# A Case Study on - Enriching Learning Ability among Students By Adapting Collaborative Experiential Learning Based on Kolb's Model

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***Abstract***— **This study explores the implementation of a Collaborative Experiential Learning (CEL) model in an undergraduate engineering course on 'Sensor and its Applications'. The CEL model integrates the experiential learning approach, as conceptualized by David Kolb, with collaborative learning techniques, aiming to enhance student engagement, application skills, and teamwork. The study involved 65 students working in diverse groups to design sensor-based applications, promoting hands-on experience and peer learning. The methodology was structured into phases including group formation, expert group discussions, and project execution, with an emphasis on equal participation and active collaboration. Results indicated that the CEL model significantly improved students' academic performance and practical skills, while also fostering essential soft skills such as communication and problem-solving. However, challenges such as language barriers, unequal participation, and dominance by certain group members were identified. Despite these issues, the CEL model was positively received, with students appreciating the enhanced learning experience and its relevance to future career opportunities. The study concludes that while CEL is effective in engineering education, further adjustments are necessary to optimize group dynamics and ensure equitable participation, thereby maximizing the pedagogical benefits of this approach.**

***Keywords—Experiential Learning; Kolb's Learning Model; TinkerCAD; Jigsaw; TAI; TGT; PBL; Sensors and Applications; Collaborative Learning***

**ICTIEE Track: Pedagogy of Teaching and Learning**
**ICTIEE Sub-Track: Design-based research methodology for pedagogical interventions in learning**

## I. INTRODUCTION

IN the rapidly evolving field of engineering education, traditional lecture-based instruction is increasingly being complemented by active learning strategies that engage students more deeply in the learning process. Experiential learning, which emphasizes learning through direct experience, has emerged as a particularly effective approach in this context. This pedagogical strategy aligns with the principles of active learning (Prince, 2004) and has been shown to enhance student engagement, comprehension, and retention of complex concepts. Experiential learning, as conceptualized by David Kolb, involves a cyclical process of experiencing, reflecting, thinking, and acting. This model showed in Fig.1, often referred to as Kolb's Experiential Learning Model, is particularly well-suited to engineering education, where practical application of theoretical knowledge is essential. The model's four stages—Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation—provide a comprehensive framework for designing educational activities that foster deep learning.

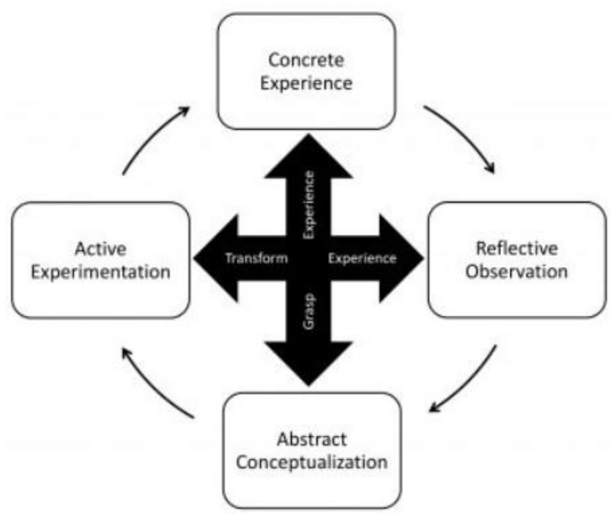



Fig 1. Kolb's Experiential Learning Model [3]

This model emphasizes learning through experience, reflection, conceptualization, and experimentation, making it particularly suitable for application-based course like 'Sensor and its Applications' (Kolbs,1984).

While experiential learning; with its emphasis on direct experience and reflective practice, offers significant advantages in engineering education, it has certain limitations compared to collaborative learning (Johnson et al., 1991). One notable shortfall is that experiential learning tends to focus more on individual experiences and personal reflection, which can sometimes limit the scope of peer interaction and collective problem-solving (Harasim, 2012).

In contrast, collaborative learning explicitly encourages teamwork, communication, and the sharing of diverse perspectives, which are critical skills in engineering practice (Brown et al, 2014). Collaborative learning fosters a sense of community and leverages the strengths of group dynamics, which can lead to more innovative solutions and a deeper understanding of complex concepts through shared insights and cooperative efforts (Freeman et al, 2014). This collective approach can be particularly beneficial in addressing multifaceted problems that require interdisciplinary knowledge and collaborative skills (Stice, 1987).

