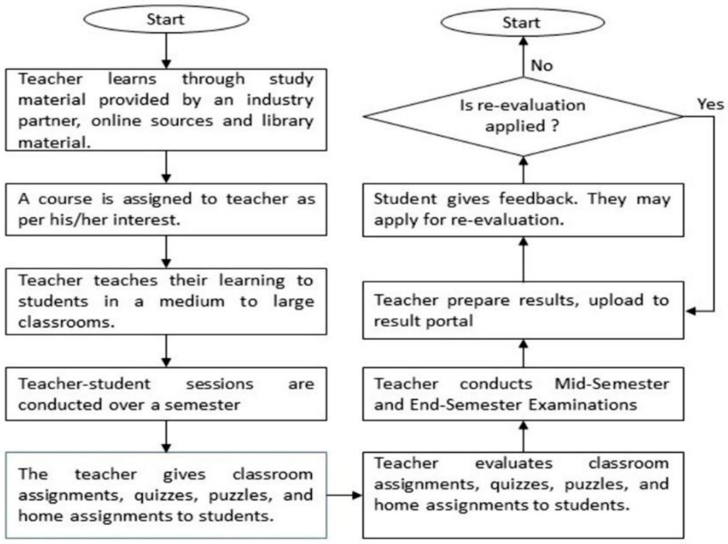


Figure 1: Traditional learning process

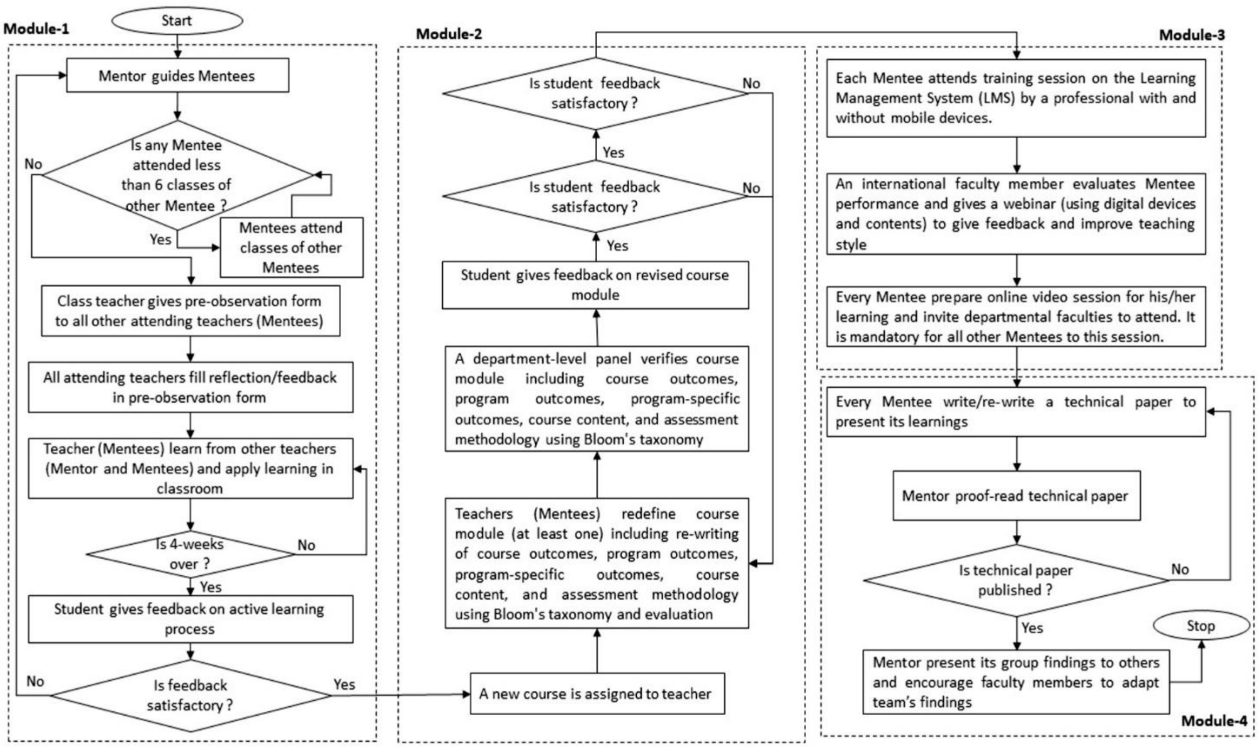


Figure 2: Proposed Active-learning process

Figure 3 shows how the proposed active learning process is applied and compared with the traditional learning process. This shows the real-scenarios followed in engineering and science disciplines. In both proposed and traditional active learning processes, a maximum of 120 students are allowed to register in one subject of the same year. In the classroom experimentation, 120 students are randomly divided into two groups consisting of 60 students each. It has been observed that there was no debarred student in selected courses for experimentation. Now, both proposed and traditional learning processes are applied in parallel. Here, the success ratio of both learning processes is measured after mid-semester and end-semester evaluations with assignments, class-tests quizzes, and examination performances. Sufficient digital content is delivered to students for their self-learning. There are three slabs (percentage of students earning more than 80% marks, 70 to 79% marks, and less than 70% marks) set to evaluate the performance of the proposed approach. This is as per the upper limits of the University Grant Commission (UGC) Course Objective (CO)/ Program Objective (PO) charting.

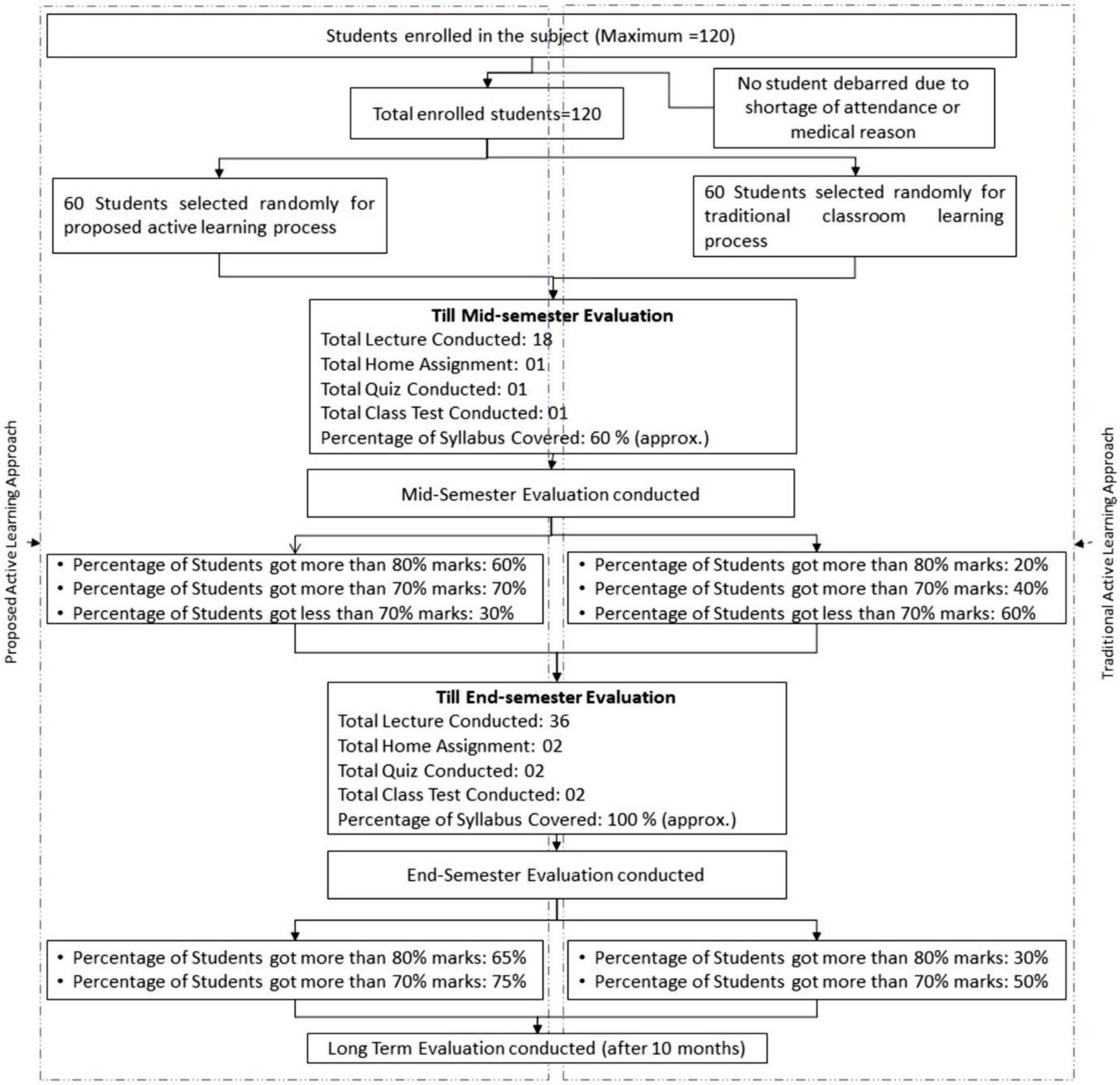


Figure 3: Flowchart of Proposed and traditional active learning processes with the provision to use mobile devices.

