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Active Blended Learning Model for Teaching IoT Application Development Course: A Case Study

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***Abstract*—Traditional University learning approaches in Software Engineering, focusing on students listening to lecturers, then individually performing tasks is an isolating experience, a long way from the inherently collaborative approach in the workforce. Active learning focuses on student-centered learning in a much more authentic experience. This paper focuses on experiences in developing a course in the transnational education context involving a partnership between Indian and Australian universities. It highlights the design of a technical Software Engineering course for Internet of Things (IoT) application development with blended and active learning strategies and focuses on insights gained from implementing this curriculum for two different cohorts at an Indian university.**

***Keywords*—Active Learning, Blended Learning, IoT, Student Engagement, Embedded System, Software Engineering.**

***JEET Category*— Practice**

I. INTRODUCTION

The concept of Blended Learning (BL), which has been in existence for centuries, was eventually formalized into mainstream education. It has experienced significant growth from its early beginnings such as the first distance course offered by Sir Issac Puttman in the 1840s, to its current integration across various disciplines. This integration has been seamless due to the relevance and effectiveness of BL. (Lalima, 2017; Hrastinski, 2019, Prisla, 2020). According to (Graham, 2004), BL is defined as "*a system that combines face-to-face instruction with computer mediated instruction"*, whereas (Pankin et al., 2012) defines it as "*structured opportunities to learn, which has more than one learning or training method, inside or outside the classroom".* Based on these definitions, BL combines multiple learning strategies and thrives in an educational environment where infrastructure support like computers and Internet services are readily available, (Banditvilai, 2016; Bowyers, 2017; Hrastinski, 2019; Silberman, 2006, Mantri, 2008).

As per UNESCO Education 2030 framework presented by United Nation Sustainable Development Goal (SDG4), inclusivity, quality education and lifelong learning are recognized as three principles to ensure quality education among masses (Castro, 2019). To achieve these key goals, present educational setup has witnessed a transition from traditional teaching to technology-enabled teaching style, using modern teaching-learning pedagogies, ICT tools, Massive Open Online Courses (MOOC's), e-learning, immersive technology-based learning tools and digital learning platforms to overcome the shortcomings of conventional teaching style (Lalima, 2017; Singh, 2019; Singh, 2020; Kumar, 2020). In the current context, the most common approach followed in Higher Education Institutes (HEI's) is blended learning, where teachers provide online and offline instructions and resource materials to the students. The strategic use of this approach inside the classroom has accredited improved course outcomes (McCarthy, 2023; Almmary, 2014; Bernard, 2014). Blended learning approach allows teacher to use classroom time judicially by engaging students in active and substantial activities thus enhancing their attention span (Bowyers & Chambers, 2017). However, blended learning implementation may not yield expected results in terms of student learning if it not implemented judiciously. Factors like lack of infrastructure, non-availability of skilled teaching staff, indirect supervision, increased cognitive load of students and increased workload of faculty and student, may purpose offset all the positive outcomes of implementing blended learning in the classroom (Rasheed, 2020; Szadziewska, 2017). Further, this transition also ratifies displacement of teacher-centric style to student-centric learning style and emphasizes activities which can be performed inside or outside classroom.

To overcome these challenges, some Active Learning (AL) strategies are integrated into BL (Cummings, 2017). Active

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learning is one of most predominant form of learning style to impart STEM education at various levels of education. It has various sets of activities which can be deployed inside or outside class and with or without use of technology. The primary intention of AL activities is to increase interaction and engagement at all levels and encourage students to take more responsibility in their own learning (Edison, 2010). Furthermore, AL activities contributes towards improved student engagement, learning motivation, higher order thinking skills and enhanced retention time inside classroom (Capone, 2022; Jensen et al., 2015). This learning style is successfully deployed in teaching courses like mathematics, embedded system, and computing during Covid 19 times and pre-post to that too. Based on the studies reported in (Aji, 2019; Suchithra, 2023; Shoufan, 2021; Tewolde, 2017), implementing AL has impacted positively on student engagement and motivation towards learning. Thus, integration of active learning activities in blended learning environment focusses more on different types of interactions, student-student, student-teacher, student-content, in appropriate classroom setup. This paper presents the case study on implementation of active blended learning (ABL) model to teach IoT application development courses to undergraduate students. The remainder of the paper is organized as follows. Section II introduces the proposed ABL model and implementation plan of this ABL model in SIT2019 in section III. Section IV discusses challenges in implementing ABL in the course and the lessons learnt followed by concluding remarks and future scope in Section V.