Collaborative learning, a pedagogical approach where students work together to achieve shared learning goals, has gained prominence in educational settings across disciplines (Garrison et all, 2008). When students work together, they are exposed to diverse perspectives and approaches to problem-solving. This interaction promotes critical thinking as students evaluate and integrate different viewpoints (Entwistle, 2009). Effective collaboration requires clear communication.

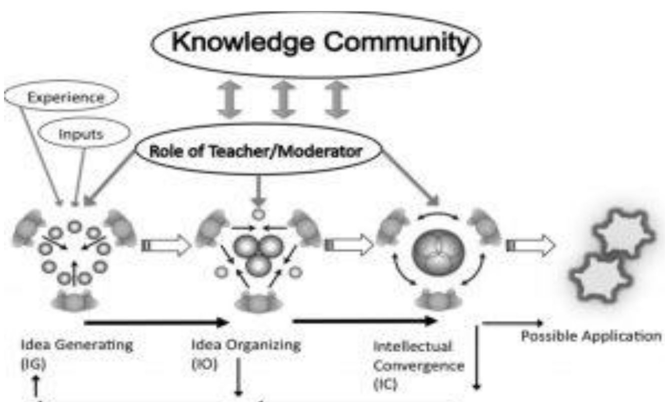



Fig 2. Linda Harasim's Online Collaborative Learning Model: Pedagogy of Group Discussion (Brindley et all,2009)

As depicted in Fig 2: through group work, students practice articulating their ideas, listening to others, and negotiating solutions, all of which are essential skills in the professional world (Brindley et.al, 2009). Collaborative activities often require students to explain concepts to their peers, which reinforces their own understanding and aids in the retention of information. Teaching others is one of the most effective ways to learn (Perkins, 2009).

One effective method of collaborative learning is the Jigsaw technique, where students are divided into small groups, and each group member is assigned a unique segment of the material. After becoming "experts" in their segments, they reconvene to share their knowledge with their original group members. Methodology session gives detailed explanation on the same (Shulman, 2005).

Hence in the proposed Collaborative Experiential Learning (CEL) model, author blends both experiential learning and collaborative learning approach to enrich learning ability among engineering students. In line to this, author implemented proposed model in one of the undergraduate courses on 'Sensor and its Applications'. This work aims to assess the impact of the unique collaborative learning method on student engagement and learning outcomes in a 'Sensor and its Applications' course.

Additionally, it seeks to identify the challenges and obstacles encountered during the implementation of the proposed approach and its strategies for improving the effectiveness of Collaborative Experiential Learning activities in engineering education (Felder, 1988). By exploring the implementation of Collaborative Experiential Learning, this study seeks to provide insights into how teamwork and shared learning experiences can enhance skill based educational outcomes in engineering. The findings will contribute to the broader understanding of Collaborative Experiential Learning (Leslie & Gorman, 2017) and its role in preparing students for professional engineering practice, holding up them for placement opportunities and to support skill India Abhiyan.

## II. RELATED WORK

The "Experiential Learning in Engineering Education" (Alan, 2023) provides an in-depth exploration of Experiential learning (EL) in engineering education, emphasizing hands-on, practical applications of theoretical concepts. Steele integrates global research case studies and his extensive experience to offer valuable strategies for educators and faculties, particularly in adapting to post-pandemic educational challenges. The book underscores the iterative nature of EL, highlighting the importance of continuous experimentation, observation, and reflection to enhance critical thinking and problem-solving skills. Key aspects include innovative approaches like flipped classrooms and cooperative education, which foster deeper student engagement and practical experience (Bonwell et all, 1991). While the book excels in providing evidence-based strategies, it also points out areas for improvement, such as the need for consistent depth across chapters and clearer guidance on student reflection. Addressing the implications of AI tools in assessments is also crucial. Overall, Steele's work serves as a comprehensive guide for integrating EL into engineering curricula, preparing students for real-world challenges and promoting the development of critical skills and societal awareness (Wenger, 1998).