Table 2 shows the evidence and feedback of the Post-Graduate Certificate in Academic Practice (PGCAP) workshop with active learning practices. PGCAP is conducted in UPES for more than 20 faculty members in addition to the mentors for a duration of more than 8 months. After the PGCAP Bootcamp/workshop experience, all mentors and mentees encourage other experienced and young faculty members to have such alternative teaching and learning approaches experiences in their classroom because it will help everyone and then compare them with their styles to see the difference. Further, the pros and cons of an individual teacher can be self-analysed to improve their knowledge level, their interactions with students, and improve the performances of students.

Table 2: PGCAP Workshop Evidences and Feedback.

Acadamic Title	Mentor / Attendee	Feedback	Youtube Feedback Link
Professor & HoD	Mentor	"As a teacher, significant aspects are teaching, learning, assessment, curriculum and pedagogy. PGCAP program touches all of these. It is bringing all these aspects close and allowing you to experiment and reflect, leave traditional barriers and come up with really something new. This is necessary because the kind of audience that we are facing	https://www.youtube.com/watch?v=H7kq86lEu8Q&feature=youtu.be

		nowadays is not that was earlier. The students are already familiar with the digital content that is going to come their way. In this environment, the PGCAP program is well placed.”	
Professor & HoD	Mentor	"PGCAP helps the teacher what, how, when and why to experiment learning practices"	https://www.youtube.com/watch?v=P3A9GjJfJ2o&feature=youtu.be
Professor	Mentee	"PGCAP is incredible. It helps a teacher to achieve his/her own excellence. It simulates to create new designs and pedagogies."	https://www.youtube.com/watch?v=3e7vq0PDtdc&feature=youtu.be
Professor	Mentor	"PGCAP workshop helps a teacher to apply academic disciplines with enhanced student interactions.	https://www.youtube.com/watch?v=JTXuAtDak_0&feature=youtu.be
Professor	Mentee	"PGCAP helped a teacher how to apply teaching style in an efficient way. It nurtures your experiences and long-term learning practices."	https://www.youtube.com/watch?v=ZTvJN9flAys&feature=youtu.be
Professor	Mentee	“PGCAP helps to improve existing teaching methods with the help of peers and mentors.”	https://www.youtube.com/watch?v=X1eukqcKb_Y&feature=youtu.be
Professor	Mentee	"I came from an industry background. Through PGCAP, I learned what are the prevailing things in the academic world including content writing, pedagogy development, digital contents importance and usage, more interactive program."	https://www.youtube.com/watch?v=smIufAph-VU&feature=youtu.be
Professor	Mentee	"PGCAP helped me in improving academic principles including practices in curriculum development and design, and impactful implementation of teching and learning."	https://www.youtube.com/watch?v=qGJflsmyXkA&feature=youtu.be
Professor	Mentor	“PGCAP is for faculty members to develop their skills particularly teaching, pedagogy and research. PGCAP helped the faculty members to boost their confidence level, classroom experiences and analysis."	https://www.youtube.com/watch?v=0Ywwhv2rDD0&feature=youtu.be
Professor	Mentee	"This program helped a Ph.D. graduate to evolve as a faculty member. It helped in the design and develop lectures in such a manner that it covers all the levels of cognitive complexities of Bloom's taxonomy."	https://www.youtube.com/watch?v=wocm5KAWgmM&feature=youtu.be
Professor	Mentor	"PGCAP can help young faculty members to have better teaching practices adopted at the early stages and have these practices in their sub-conscious mind."	https://www.youtube.com/watch?v=wwg6EJ6z0Q4&feature=youtu.be
Professor	Mentor	"PGCAP was a unique initiative from UPES. Primarily objective was to grasp young faculty members and grain them with some of the best academic practices which would be suitable for them for their long term career. PGCAP embarks on things like how do you create a learning situation in a classroom? Different courses need different pedagogy. So, all PGCAP participants learned how to apply different pedagogies."	https://www.youtube.com/watch?v=U_1OS5DimWY&feature=youtu.be

4. Experimental Setup and Results Analysis

This section explains the two procedures (simulation and real class implementation) applied to analyse the proposed approach. Fig. 4 shows the overall real and simulation-based experiments conducted in this work. The real experimentations are performed to analyse students’ performance in computer science courses. Further, the simulation-based experimentation is used to engage students and faculty members in active learning, and simulation learning processes. These experiments are explained in detail as follows:

4.1 Real-Class Scenarios

This sub-section explains different real-class scenarios taken into consideration followed by experimental evaluations. A detailed explanation of scenarios and their evaluations are as follows:

