Research Article

Student Learning Journey Map (SLJM): an instructional design process and toolkit to support constructive enhancement

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Abstract

Engineering education has gradually shifted from knowledge-focused teacher-centered learning to competence-focused student-centered learning attempting to expose students to a variety of learning activities as experience gained is crucial for the internalization of their knowledge and development of their competence. Besides intensive lectures and laboratory sessions, several teaching and learning methods have been brought to the discipline as an effective alternative accelerator supporting student learning within outcome-based learning. However, some instructors may find it difficult to employ the methods for enriched learning experiences since unique implications for individual methods, alignment to content, and other course design components are necessary. As a consequence, journeys become malfunctioned and unengaged, hindering achieving course learning outcomes. Therefore, this paper presents a course planning and preparation process and toolkit under the view of students to enrich their learning experience. SLJM is developed based on Kolb's Experiential Learning Cycle and the LOVE learning experience model. It navigates the instructors through the process of transforming a course into an engaging and constructive learning journey with a step-by-step visual representation of how to choose and arrange the methods and prepare other course components. An intensive graduate course on Product Design and Development is employed to demonstrate the SLJM's usefulness.

Keywords: engineering education, knowledge internalization, constructive enhancement, learning journey map, design toolkit.

1. Introduction

Competence-focused student-centered learning has attracted attention in engineering education due to the increasing demands from industry sectors for competent graduates. High expectations are set for the graduates from day one. With little to no workplace training, the graduates are expected to be able to work collaboratively with people from various disciplines to effectively and creatively solve unseen and ill-structured problems using knowledge and skills from both engineering and non-engineering areas in order to support the organization in surviving within the rapidly-changing and technology-driven societies. Therefore, the competent graduates must have not only new knowledge, but also various skills, including creativity and innovation, critical thinking and problem-solving, communication, and collaboration (the 4Cs), which are collectively known as transdisciplinary skills (T-skills) (University of Minnesota, 2022).

According to that, greater attention has been paid to the student-centered learning approach (Mohd-Yusof, 2017; Koomsap, 2018) and the development of student learning experience (Fink, 2007), which is the source of knowledge internalization (Zull, 2002; Tsai & Lee, 2006) and competence development (Koomsap et al., 2019). Instructors have focused more on how to keep students motivated (Prensky, 2001) and engaged with the learning activities to deeply understand the content and develop higher-order thinking skills. Consequently, conventional teaching methods, particularly lectures, which have been used since around the 12th century (Sheely, 2006), have been criticized as insufficient to encourage students' intellectual and emotional participation in the cognitive process. In addition, the lecture restricts students' roles to only passive receivers (Peyton et al., 2010), which are perceived as insufficient for deeper understanding, problem-solving, and creative activity (Sajjad, 2010).

Therefore, several modern and technology-enhanced teaching and learning methods associated with active learning have been introduced and promoted in the discipline as effective alternative accelerators for student learning to intensive lectures and laboratory sessions and as contributors supporting outcome-based learning. Examples of the said methods are game-based learning, project-based learning (Arana-Arexolaleiba & Zubizarreta, 2017), problem-based learning (Salleh et al., 2007), peer-to-peer learning (Gelmez & Arkan, 2021),

flipped classroom (Zappe et al., 2009), visual laboratory (Coşkun et al., 2019), virtual laboratory (Schuster et al., 2016), and Industry 4.0 laboratory (Wanyama et al., 2018). However, only some of them have gained popularity within specific communities, and the lecture is still the most commonly applied and has dominated current teaching practices (Serin, 2018; Hussadintorn Na Ayutthaya et al., 2019).

One of the main reasons is that some instructors find it challenging to utilize the methods for enriching student learning experience because specific implications for individual methods and their alignment to the content and other course design components are required (Reynolds & Kearns, 2017). As a result, their teaching practice would be less effective than expected, resulting in malfunctioned and unengaged learning journeys that hinder achieving course learning outcomes. Although some instructors have been exposed to the modern methods through their teaching communities and some professional development programs, assistance is still necessary to ensure that their developed teaching practice will successfully support student learning and achievement.