The study by (Harasim, 2012). addresses the significant challenge of high dropout rates in online learning environments by leveraging machine learning algorithms to predict at-risk students. This research underscores the importance of experiential learning in developing robust predictive models. By utilizing historical data from the Learning Management System (LMS) at BINUS Online University, the authors applied four machine learning algorithms—Naive Bayes, Logistic Regression with Lasso, Logistic Regression with Ridge, and Support Vector Machine (SVM)—to predict student dropouts (Monchai & Sanit, 2013). Each algorithm's performance was meticulously evaluated, revealing that Logistic Regression with Lasso and SVM achieved the highest accuracy and precision. This iterative process of model testing and refinement embodies experiential learning, where continuous feedback and real-world data inform and enhance predictive accuracy. The study highlights the practical benefits of such an approach, enabling timely interventions to support at-risk students, ultimately reducing dropout rates and improving educational outcomes (Ramsden, 2003).

Collaborative learning approaches, including Jigsaw, TGT (Team Game Tournament) (Noor Mardliyah, 2020) and TAI (Team-Assisted Individualization), have been extensively studied for their effectiveness in diverse educational settings. The Jigsaw (Océane Cochon Drouet, 2023) method promotes interdependence by having students learn different segments of a topic and then teach their peers, which fosters accountability and enhances comprehension (Yogesh et all, 2023). TGT builds on this by introducing competitive elements, motivating students through structured games that reinforce learning and drive engagement (Michaelsen et all, 2004). TAI further personalizes learning by allowing students to progress at their own pace while still benefiting from peer support, effectively merging the strengths of individualized and cooperative learning (Higinio et all, 2020). These methods collectively address varied learning needs, promoting active participation and personalized learning, though challenges remain in ensuring consistent group dynamics and equitable participation (Chickering,1987).

The Jigsaw method stands out as the most effective collaborative learning approach among various methods like TGT (Team Game Tournament) and TAI (Team-Assisted Individualization) (Ana Marie, 2023). The Jigsaw approach's emphasis on interdependence and accountability fosters a deeper understanding of content, as students must not only learn their assigned material but also teach it to their peers. This process ensures that each student is actively engaged and responsible for the learning of others, thereby promoting both individual and collective comprehension. While other methods like TGT introduce competitive elements to enhance motivation and TAI merges individual and group learning benefits, Jigsaw's unique structure maximizes engagement and comprehension by making each student's contribution indispensable to the group's success (Salter et all, 2013).

However, despite the strengths of the Jigsaw approach, there are some gaps and challenges that need to be addressed to optimize its implementation. These include ensuring consistent group dynamics, which can be challenging if not all students are equally motivated or capable of contributing effectively. Additionally, equitable participation must be guaranteed so that all students benefit equally from the collaborative process (Jensen & Lawson2011). Therefore, the proposed methodology, Collaborative Experiential Learning (CEL), aims to bridge these gaps by enhancing both group dynamics and active learning, combining the strengths of existing collaborative approaches to create a more balanced and effective learning environment (Chickering, 1987).

## III. METHODOLOGY

The proposed methodology outlines a collaborative experiential learning activity implemented in an undergraduate course on 'Sensor and its Applications'. The goal is to enhance student engagement, application skills, and collaborative learning through this proposed CEL model as represented in Fig.3. The study involved 65 undergraduate students divided into 13 groups of five, formed based on their previous academic performance to ensure diverse abilities and overcome issues such as free-riding and dominance by more competent students.

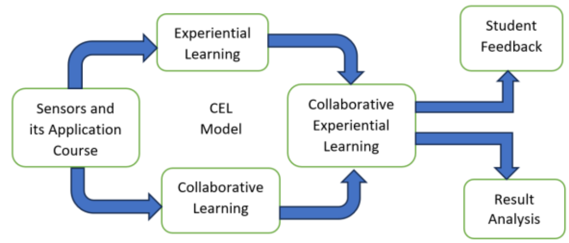



Fig 3. The proposed approach for Collaborative Experiential learning (CEL)

The course 'Sensor and its Applications' consists of FIVE units in the syllabus; the proposed CEL activity is planned after the completion of 4th unit and before the commencement of 5th unit. The reason is 5th unit dealt with applications. Before, teaching the 5th unit with existing applications, an opportunity is provided to the students to think 'out of the box' to enhance their application skills. The unit-1 to unit-4 gives the detailed information about all the sensors, processor/controller and actuators.