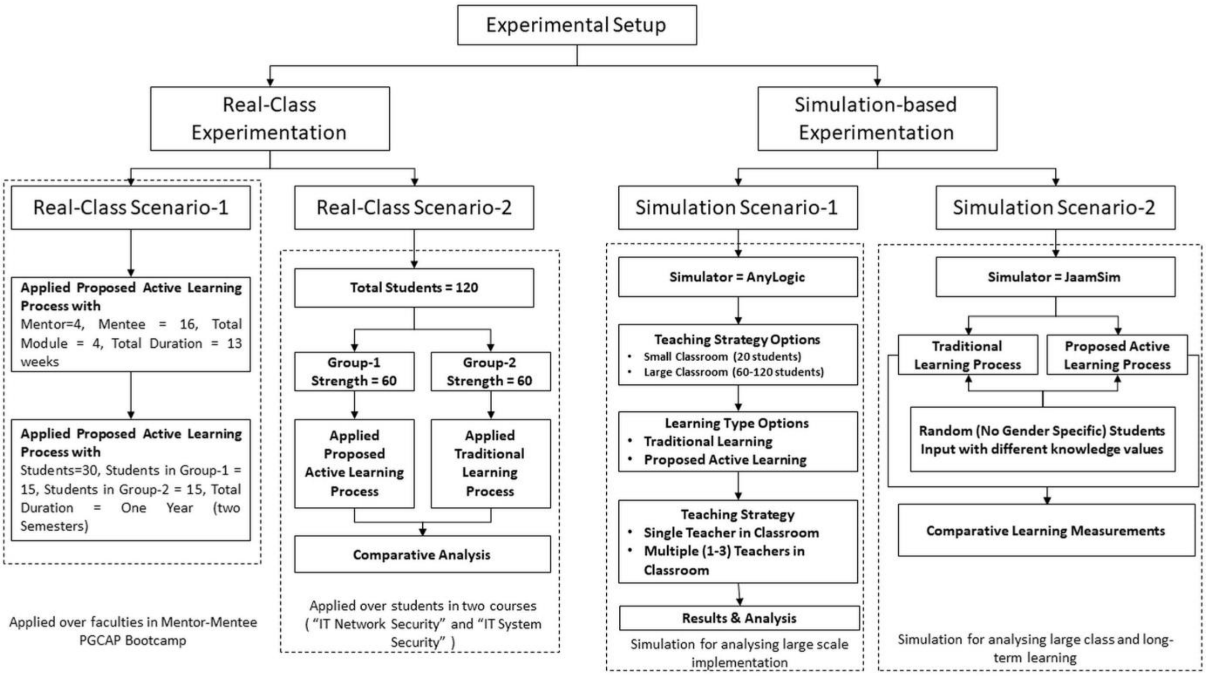


Figure 4: Real and Simulation-based Experiments Conducted in this Work

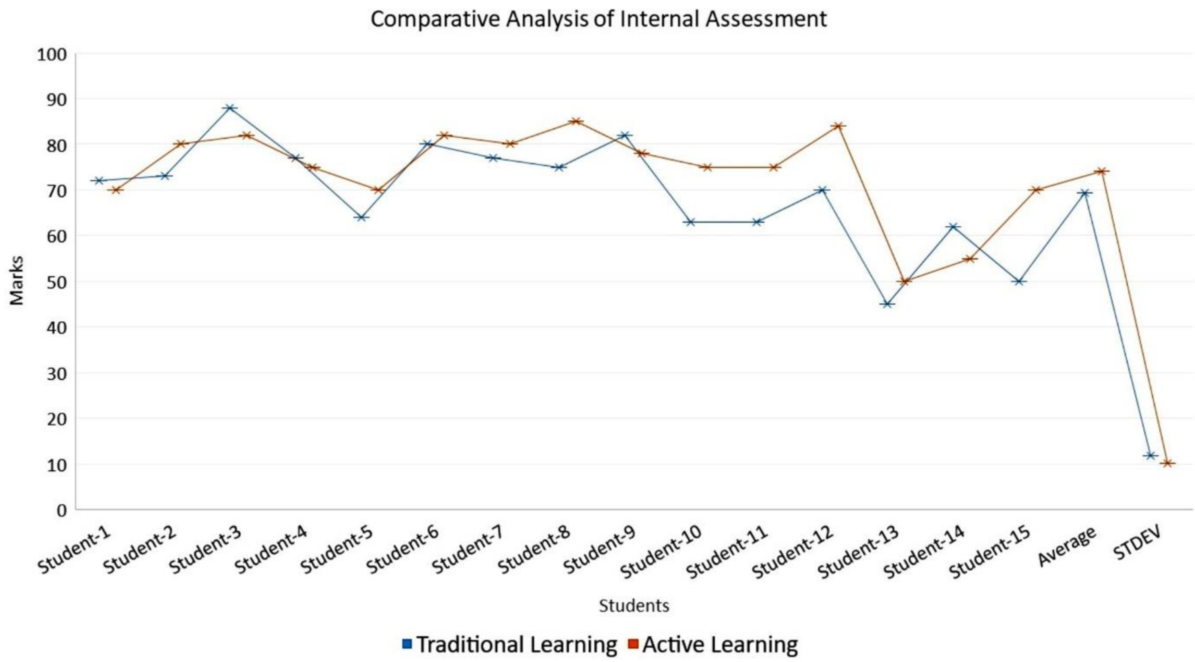
4.1.1 Real-Class Scenario-1

The real class scenario is different from the simulation environment. As recommended, small teacher-student course scenarios (PGCAP Bootcamp) are taken to analyse the performance of the proposed active learning process and availability of study material through mobile devices. Table 3 shows the evaluation strategy taken for teacher boot-camp. Here, faculty and observer names are replaced with anonymous entries because of security compliances. Here, each of the teachers visits other teachers or mentors' classes a minimum of 4 and a maximum of 8 times (see observer1 and observer2 in Table 3). Each class observer must generate his/her report a minimum of 5 and a maximum of 10 times (see observer's report in Table 3). Further, each teacher makes his/her reflection report a minimum of 7 and a maximum of 10 times incorporating the enhancements that one has made in teaching strategy (see self-reflection column in Table 3). As teacher boot-camp is having four modules, peer observations and feedback varies from a minimum of 7 to a maximum of 10 times. In total, the reflection module was executed 13 times over 13 weeks (see week no. column in Table 3) to have a well-trained system with improvement in student performance. Table 3 shows the time duration of these executions in detail.

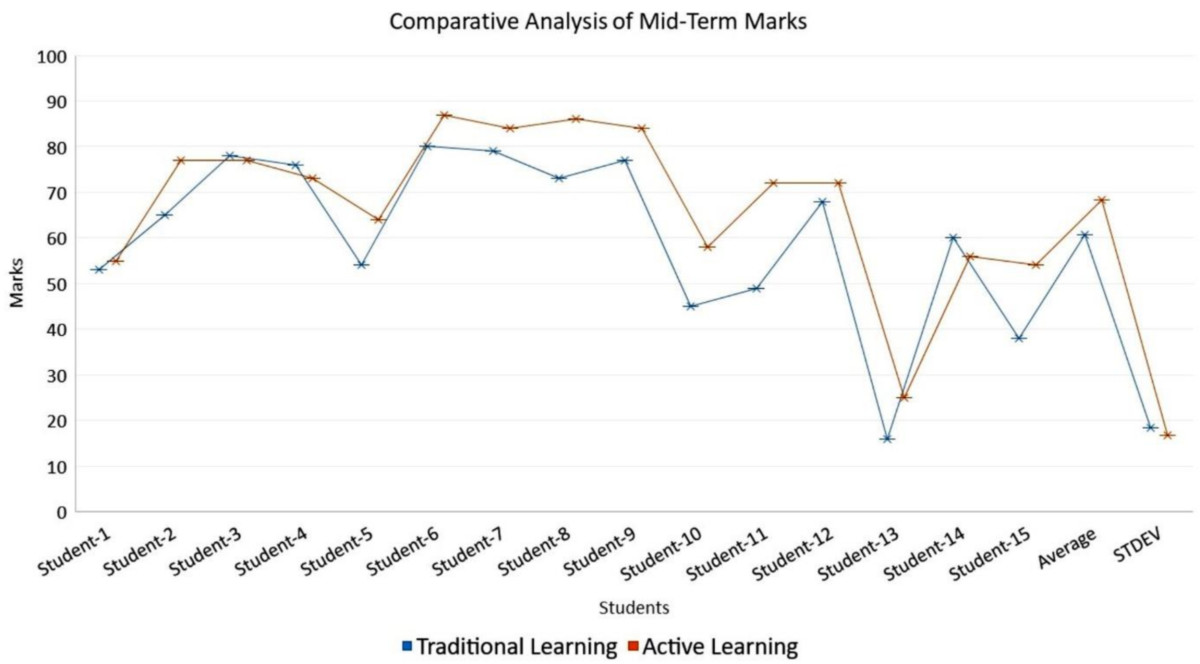
Table 3: Teacher evaluation strategy for teacher boot-camp in the real scenario

S. No.	Name of the Faculty	Observer1	Observer2	Meeting with Mentor before peer observation	Class Visit	Observe's Report	Self Reflection	Meeting with Mentor after peer observation	Reflection Module 1	Week No.	From	To
	Peer Observation (Cycle 1)									1	#########	#########
				Week No.						2	#########	14/10/2018
1	A	B	C, E		4	5	7	8		3	15/10/2018	21/10/2018
2	B	C	D, E		4	5	7			4	22/10/2018	28/10/2018
3	C	D	A, E	3	5	7	8		13	5	29/10/2018	#########
4	D	A	B, E		5	7	8	9		6	#########	#########
5	E	A, C	B, D		5	7	8			7	#########	18/11/2018
	Peer Observation (Cycle 2)									8	19/11/2018	25/11/2018
1	A	C	D, E		7	8	9	10		9	26/11/2018	#########
2	B	D	A, E		7	8	9			10	#########	#########
3	C	A	B, E	5	8	9	10		12	11	#########	16/12/2018
4	D	B	C, E		8	9	10	11		12	17/12/2018	23/12/2018
5	E	A, D	B,C		8	9	10			13	24/12/2018	30/12/2018

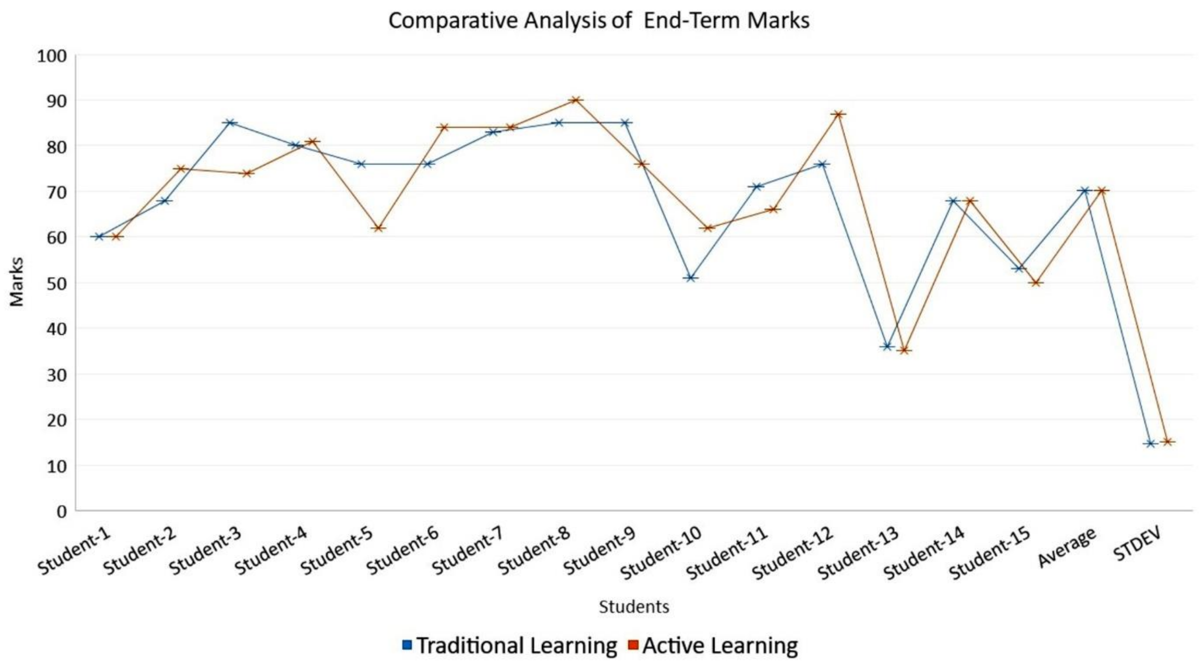
After PGCAP Bootcamp, the proposed approach (as discussed in algorithm 2) is applied to a small group of students initially. Figure 5 shows the comparative analysis of four components of a course. This comparative analysis is performed between iterative and evidence-based active learning processes and traditional learning processes with the use of digital technology and mobile devices. In this experimentation, the Figure 3 process is applied twice to a group of 30-students (instead of 60-students). In the first execution, group-1 (of 15 students) followed traditional, and group-2 followed the active learning process, whereas the process reverses in second execution. In the second execution, the group-1 followed the active learning and group-2 followed the traditional learning. Both groups are constituted in such a way that there is equally likely probability of weak, moderate and strong students in both groups. Figure 5(a) shows the comparative analysis of internal assessment marks for 15 students (group-1). Internal evaluation is kept for 30 marks and 12 out of 15 students improved their performance in this evaluation. Three students' performance is comparatively lower because of medical, personnel, and other absentee cases. Similarly, Figure 5(b) to Figure 5(d) shows the comparative analysis of mid-term, end-term, and total marks evaluation for 15 students in one course. Results show that 80% of students' marks are improved (with a significance of 5% using χ^2 test) with the proposed iterative learning process. The majority of the four components of the course show improvement in the class's average marks as compared to the traditional learning-based student whereas, the standard deviation in the marks is lesser for the proposed active learning approach (Algorithm 2) as compared to the traditional approach (Algorithm 1). This motivates us to apply these strategies for large-scale implementations. Besides, the physical activities of each of these students are also increased because of active learning iterative and group events. Students' feedback has shown that this increase is mainly due to the usage of mobile devices and other digital technologies in their learning process. As observed in the literature survey, a similar process is fruitful and helpful in making necessary changes in academic policies for any university. The reason behind not achieving 100% student performance improvement is because of absentee cases (medical, personal, or other reasons). Without absentee cases, performance was 100%. The absentee cases has shown slight improvement in those components which they attempted. Similar trends are observed with group-2 with a variation of 3.2% in total marks. Overall, the average marks of the class with active learning experiences are 4.2% higher compared to traditional learning (for both groups) with a standard deviation of 2.4.