II. Proposed ABL Model

The Active Blended Learning model (ABL) is an integration of two different teaching-learning strategies resulting in unique virtue to cater all needs 21st century learners. The proposed ABL model for this work is depicted in figure 1 below.

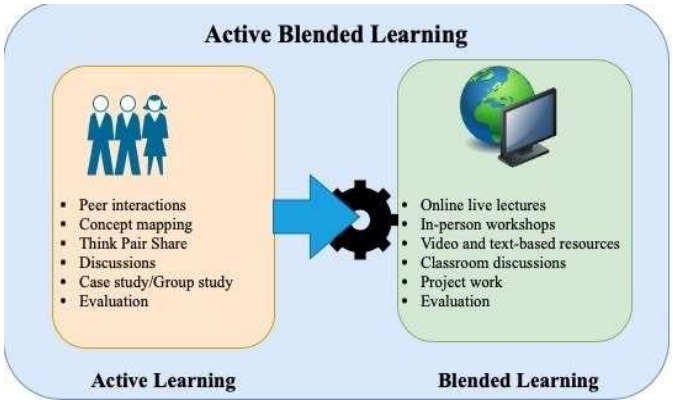


Fig 1: Proposed ABL Model

The schemas of AL and BL are combined in such a way that it results in novel teaching pedagogy whose characteristics are as follows:

- *Interaction:* improved interaction with peers, teachers/faculty/tutor, and teamwork.
- *Type of activity*: learning activities which entertain all learners needs.
- *Resources:* up to date access to digital resources used for teaching.
- *Skills gained:* critical thinking, social skills, collaborative skills, technical competencies, and computing skills.
- *Future implication*: high degree of digital integration with technology and learning environments.
- *Evaluation and Feedback: Rubric* based evaluation of task and continuous feedback through OnTrack LMS.

III. Implementation of ABL Model

A. About the Course

The proposed ABL model was implemented in the two credit-point SIT209 – Software Engineering 2: Development of Internet of Things course. The Internet of Things (IoT) refers to a network of interconnected objects that are capable of sharing data with other systems and devices through a network. As per the literature, this technology has shown a high degree of correlation with learning behavior and acceptance among undergraduate students, thus included in the curriculum (Malhotra,2021). The course is undertaken by the students in Bachelor of Engineering (Software Engineering) at Chitkara University, India under the academic mentorship of Deakin University, Australia. The overall course is structured into two modules: **Learning and Deployment**.

1) **Learning module**: The first part of the course is dedicated to learning of the course content which the students will then use in the deployment part of the course. During this module, the basic concepts such as introduction to web development, backend development, connecting things, testing, and deploying IoT solutions, security and data analytics are delivered to the students using BL and AL activities.
2) **Deployment module**: Using the knowledge gained through the learning module, the students engage in a group, ideally 5 student members, project during the deployment stage. The students undergo four sprints, where a sprint is a weekly execution plan, to carry out their project work. Each sprint consists of several activities such as weekly team meetings, role distribution, task assignment, peer feedback and evaluation, individual and group sprint retrospective report submission on OnTrack. Students make use of project management software tools like Jira or Trello to track project progress throughout this module and submit evidence of their individual and group contributions in their reports and final portfolio submissions.

B. Course Learning Outcomes

The course is designed to achieve six course learning outcomes (CLOs) as illustrated in Table 1.

Table 1: Course Learning Outcomes – SIT209

Course Learning Outcomes (CLO)	Description
CLO1	Research real world web application development technologies and best practices.
CLO2	Develop working web application prototypes for cyber-physical systems that demonstrate effective application of underlying technologies and approaches.
CLO3	Contribute effectively to team-based agile development projects by applying appropriate practices and project management techniques.
CLO4	Establish and evaluate continuous delivery infrastructure that supports web application development, testing and deployment.
CLO5	Prepare application documentation that clearly articulates key technologies and processes used in application development, implementation, testing and deployment.
CLO6	Analyze, critique and reflect upon a portfolio of artefacts to reason about and evidence achievement of specified objectives and goals.