Inline to this, CEL activity was conducted among students' group to design the applications using the selected sensors. This activity creates interest among individual students, because each student needs to work on one part of the application in a team. The activity gives equal opportunity and scope to each and every student which overcomes the obstacles like 'lack of collaboration' and competence status.

All the students' need to works actively, then only the team can come up with an application. This ultimately overcomes the free ride and friendship obstacles. The selected topic and selected activity will enhance the students thought process on a particular sensor usage as well improves their academic performance. Fig.4 shows the execution flow of the CEL activity.

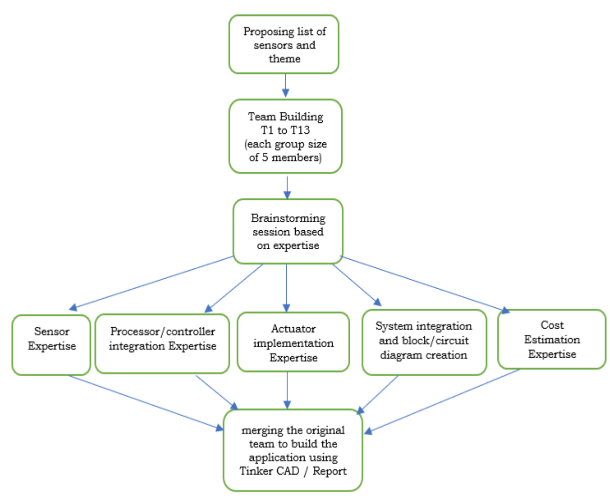



Fig 4. CEL Execution Flow

***Stage 1: Group Formation and Task Assignment***

The activity begins by dividing the class into groups, each tasked with selecting a sensor and brainstorming its application in a home automation system. This phase allows students to immerse themselves in a hands-on project, dealing directly with the sensors, discussing their functions, and exploring potential applications. The Table.1 gives the activity time split up chart.

Each group selects one of the five sensors. (Ultrasonic, Gas, Motion, IR, Humidity/Temperature).

Tasks are distributed within each group:

- Member 1: Sensor functionality
- Member 2: Processor/controller integration
- Member 3: Actuator implementation
- Member 4: System integration and block/circuit diagram creation
- Member 5: Cost estimation

TABLE I
ACTIVITY TIME SPLIT-UP CHART

| Sl.No | Activity | Time Duration |
|---|---|---|
| 1 | Identifying the Application | 60 Min |
| 2 | Expert Group Discussion | 60 Min |
| 3 | Parent Group Discussion and execution | 90 Min |
| 4 | Feedback on Activity | 20 Min |
| Total | | 230 Min |

***Stage 2: Expert Group Discussion***

After the initial brainstorming, students are reorganized into expert groups based on their specific roles (e.g., working of sensor, processor/controller, actuators, integration, and cost estimation). In these expert groups, students discuss the pros and cons of their respective subtopics. This stage encourages them to reflect on their initial ideas, observe different perspectives, and critically analyze their contributions and the insights of their peers. Reflective observation is crucial as it helps students internalize their experiences and prepare for the next phase of learning.

***Stage 3: Parent Group Discussion and execution***

Students then return to their original groups, bringing back insights from their expert discussions. The group integrates all components (sensor, processor, actuator, system design, and cost estimation) to develop the home automation system. The groups integrate these insights to prepare a final report or presentation on their application, encompassing all subtopics. This stage involves synthesizing information and forming abstract concepts or generalizations from their reflective observations. It fosters critical thinking and helps students develop a conceptual understanding of the entire project. In this activity, students are encouraged to develop the applications using TinkerCAD or power point presentation. TinkerCAD, a free, easy-to-use web-based application for creating circuits, and code integration. TinkerCAD offers an interactive platform where students can simulate and visualize their projects in real-time. The Fig.5 shows the one of the group sample project executions done in TinkerCAD.