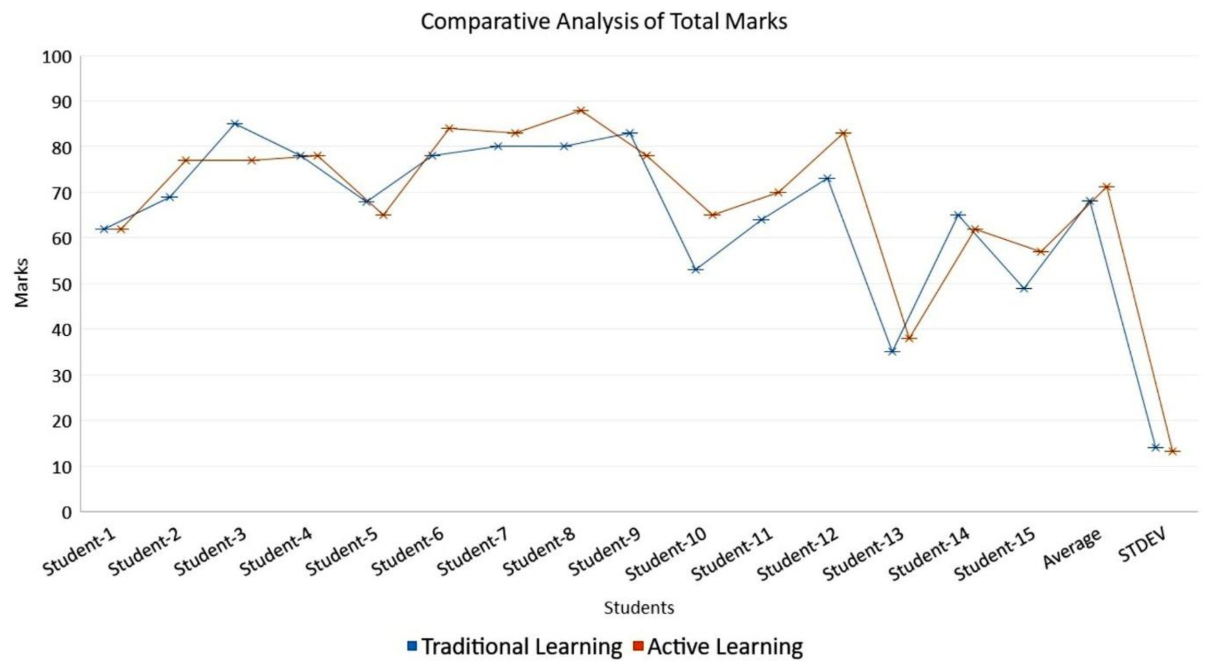
5(a): Comparative analysis of Internal Assessment Marks



5(b): Comparative analysis of Mid-Term Assessment Marks



5(c): Comparative analysis of End-Term Marks



5(d): Comparative analysis of Total Marks

Figure 5: Comparative Analysis of Traditional vs Active Learning Assessments having provisions to use mobile devices (Active Learning is better than traditional learning).

4.1.2 Real-Class Scenario-2

In this scenario, two randomized parallel academic study-based community groups were developed. Here, Group-1 was assigned an iterative and evidence-based active learning methodology with mobile device usage, and it is implemented during practical and theoretical teaching sessions. On the other hand, group-2 was assigned a traditional teaching methodology i.e. a single teacher teaching a master class. These methodologies are applied for the subjects “IT System Security” and “IT Network Security” in Bachelor of Technology (B. Tech.) Degree in Computer Science and Engineering at UPES. Here, instructors created small groups having equally likely probability of weak, moderate and strong students in each group.

Both subjects (“IT System Security” and “IT Network Security”) are compulsory courses offered during the sixth semester of the third year. IT System Security subject consists of five units. In digital content, the first unit introduces the basics of system security aspects followed by security primitives and protocols in the second unit. The third unit covers the system penetration-testing at local and network levels[34]-[36]. The fourth unit discusses the various system architectures and their integration with security primitives and protocols to provide a fool-proof security system. Lastly, various real-time case studies are discussed in the fifth unit. The IT Network Security subject consists of four units. The first unit covers an overview of network security and access control aspects. The second unit differentiates between lightweight and heavyweight security aspects for different network scenarios i.e. mobile networks, laptop/desktop networks, and sensor networks. The third unit covers the ethical hacking feasibilities in small to large scale networks. Cost and complexity measurements are performed in section four. Section five covers the advanced network security aspects including designing and developing machine learning-based smart security solutions. These digital contents are prepared with the help of multiple academic and industry partners and delivered to students in a regular and timely manner.

The population size considered for experimentation consists of students registered in both of these courses during the 2018-19 academic year. The participants of both of the groups in each subject are allowed to be part of this experiment who attended continuously both the theoretical and practical classes during the academic year 2018-19. Evidence-based iterative and instructional active learning and traditional learning methodologies were developed and experimented over 24 weeks during the months from Jan 2019 to June 2019. There were five teaching hours per subject, three of theoretical sessions (one hour each), and two hours of practical sessions (once per week).

Table 4 shows the comparative analysis of proposed and traditional active learning processes and their performances for two subjects. Results show the class age levels and group-wise performances. It has been observed that the proposed approach improved the student's grade performance to a much higher level as compared to traditional learning. According to student feedback, teacher-student interactive levels of the proposed approach helped in increasing their performance. Table 5 shows the detailed feedback and evaluation level improvements for two subjects. In the majority of the cases, the proposed approach is found to be better as compared to the traditional approach. Table 5 shows the long-term outcomes (after 11 months i.e. Jan 2019 to November 2019) as well. All of these results validated the student's performance improvement abilities in the proposed active learning process. Results shown are significant to 5% using χ^2 test. Table 5 shows the detailed quantitative evaluations. Here, two processes are followed to collect the feedback: (i) blind feedback considering that the students should not be influenced by teachers, and (ii) with names considering that for a comparative analysis with blind feedback results. Some of the quantitative evaluations collected from student feedback are as follows:

"*Evidence and instructional active learning process and teaching style are awesome. Using this approach, a teacher always tries to give us the knowledge of every field and their integration importance. The best part of the way of teaching is that the daily life examples and the importance of mobile device technology in it are discussed in the classroom and doubts were taken in one-to-one interactions.*"

-Blind Feedback

"*the adopted active learning process does not allow any teacher to become partial with certain students as compared to traditional learning. Real-life examples are qualitative ways of explaining the importance of technology in education. We would love to continue with similar practices in our other courses*".