As per the course learning outcomes, a significant emphasis is laid on the following points,

- **Application:** encouraging the students to apply the knowledge gained during the Learning module to design and implement solutions to real-life problems through project demonstration.
- **Communicate:** encourage the students to have healthy communication with instructor, content, and peers throughout the unit.
- Reflect on learning: encourage the students to reflect on their learning through project demonstrations, report and portfolio submissions and interviews.

C. Evaluation Scheme of SIT209

The evaluation of the course is 100% portfolio based and is carried out through the OnTrack submission system (Renzella, 2017). The OnTrack is a proprietary assessment and evaluation tool developed by Deakin University to promote continuous student progress through active, timely and constructive feedback to students. Throughout the semester, the students work on OnTrack tasks, receive feedback on their work, and compile them into a learning portfolio for final evaluation. The assessment of the unit is again structured in relation to the learning and deployment modules of the course. Table II shows the categorization of the tasks and their associated grade.

Table II: Categorization of Target Grade

Type of Task/Count	P	C	D	HD
Individual Tasks (10)	■	■	■	■
Above and Beyond Task (5)		■	■	■
Individual Project (1)			■	■
Group Project (1)	■	■	■	■

Table II shows the categorization of the tasks and their associated grade. Based on this, a student targeting a Pass grade should submit all 10 Pass tasks and the group project. A Student opting for a Credit will need to submit all Pass tasks, all Credit tasks, and the group project. On the other hand, students targeting Distinction and High Distinction will need to submit all Pass, Credit and complete both individual and group projects. The complexity of the individual project will determine if the student receives a Distinction or a High Distinction.

Table III: Description of Grades

S. No	Abbreviation	Type of Grade	Marks in Range
1	F	Fail	0-49
2	P	Pass	50-59
3	C	Credit	60-69
4	D	Distinction	70-79
5	HD	High-Distinction	80-100

Table III shows the description of grades on the OnTrack system. The student combines all task submissions into a learning portfolio and submits them on OnTrack for final evaluation. The evaluation will share the rationale of the portfolio and give marks as per table III, which will be utilized for preparing final grade summary of student.

During the Learning module the OnTrack tasks are related to the active learning tasks sheets that the students work on during in-person workshops. The learning content pertaining to a given week is made available on-line for students to go through before joining the class. The students then go through the AL task sheets as groups through peer discussion and feedback under the supervision and guidance of the tutor/lecturer. The outcomes of these AL task sheets are then

submitted as OnTrack tasks and receive feedback from the tutors/lecturers. During the Deployment module, the students work in groups designing and deploying a web application integrated into an IoT system. The progress of the project work, which details the student contribution in technical, project management and communication is reported through OnTrack for feedback. The assessment components during both Learning and Deployment modules therefore consists of significant student-to-student, student-to-educator, and student-to-content interaction.

D. Implementation of ABL Model

As discussed in Section II, the ABL model implemented in SIT209 consists of active learning and blended learning approaches. Figure 2 illustrates the ABL model implemented with different AL and BL strategies implemented at different stages of learning.

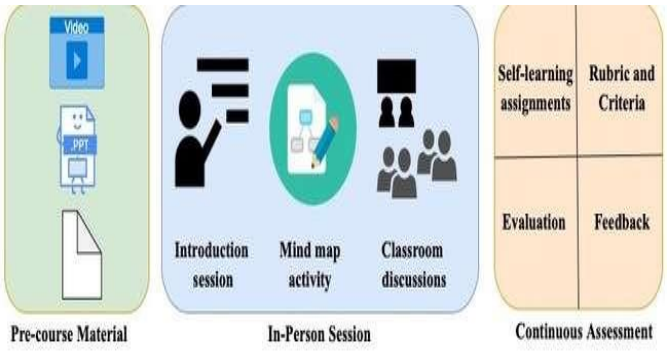


Fig 2: Implementation plan of ABL in SIT209 course

Pre-course material: Weekly learning material such as lecture slides, recorded videos and reading materials are made available to the students at the beginning of the semester. This allows students with different learning styles and grade expectations to progress in their studies at their own pace. Different learning material also caters to different learners, thereby improving the student interaction with the learning content.