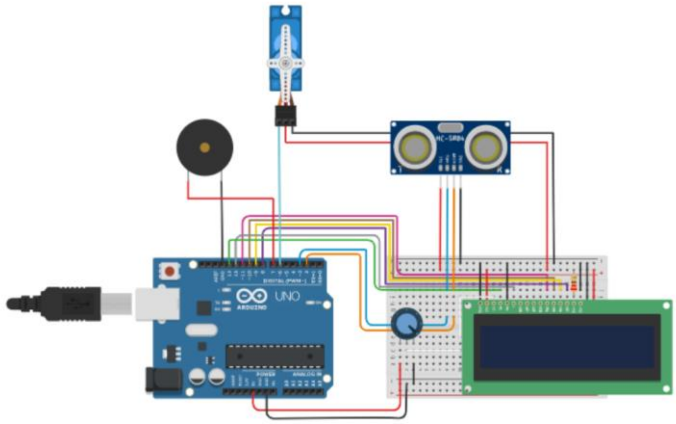


Fig. 5. Ultrasonic sensor-based home security system

After the completion of execution, students were required to upload their designs, presentations, final reports and a recorded video of their activities to the course web portal within three days. These submissions were evaluated by the faculty members and final-year students.

***Stage 4: Feedback Collection and Reflection***

The feedback was collectively taken from the students on the activity conducted based on few parameters. The feedback taken on the scale of 1-5 (1 is Not Satisfactory, 2 is Satisfactory, 3 is Good, 4 is Very Good, and 5 is Excellent), covering aspects such as enjoyment of the activity, the effectiveness of Collaborative Experiential Learning, teacher preparation & knowledge transfer, group formation & satisfaction, enhancement of knowledge & thinking skills, frequency of such activities, the role of expert group discussions, appreciation of ideas, and impact on placement and higher studies. Specific student comments highlighted issues such as shyness, language barriers, competence differences, lack of encouragement, nervousness, and dominance within groups. The statistical analysis on feedback focused in quantitative analysis result section.

**Challenges encountered during the activity are:** designing appropriate tasks, composing groups, managing class time, monitoring behavior, providing materials, assigning roles, and establishing teamwork norms. Observed obstacles during the activity included a lack of collaborative skills, unequal participation, dominance by certain members, and the impact of friendships on group dynamics.

To address these issues in future implementations, guidance on the importance of Collaborative Experiential Learning, encouragement of regular class attendance, heterogeneous grouping, and the discouragement of free riding and favoritism were planned. Additionally, more time would be allotted for activities, and students would be informed about the long-term benefits of active participation in CEL activities.

## IV. Results

**The proposed method was analyzed by qualitative and quantitative analysis.**

**Qualitative Analysis:** Students appreciated the hands-on approach and the opportunity to work in groups, which fostered a deeper understanding of sensor applications. Many students found the expert group discussions particularly beneficial, as they provided diverse perspectives and specialized knowledge.

Language barriers and varying competence levels within groups sometimes hindered effective collaboration. Some students felt that dominant members overshadowed others, leading to unequal participation. A few students reported discomfort in mixed-gender groups, which affected their willingness to participate actively.

The main challenges identified were a lack of collaborative skills, unequal participation, and time constraints.

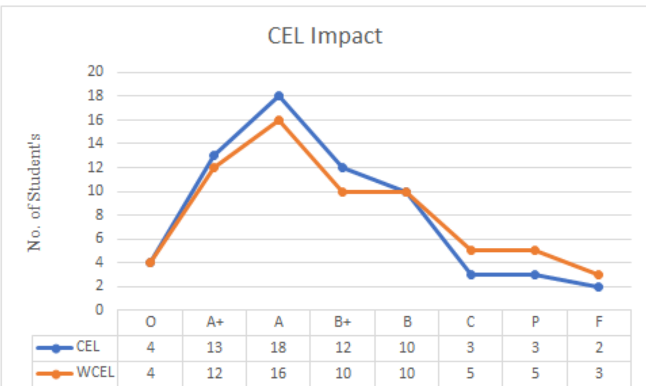
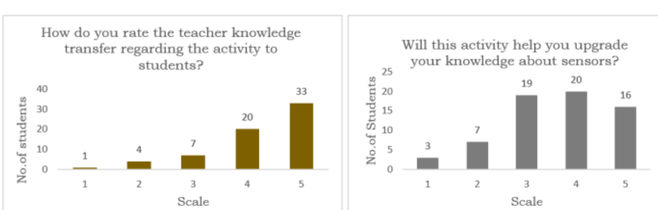