-Blind Feedback

"*the adopted teaching style made me more interactive and bound me to be a constant learner.*" *-Blind Feedback*

"*the use of mobile devices and other digital technologies encourages us to continue our learning when most of the universities closed face-to-face teaching because of coronavirus*" *-Blind Feedback*

"After active learning practices in our class, I find myself a better professional than I was before, I have great ambitions & want to achieve things in the future." *-Nandini Nikumbh (BFSI-IV semester student)*

"Overall, throughout this course, I made a care that one can't be professional until one does work actively with mind and eyes both open. Digital contents are equally important in improving the overall quality of my learning" *-Ms. Anupriya Uniyal (BFSI-IV semester student)*

All of the above comments reflect a qualitative teaching style and students' interests in education for their lifelong learning as compared to simply passing exams.

Table 4: Comparative analysis of the proposed active learning approach (with mobile devices usage) with traditional active learning processes for two subjects (IT System Security and IT Network Security).

Variables	**Total Sample Size=120**			
	IT System Security		**IT Network Security**	
	Mean	Median	Mean	Median
Age	22.5	21	22.5	21
Group-2 Passing Percentile (traditional active learning)	59.17	61	64.17	66
Group-1 Passing Percentile (proposed active learning)	91.67	93	93.34	95
Male/Female Percentage	60% (Male) / 40 % (Female)			

4.2 Simulation Setup

This section explains the simulation studies for the proposed approach. This simulation-based study has been conducted to observe the impact of proposed approach by varying the input parameters such as student's intake, new knowledge inter-arrival time and brain learning rate. Brain learning rate is long term (assumed to be more than one year in this work) recall and reasoning ability (explain a concept with facts). In other words, brain learning rate is student's technical retention power. The real-time scenario provides few observations in real-time but simulation can generate different possibilities by varying the input parameters. The detailed simulation using AnyLogic 8.5.1 [37] and JaamSim [38] simulators are as follows.

4.2.1 Simulation Scenario-1

In the simulation, a large classroom is divided into small groups and the proposed active learning process is simulated along with the traditional learning process for comparative analysis. Table 6 shows the simulation parameters taken for analysis. In the simulation, AnyLogic 8.5.1 [37] simulator is used to simulate the proposed active learning approach. Total memory space required over Intel Core i5 7th Gen machine to execute the simulation is 512 MB. This simulation uses a different number of teachers in different scenarios. Variations in the number of teachers are explained as follows:

- *Single Teacher*: One teacher is allowed to enter the classroom in both traditional and complete iterative active learning processes. The teacher has the flexibility to pick any digital technology or mobile device in teaching style. Every single teacher should provide digital contents of subjects covered in their courses.
- *Multiple Teachers*: 15 teachers (maximum) can attend classes of another teacher for learning his/her strategy, usage of digital technology and mobile devices, and give feedback.
- *Multiple Teacher with Active Learning*: In an active learning process, a maximum of 16 teachers can be present in a class with a student count of 1000 (scenario-1), 2000 (scenario-2) and 3000 (scenario-3).

In other simulation parameters, a teacher can be hardliner or lenient. A hardliner teacher is strict in deadlines and expectations from themselves and students, whereas a lenient teacher is flexible in dates and expectations. To integrate mathematical grade calculation, students' grades are measured in a range of 0 to 1.2 as specified in table 6. Although simulation is executed and a record of 1000, 2000, and 3000 students is maintained the complete simulation is a never-ending process. Interested people can extend the record keeping to an infinite class count. Large student count classes (1000, 2000, and 3000) are taken for simulation because some universities in India have high numbers in a single course. Simulation can be executed either in a virtual or real mode. In virtual mode, several months of teacher-student behaviours can be executed and analysed in a few minutes or hours whereas real mode executes the behaviours along with current time. Different input (Teaching Strategy, Disruption type, and Teaching Quality) and output (Student Grades, Gaussian Curves, and Impact of disruption over student performance and student grades) parameters are specific in modelling. The lecture hour for a teacher is fixed for 1 hour per course. The area for simulation is specified as 500 X 500 square meters and simulation is two-dimensional.

Table 6: Simulation Parameters for AnyLogic Model

Parameter	Value
Simulator	AnyLogic 8.5.1
Maximum available memory for model	512 MB
No. of Teachers	1 for Single Teacher Scenario, 16 for Multiple Teacher Scenario, 16 for Flipped Teaching Strategy Scenario, 16 Teacher and 1000/2000/3000 students for Iterative Student-Teacher active learning and 1 for single classroom active learning scenario.
Teacher Teaching Strategy	Teacher can allow disruption or force no disruption in traditional teaching but disruption is allowed in active learning.
Teacher Type	Ideal and Less Ideal
Grade Levels	1.2 for A+, 1.0 for A, 0.8 for B+, 0.6 for B, 0.4 for C+. 0.2 for C and 0 for F
Animation Stop Level	Never
Execution Mode	Virtual (for fast execution in small duration) and Real for a scale of 1:1 with current time.
Simulation Start Date	02 July, 2019
Simulation End Date	07 October, 2019
Input to Model	Teaching Strategy, Disruption type, Teaching Quality
Output from Model	Student Grades, Gaussian Curves, Impact of disruption over student performance and student grades
Teacher Lecture's recurrence time	1 hour
Simulation Space	500 x 500 square meters (2D simulation)

Figure 6 and figure 7 shows the different ways of implementing active learning processes. Figure 6 shows the active learning process simulation with a large number of students handled by a set of teachers in groups. This scenario shows a single teacher associated with multiple group-teachers as well, attends their classes, and invites them to learn from his/her experiences. Figure 7 shows the flip-flop strategy in simulating a large class count-based student learning. In one role, a teacher is a student and is being actively monitored by a mentor and the teacher plays the role of instructor to the student in another role. In both Figure 5 and Figure 6, two groups are constituted. The first group consists of multiple teachers executing the mentor-teacher Bootcamp and the second group is of multiple students with single teacher association for course learning. Simulations (shown in Figure 6 and Figure 7) are used to construct a database for analysis. Here, students' learning abilities, mean score value, and variations in marks are collected.

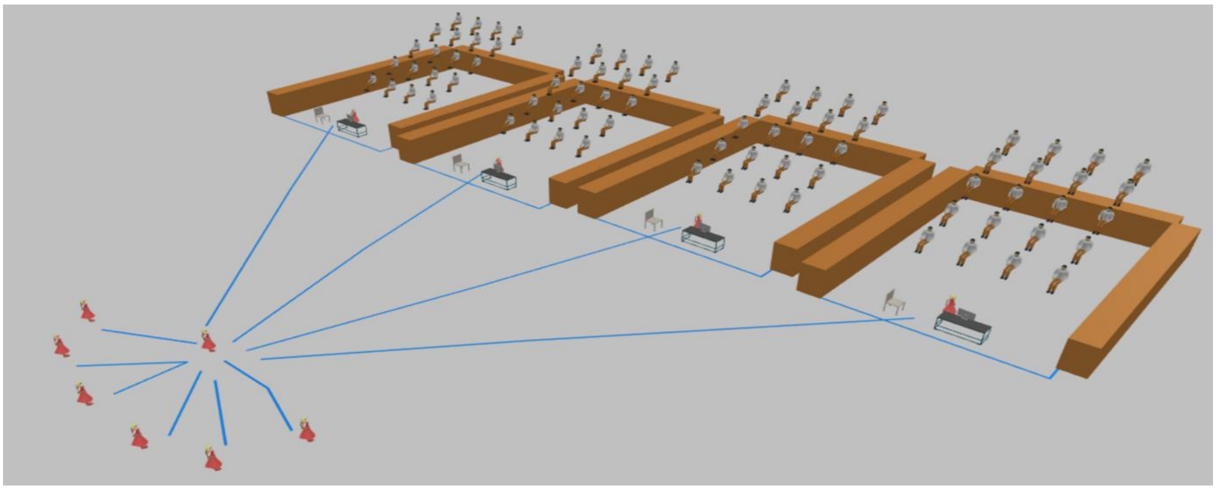


Figure 6: Simulating multiple teacher-multiple students based active learning process in a large classroom (Strategy-1)