In-Person Workshop: The students attend weekly in-person workshops guided by the lecturer/tutor. It is assumed the students have gone through the technical content available online when they attend the in-person sessions. The tutors from both universities, Deakin, and Chitkara, are present in the workshop sessions for discussion and guide students in clearing any doubts they may have. The sessions start with an initial introduction into the weekly content followed by Think-Pair-Share and mind-map activity to build upon the theoretical foundation of concept. During this activity session, students are engaged in peer discussion and receive constructive feedback from the tutors. In the end of session, teacher summarize all important points of concept taught and discuss the task sheet with students and tell them about the expected outcome from the task.

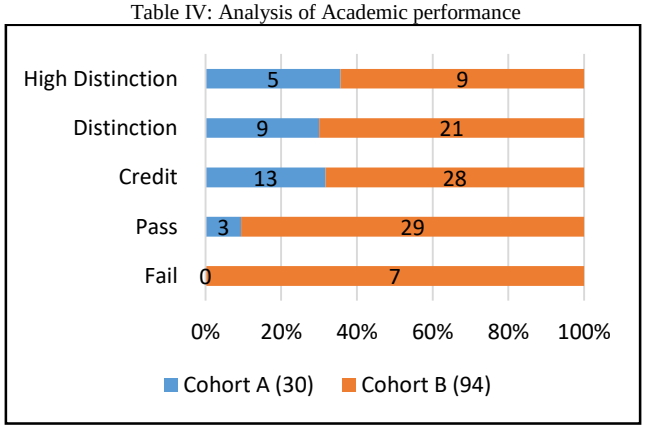
Assessment: As discussed before, the assessment of the course is done through OnTrack with weekly tasks related to active learning sessions (Weeks 1-5) and group project (Weeks 6-11). In OnTrack, students first submit their tasks, which are then evaluated by the markers. Upon receiving the feedback, the students can resubmit the tasks. This continuous evaluation scheme helps students to understand their shortcomings and have a chance to revise the submission in correct version. Most importantly, the feedback mechanism allows students to engage more with the staff.

As can be seen in this model, the students have multiple points of contact with their peers, course staff and learning content throughout their learning journey. The unit content, assessment and the teaching style are structured in such a way that the students must take initiative in each of these interactions and thereby focus on a more student-led learning approach.

E. Impact of Implementing ABL in SIT209

The impact of implementing ABL in SIT209 is evaluated using academic performance of two student cohorts who went through purely blended learning (named as Cohort A) during COVID-19 against active learning infused blended learning (named as Cohort B) post-pandemic time. The comparative analysis of academic performances of two cohorts are given in table IV below:

Table IV: Analysis of Academic performance



Analyzing the data presented in figure IV, it becomes evident that in cohort A (30 students), a substantial number of High Distinctions and Distinctions were observed indicating abnormal final grade distribution. This trend was coupled with a skewed distribution, which leaned towards a higher frequency of Credits compared to Pass grade students. Experience shows that a well-designed assessment approach in conjunction with optimized course delivery model should lead to a move or even spread of results. In the second cohort B (94 students), the expectations of the assessors were increased, and with this communicated to the students at the outset. This led to a naturally more even spread in Cohort B, with less students achieving the highest grade and more students choosing to focus more on ensuring the pass level. It is worth noting that student satisfaction was higher in Cohort B, attributed to a

generally increased understanding of the ABL approach to learning.

IV. CHALLENGES AND LESSONS LEARNT

Implementing ABL in Chitkara University, India presented multiple challenges that were attributed to general higher education sector and to Indian education context. This section presents these challenges and our strategies towards overcoming them.

A. Challenges

1) Change in teaching style:

Before implementing ABL in SIT209, the course was delivered in pure BL method where the content is available online, but a lecturer-led teaching style is practiced during in-person workshops. However, introducing active learning strategies into the in-person workshops required the lecturers and tutors to also change their teaching approach. This has been demonstrated to have substantial benefit in the Software Engineering context, particularly when combined with persona-based assessment (Arora, 2023).