Fig. 6 . CEL Impact on Academic Performance

The application of innovative concept of CEL, has led to marked improvements in academic performance among undergraduate engineering students by enhancing lower grade to higher grades as shown in Fig.6. Experiential learning in a collaborative environment not only deepened students' understanding of course content but also cultivated essential soft skills such as teamwork, communication, and problem-solving. These skills were prominently demonstrated during their presentations, which formed a key part of the qualitative assessment within the experiential learning framework. Despite the potential vulnerabilities, the structured approach of Kolb's model provides a robust framework for skill upgradation at the teaching-learning level, making it an effective pedagogical strategy for engineering education.

**Quantitative Analysis**



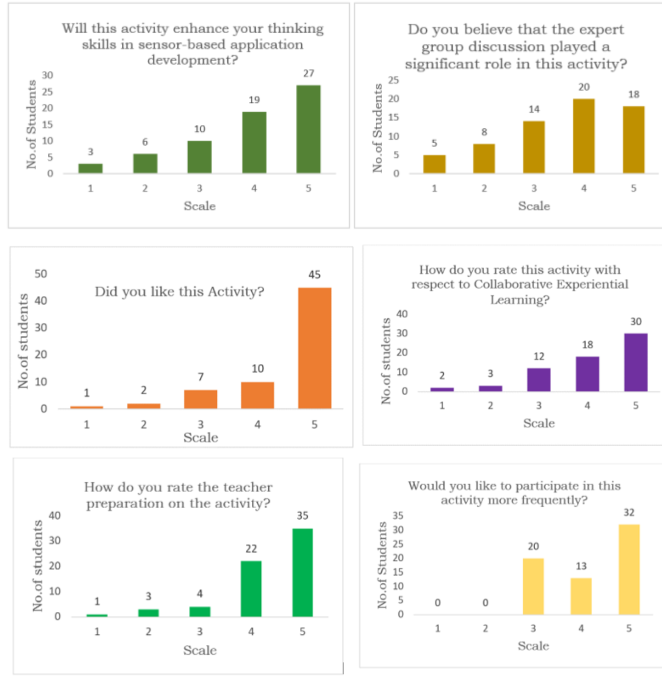




Fig.7. CEL Implementation feedback

***Collaborative Experiential Learning Rating:***

The evaluation of the collaborative learning activity revealed that students generally had a positive experience, with high ratings for both the collaborative learning aspect (4.3/5) and the enhancement of skills in sensors and application development (4.4/5). Teacher preparation and knowledge transfer were particularly well-received, scoring 4.5/5, indicating effective instruction. However, group dynamics received a slightly lower rating (3.9/5), suggesting some challenges related to language barriers and differing academic performance levels within groups has depicted in fig.7. The activity was also seen as valuable for future career opportunities, with a rating of 4.2/5.

*Future Adjustments:*

*Enhanced Training:* Provide additional guidance on collaborative techniques and emphasize the importance of equal participation to improve collaborative skills.

*Balanced Group Formation:* Ensure a mix of students based on competence levels to avoid dominance by stronger students and encourage mutual learning.

*Extended Time Frames:* Allocate more time for each phase of the activity to allow thorough discussion and integration of ideas.

## V. Discussion

The collaborative experiential learning method, showed considerable promise in enhancing students' practical skills and fostering a collaborative learning environment. The qualitative results demonstrate the CEL impact on the academic performance. The high ratings for teacher preparation and knowledge transfer underscore the importance of effective instruction in facilitating such activities.

However, the quantitative feedback reveals some significant challenges. Language barriers and differences in academic performance levels within groups affected the overall group dynamics. These challenges led to unequal participation, with some students feeling overshadowed by more dominant group members. Furthermore, a few students expressed discomfort in mixed-gender groups, which impacted their willingness to participate actively.

In conclusion, while the CEL method proved effective in promoting collaborative learning and experiential Learning enhancement, the identified challenges must be addressed to maximize its benefits. Future implementations should focus on providing more support for collaborative skills, balancing group compositions, and allocating sufficient time for activities to ensure a more inclusive and productive learning experience

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