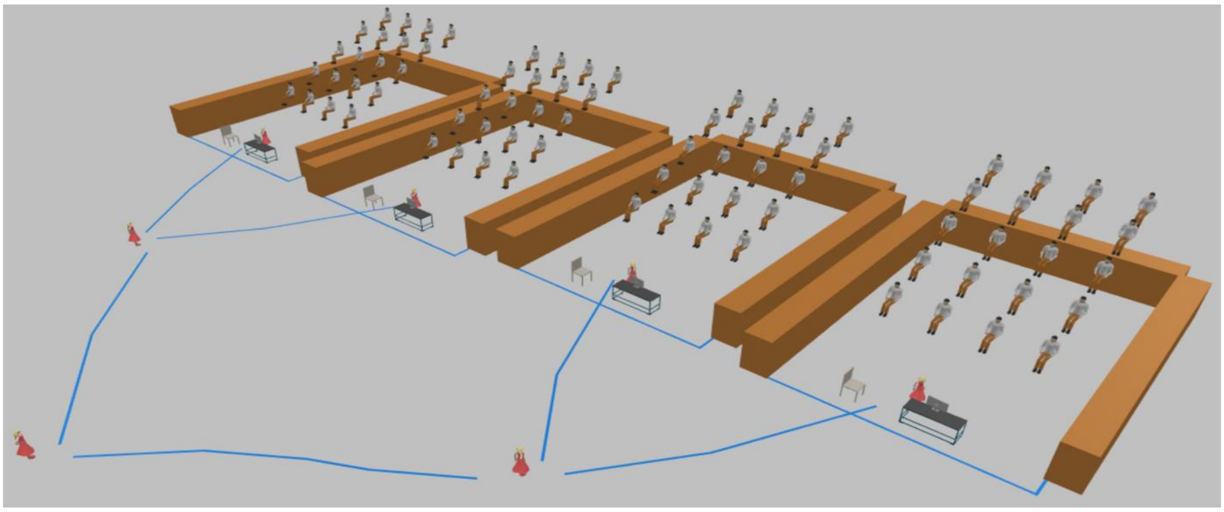


Figure 7: Flip-flop experimental scenario for implementing active learning process with mobile device usage (Strategy-2)

Now, simulation and results analyses are performed for online mobile-based teaching (in classrooms only) irrespective of teacher-teacher strategies proposed in Figure 6 and Figure 7. Figure 8 shows the simulation options for different teaching strategies. Here, a teacher can select a small classroom-based or large classroom-based option in his/her teaching. Further, a single or multiple (maximum of 3) teachers are allowed to enter the class. If there are multiple teachers then they can divide the teaching time among themselves. The learning types are implemented with two options: traditional learning (as proposed in Algorithm 1) and active learning (as proposed in Algorithm 2). Figure 9 shows the analysis of the comparative results of the percentage of mobile devices usage using traditional (Algorithm 1) and proposed active learning (Algorithm 2) processes. Results show that active learning processes increase the usage of mobile devices with time. Figure 9 shows the simulation results for 35 days. However, the simulation is dynamic and variations of these results are in a window of 35 days. Overall, it is observed that proposed active learning increases mobile usage and student's interest in learning as well. Figure 10 shows the percentage of time utilized in student's Q&A during the class.

Results show that the Q&A time during the start of classes was high because a large number of queries were raised to set up the system over mobile devices. Thereafter, it is found that 21% to 24% of time is utilized for student's Q&A. Figure 11 shows the comparative analysis of the student's brain learning abilities on a scale of 0 to 100 using simulation. Student's brain learning rate is measured (after each year completion) from the grading point earned during the degree time. The class's overall performance is rated on a scale of 0 to 100. The average value of student's grades is considered for this analysis. Results show that the proposed active learning approach constantly improves the student's abilities to grasp and learn technological aspects as compared to the traditional learning process. This experimentation is executed for a course overall semesters to earn a degree. As a result, both quantitative, qualitative, and simulation processes validated the proposed active learning process is much better as compared to traditional learning.

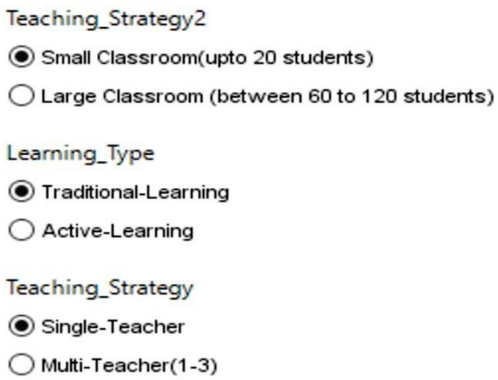


Figure 8: Simulation Options for Teaching Strategies

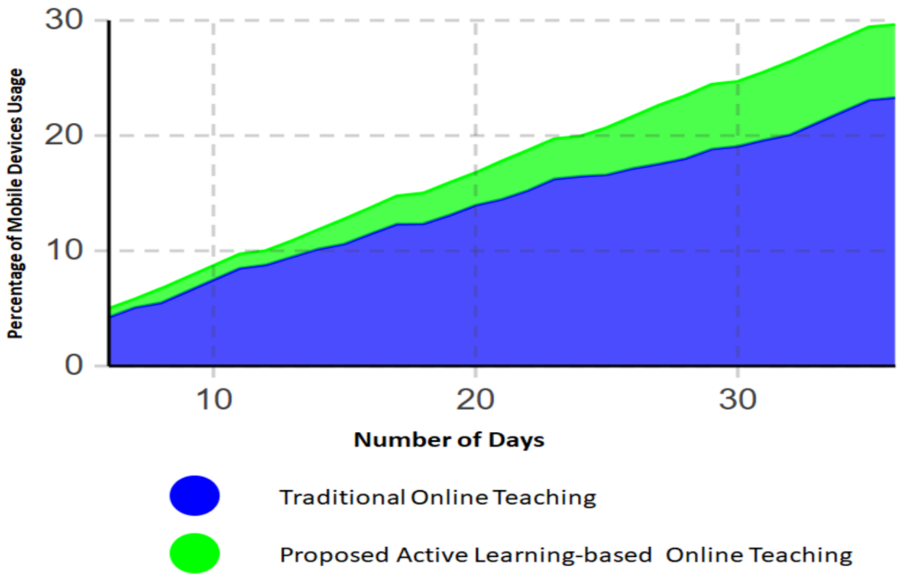


Figure 9: Simulating Peer Group Strategy

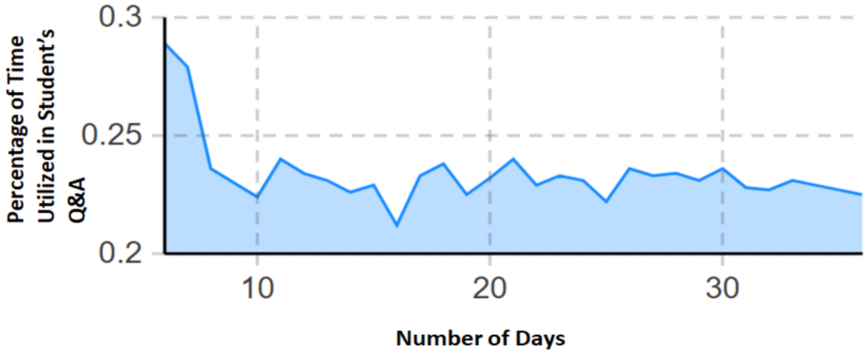


Figure 10: Student's Q&A's time variation analysis for proposed Active Learning process.

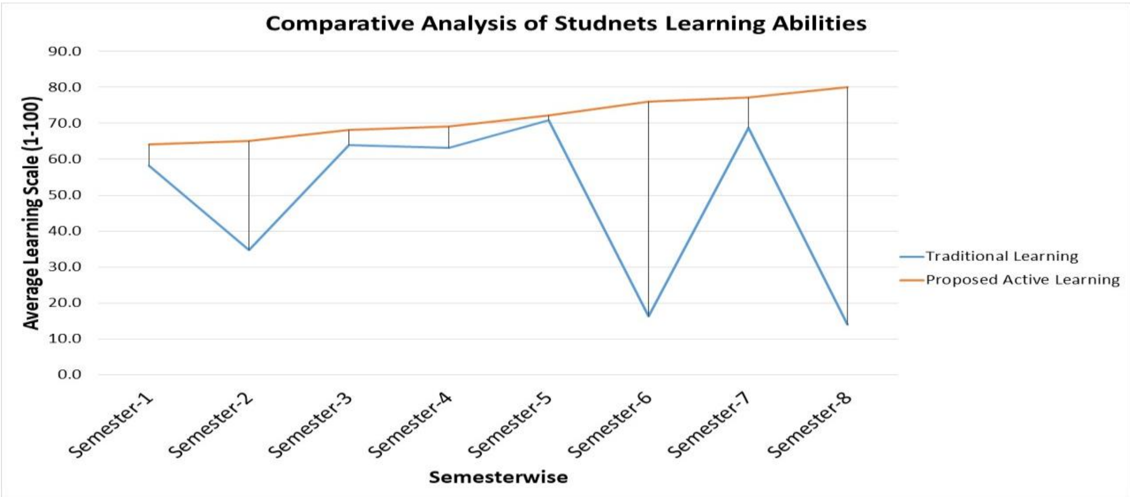


Figure 11: Comparative analysis of students learning abilities with mobile devices and digital technology usage in the active learning process (using algorithm 2).