2) Student perception and cognitive load:

As discussed above, the students are accustomed to teacher-led learning in traditional learning approaches which is common in the Indian content, struggle with student-lead learning which is becoming more common in the Australian context. Substantial effort was required to convince students that driving their own learning was beneficial. In SIT209, this was demonstrated through requiring students to reflect on their learning, which convinced them it was a beneficial approach.

3) Availability of teaching spaces to support active learning:

Active learning is focused on students engaging in activities as individuals and teams, in interactive sessions. This works best with large flat-floor classrooms rather than traditional lecture rooms. As such, it was important that these spaces were available to allow SIT209 students to engage. Figure 3 and Figure 4 illustrate a learning space specifically designed for AL at Deakin University and Chitkara University respectively. The layout facilitates group discussions, inter-group discussions and open interactions with the teacher guiding the class. The lack of such specifically designed spaces at Chitkara University made it challenging for the staff to conduct in-person sessions in a more engaging manner.

4) Student cognitive technical load

The course was demanding for students in two ways, i) the active learning-based approach, and ii) the technical content. To provide a challenging and authentic software engineering project experience, it was important for students to develop a range of skills. In SIT209, this included learning core technologies (Node.js, web technologies), integration technologies (web APIs, Express), data technologies (MongoDB) and presentation technologies (CSS, GUI frameworks). The work ethic of students in the Indian context ensured that the students learned these technologies to a high standard, ensuring that the active learning aspects in the projects was successful.

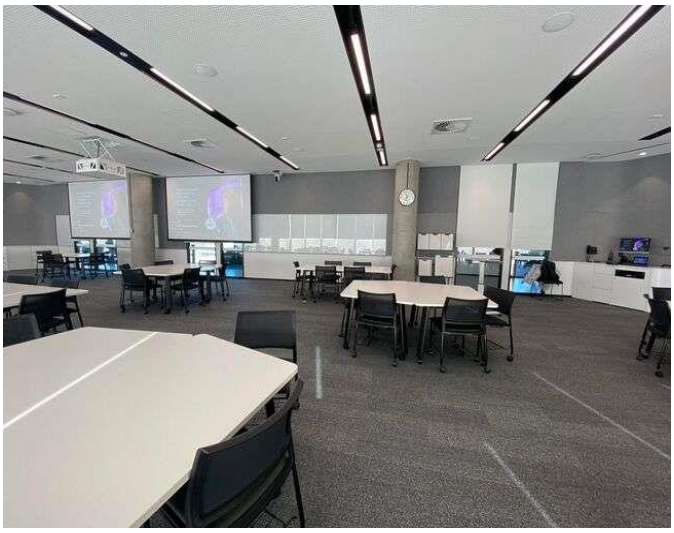


Fig 3: Active Learning Classroom at Deakin University

Fig 4: Active Learning Classroom at Chitkara University

B. Lessons Learnt

Delivering SIT 209 under an ABL model exposed the lesson learnt after implementing ABL in SIT209 unit was that the flexibility provided by the model to work and learn at your pace proved to be exceptionally beneficial, especially for diverse range of learners. Further, due to the technical complexity and range of technical skills gained through the unit, some students opted for real-time problems and industry-grade projects which gave them wide exposure to learn several new tools and techniques which were not incorporated in even the syllabus of the unit. On the other hand, slow learners of the class also got chance and handholding from fast-learners group of students to understand netiquette of tasks and do their submissions on time. Thus, overall experience of implementing ABL model in SIT209 unit is quite enriching in knowledge and learning for both teacher as well as for student.

V. Conclusion

This paper has discussed a case study of the use of Active Blended learning for teaching a highly technical course on IoT application development to Software Engineering students. The context was a course developed in partnership with an Indian and an Australian university which offered unique challenges and opportunities. The ABL approach in this context allowed students to gain a range of technical skills quickly and use these to demonstrate their learning in a reflective way and participate in team projects. The use of this approach across two cohorts demonstrated lessons in teaching style, student perception, the required teaching spaces, and student cognitive load. The proposed ABL model presented the course contents to students in a comprehensive manner and helped students develop IoT applications from scratch. Overall student experience while undergoing the course is notable with improved student learning outcomes.

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