Therefore, this paper presents Student Learning Journey Map (SLJM), an instructional design process and toolkit focusing on enriching the student learning experience. Based on customer journey mapping and student learning experience design, SLJM reorients the instructors' view to the student side, resulting in a simplified instructional design process. SLJM utilizes the Kolb's Experiential Learning Cycle (Kolb, 1984) to ensure that the selected methods support the student learning process and knowledge internalization for all individual topics. It also employs the LOVE learning experience model (Hussadintorn Na Ayutthaya & Koomsap, 2017, 2019) for the development of a strong and engaging learning journey.

SLJM aims to serve as a personal assistant to navigate the instructors through the process of transforming a course into an engaging and constructive learning journey, with a step-by-step visual representation of how to choose and arrange the methods and prepare other course components. Although the SLJM is a work in progress, its usefulness has been realized through the case research on an intensive graduate course on Product Design and Development. According to the training evaluation results from the two classes offered at different venues, all the quality dimensions of the course received positive feedback from the trainees. In particular, the two classes scored the highest on the trainer's effective approach.

SLJM concept, process, and toolkit are described in the next section, followed by the case research on an intensive graduate course in Product Design and Development. Following that, class ambiances and learner feedback are presented. The last section is conclusions and future works.

2. Design method

The concept of SLJM (Figure 1) has been developed based on our belief that strong learning experience, which is the essential source of knowledge internalization leading to the success of competence development, is the result of a good student learning journey design. The journey that composes of various learning activities that activate student engagement and accelerate the learning process.
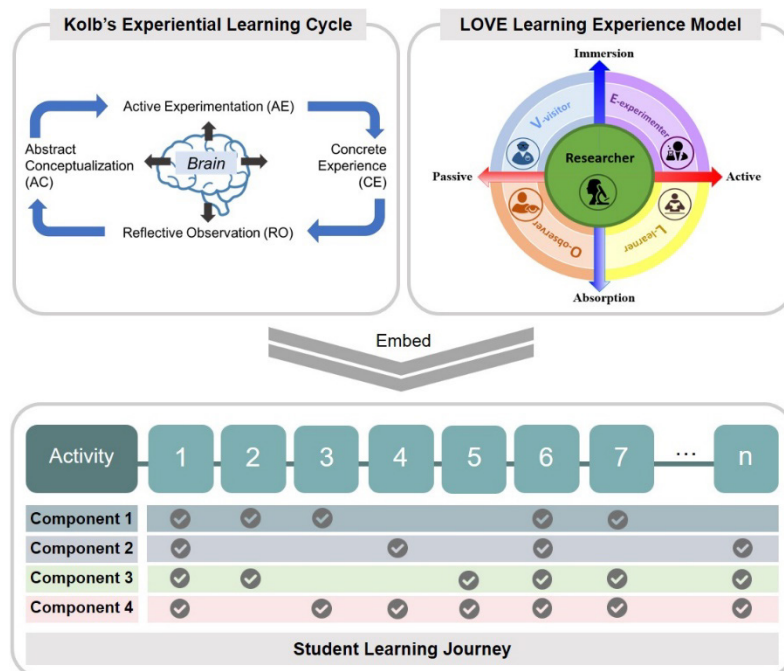

Figure 1. Student Learning Journey Map: concept development.

According to that, the basement of SLJM was based on the customer journey mapping concept, which provides a space to unfold and visualize all components of individual learning activities for the design and enrichment process. The student learning experience design was brought to reorient the instructors' viewpoint and cast them into the students' roles throughout the design process. The reoriented view prioritizes how students interact and engage with activities rather than how the activities are constructed and delivered. The Kolb's Experiential Learning Cycle (Kolb, 1984; Zull, 2002) and the LOVE learning experience model (Hussadintorn Na Ayutthaya & Koomsap, 2017, 2019) were together embedded into SLJM for the proper selection and arrangement of teaching and learning methods. Each model contributes differently to the design process.