4.2.2 Simulation Scenario-2

Like AnyLogic Model, JaamSim Model's simulation parameters are specified in table 7. A hardliner (strict with deadlines) or lenient (flexible with deadlines) teacher evaluates the students on a scale of 0 to 100 and grade them as specified in table 7. Although the proposed model considers a large number of students (maximum up to 3000) registered in one subject a maximum of 60 students are allowed to sit and learn from a single-teacher. Using JaamSim Model, various inputs (teaching strategy, random student distribution, random student learning, and uniform student learning) and outputs (student grades, gaussian curves, student's brain learning states, job priorities and sequence, and student grades) can be planned for proposed or traditional learning processes.

Table 7: Simulation Parameters for JaamSim Model

Parameter	**Value**
Simulator	JaamSim [21]
Maximum available memory for model	512 MB
No. of Teachers	1 teacher for the single classroom (with a maximum of 60 students at one time) in proposed or traditional learning scenario, multiple and random teachers (upto 16) can attend other teachers classes for self-learning or feedback,
Teacher Teaching Strategy	The teacher can allow disruption or force no disruption in traditional teaching but disruption is allowed in active learning.
Teacher Type	Ideal and Less Ideal
Grade Levels	90 for O, 85 for A+, 75 for A, 65 for B+, 55 for B, 45 for C+. 35 for C and 0 for F
Animation Stop Level	Never
Execution Mode	Virtual (for fast execution in small duration) and Real for a scale of 1:1 with the current time.
Simulation Start Date	02 July 2019
Simulation End Date	31 December 2019
Input to Model	Teaching Strategy, Random Student Distribution, Random Student Learning, Uniform Student Learning

Output from Model	Student Grades, Gaussian Curves, Student's Brain Learning states, Job Priorities and sequence, and student grades
Teacher Lecture's recurrence time	1 hour
Simulation Space	2D/3D simulation

Figure 12 shows the JaamSim model for the proposed iterative and evidence-based instructional active learning process having mobile devices available with both teachers and students. This model considered random gender-based student (StudentType1 and StudentType2) inputs for registration. The random registration process considers students with exponentially distributed student inputs with different knowledge levels. A knowledge-based discrete distribution process randomly forms two groups in the initial state. To each student group (maximum of 60 in one classroom), one teacher is assigned for the proposed active learning strategy. An emphasis is considered for uniform knowledge distribution to all knowledge level students rather than giving more emphasis over specific category students. After classroom learning, student groups (traditional and proposed learning approach) are inputted to statistical evaluation. A comparative analysis of group statistical evaluation is performed by each teacher to evaluate their teaching strategies, the quantity of digital content before de-registration. Figure 13 shows the complete learning simulation model (traditional and proposed) execution with the use of mobile devices in learning. In the proposed learning approach, every teacher is given the flexibility to form student groups as per their convenience with random gender-based student division and provide study material offline as well in a way that students can access through mobile devices. A simulation process for this group formation is presented in Figure 14. Figure 15 shows the output event viewer screen with event ticks, simulation time, event priority, event description, and event state (complete/incomplete). Here, the teacher's responsibilities are to takeClass, evaluateStudent, gradeStudent, groupDivision and endStep. Similarly, student responsibilities are to registerSubject, classroomLearning, examPrepration, giveFeedback (course and teaching strategy) and endStep (deregistration). Similarly, every entity shown in Figure 12 model has a set of jobs/responsibilities.

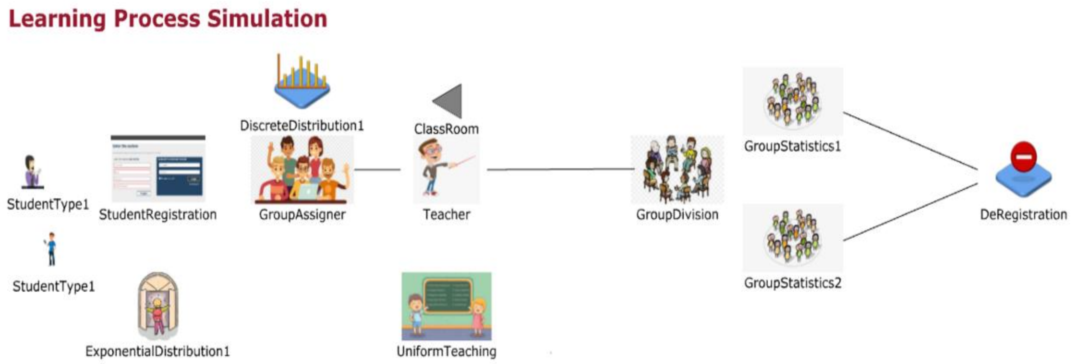


Figure 12: Traditional and Proposed Learning (with mobile devices) Simulation Model

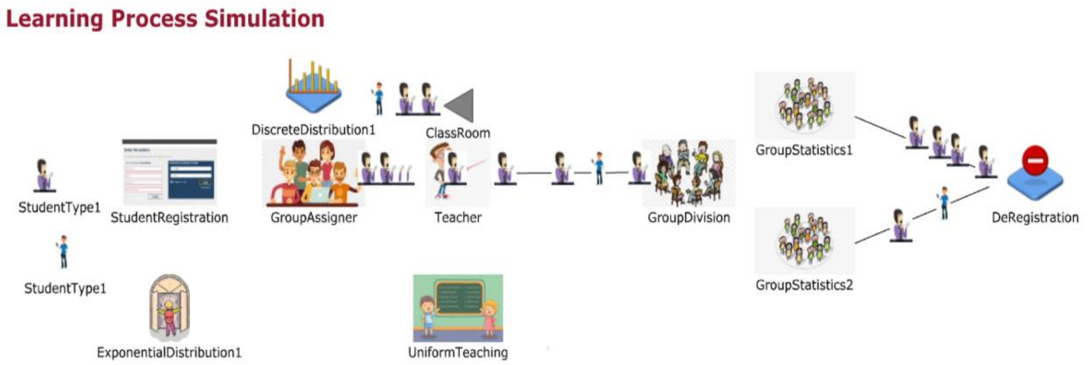


Figure 13: Traditional and Proposed Learning (with mobile devices) Simulation Model in Execution

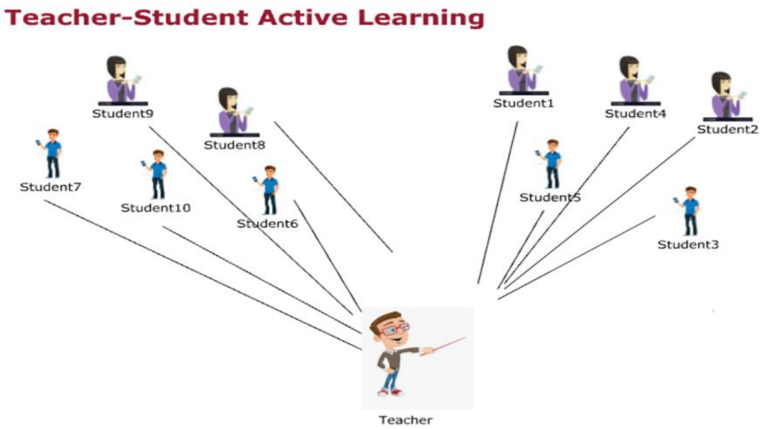


Figure 14: Teacher-Student (with mobile devices) Group Formation and Active Learning Process Simulation

Ticks	SimTime (s)	Priority	Description	State
4023253	4.02325299999...	5	Teacher.endStep	Completed
4219603	4.219603	5	StudentRegistration.endStep	Completed
4789632	4.789632	5	EntityConveyor2.endStep	Completed
4822253	4.822253	5	EntityConveyor1.endStep	Completed
4822253	4.822253	2	ClassRoom.UpdateAllQueueUsers	Completed
4842459	4.842459	5	EntityConveyor1.endStep	Completed
4842459	4.842459	2	ClassRoom.UpdateAllQueueUsers	Completed
5020943	5.020943	5	StudentRegistration.endStep	Completed
5486464	5.486464	5	EntityConveyor2.endStep	Completed
6023253	6.02325299999...	5	EntityConveyor2.endStep	Completed
6047086	6.04708599999...	5	Teacher.endStep	Completed
6219603	6.21960299999...	5	EntityConveyor1.endStep	Completed
6219603	6.21960299999...	2	ClassRoom.UpdateAllQueueUsers	Completed
6488822	6.488822	5	StudentRegistration.endStep	Completed
6536775	6.536775	5	Teacher.endStep	Completed
7020943	7.020943	5	EntityConveyor1.endStep	Completed
7020943	7.020943	2	ClassRoom.UpdateAllQueueUsers	Completed
7047085	7.047085	5	Teacher.endStep	Completed
8001458	8.001458	5	Teacher.endStep	Completed
8047086	8.047086	5	EntityConveyor2.endStep	Completed
8488822	8.48882199999...	5	EntityConveyor1.endStep	Completed
8488822	8.48882199999...	2	ClassRoom.UpdateAllQueueUsers	Completed
8536775	8.536775	5	EntityConveyor2.endStep	Completed
8789632	8.789632	5	EntityDelay1.removeDisplayEntity	Completed
8965429	8.965429	5	StudentRegistration.endStep	Completed

Figure 15: Simulation screenshot of active learning process execution, event viewer, and data collection.

Figure 16 shows the mapping of actual to simulation learning model1 for predicting the performance of large class and for long-term multiple subjects evaluations. It is observed that different teachers have a different way of adopting the proposed active learning process, and ways of self-learning and teaching. Thus, a trained model is simulated to predict the outcomes at a larger and longer scale. Here, inputs from the real scenario's outcomes are fed in the real to simulation learning model designed as shown in figure 16. This model is designed in such a way that student is expected to learn a piece of new knowledge in the form of concept, method, strategy or application after a mean intern-arrival time of 1.2 seconds. The simulation model's learning from real data is served on an average of 0.85 seconds. A simulation modelled learned knowledge is conveyed to randomly selected student brain to observe the student learning capacity and healthy brain states. An average brain learning time for each student is observed in seconds during the simulation. In the knowledgeDiscovery entity, Brain's knowledge level is conveyed to test student's ability to learned knowledge applicability. This applicability is measured with learned experiences from real scenario outcomes and evaluated in simulation's knowledgeDiscovery entity. Figure 17 shows the complete real to simulation active learning simulation model during execution. Figure 18 shows the comparative analysis of students' learning abilities for a subject's overall semesters to earn a degree. Students' brain learning abilities are measured from the grading point earned during the degree time. The class's overall performance is rated on a scale of 0 to 100. The average value of student's grades is considered for this analysis. As observed in AnyLogic analysis, JaamSim also validated that the proposed active learning approach constantly improves the student's brain learning abilities in technology understanding as compared to the traditional approach. This confirms the long-term learning abilities in the proposed active learning approach.

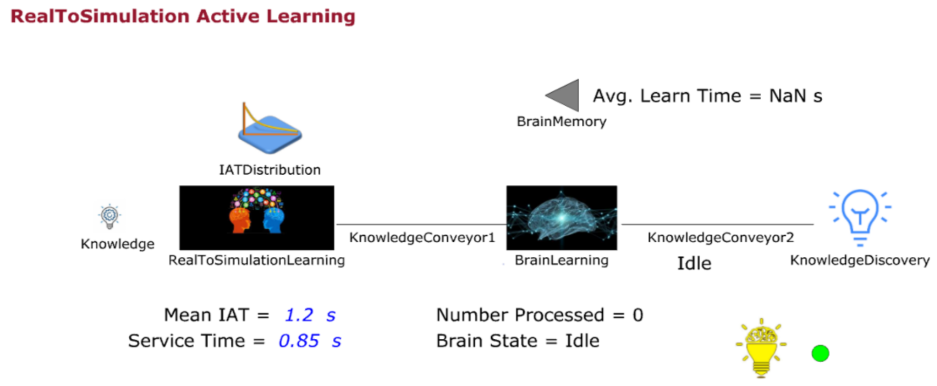


Figure 16: Real to Simulation Learning Model for Large Class and Long-Term Evaluation

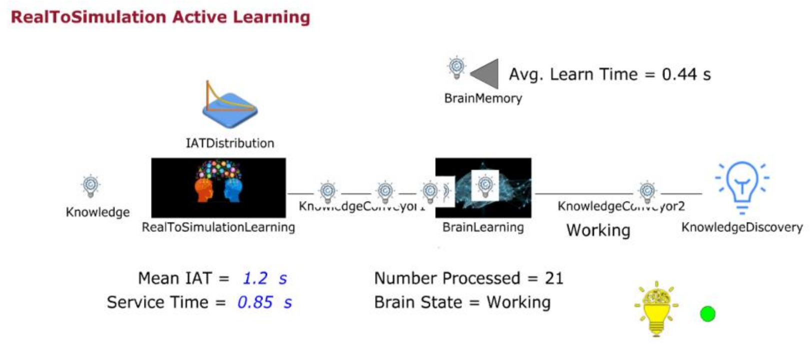


Figure 17: Real to simulation learning model in live execution mode

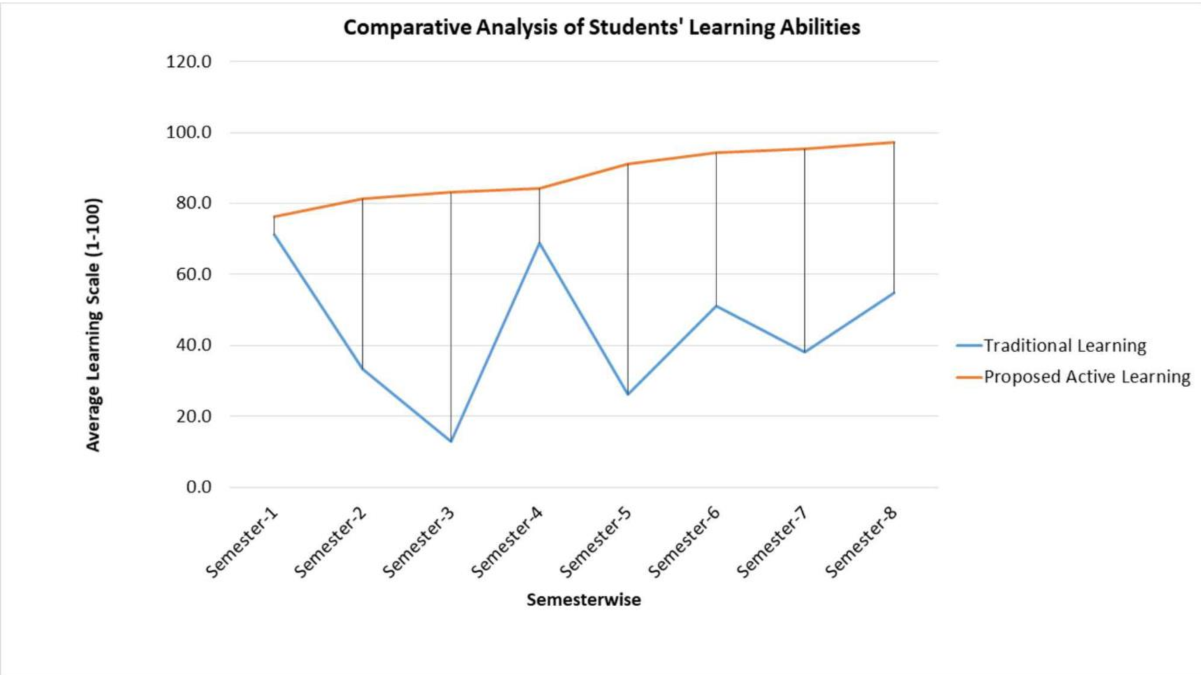


Figure 18: Comparative analysis of students learning abilities using JaamSim.

5. Conclusions and Future Scope

In this paper, an iterative active learning process for continuous teaching and learning framework has been proposed using a case study of PGCAP, which could be useful during COVID-19 Pandemic. In this iterative active-learning process, students are encouraged to maximize the use of digital devices (like mobile phones) and technologies (simulation, modelling, and learning management tools) and training is given to faculty members (in PGCAP program) to improve student performance. Further, a contiguous student interactive learning strategy in a classroom has been designed and implemented in real engineering courses. This work has been implemented an iterative and evidence-based active learning process to promote student learning and boost their performance through active participation in different subject events with various digital technology devices like mobile devices. In simulation and real-class based iterative and evidence-based active learning process**,** it is observed that active student participation in classes with mobile devices is helpful to both students and university. For students, it increases their physical activities and improvements in performance. Further, student involvement and retention in classes is shown to increase. As a result, 80% of students have shown improvements in their course grades in real scenario-1 and real scenario-2 experimentations, and student participation is found to be greater within 80% of the total classes. An online feedback process shows that students are satisfied with their learning through the proposed approach as compared to the traditional learning process. In parallel, a repository of digital content is prepared for long-term learning. Simulation analysis shows that students' grade varies between 0.4 (C+) to 1.0 (A) and their grades are much better than grades earned through the traditional learning process in simulation scenario-2. Thus, this proposed approach is very helpful specifically a in large class scenario that is common in Indian universities. In the future, the proposed iterative and evidence-based active learning process will be extended for large teacher group (more than 1000) as per the needs of the Indian university context and change in learning processes due to the COVID-19 pandemic. Strategies to enhance the quantity and quality of digital content will be proposed. Further, the feasibility of handling large student numbers by one or two teachers using digital active learning processes will be explored.

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Data Availability Statement

Significant amount of data is presented in the article. The remaining data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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