As the Kolb's (1984) cycle refers to the four adjacent learning stages, which humans usually use for learning to construct and enhance their own knowledge, it was employed to assure that the designed learning activities can foster individuals to complete their learning cycle and develop a comprehensive understanding on the taught topics. Instructors can design to expose students to any stage of the cycle: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). However, the most efficient learning occurs when they progress through all four stages. In neuroscience, the cycle allows all four primary regions of the cerebral cortex to operate, resulting in particular networks of neurons that physically reflect knowledge (Zull, 2002). When more rounds of a cycle are completed, the established networks get more intensive. This leads to a more in-depth comprehension of a particular subject as well as a higher rate of knowledge retention.

The LOVE model defines four types that collectively form a strong learning experience (Hussadintorn Na Ayutthaya & Koomsap, 2017). The model was utilized in SLJM to develop the diversity of learning activities to enhance student engagement and immerse students into both theory and practical aspects of the taught topics. For competent development, both explicit and tacit knowledge is essential. Effective communications can transmit explicit knowledge from instructors to students. However, it is not the case for tacit knowledge, which is more difficult to explain, articulate or reproduce, but can be elicited when students are immersed in practical situations (Polanyi; 1967; Leonard-Barton, 1995). According to that, the LOVE model suggests prioritizing the use of methods associated with high-impact teaching approaches rather than other methods devoted to explanations and visualizations. To effectively expose students to course content, instructors are suggested to develop a learning journey using diversified methods that collectively form the four types of learning experiences (L-learner, O-observer, V-visitor, E-experimenter) (Hussadintorn Na Ayutthaya & Koomsap, 2019). The classification of the twenty-eight existing teaching and learning methods on the LOVE model (Figure 2) aids in forming the diversified methods.
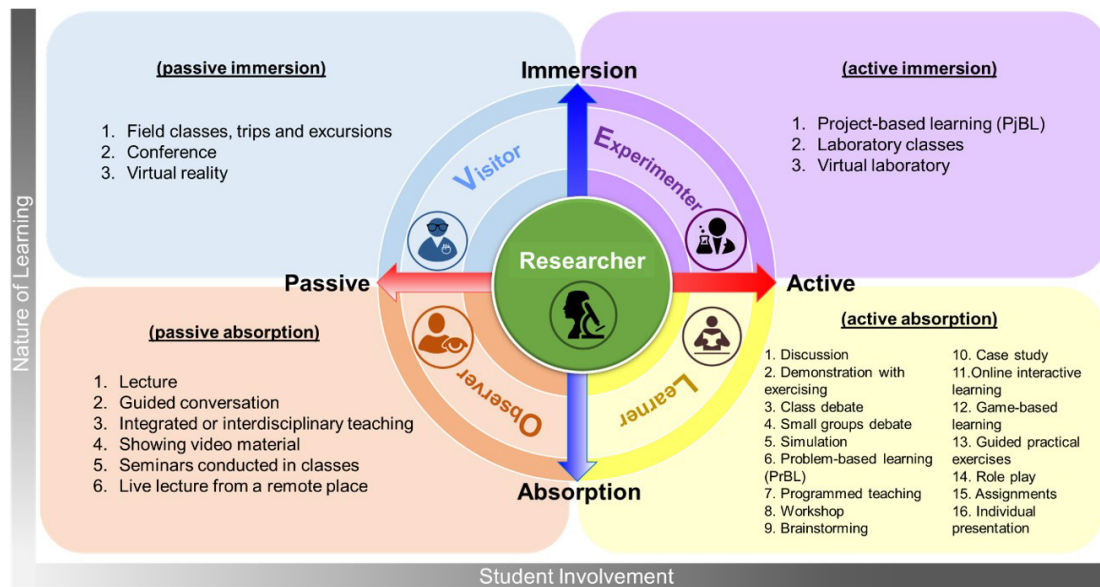

Figure 2. Classification of teaching and learning methods on the strong learning experience (LOVE) model (Adopted from Hussadintorn Na Ayutthaya & Koomsap, 2017, 2019).

According to Figure 2, the methods are classified along two dimensions: student involvement and nature of learning. Student involvement in any educational process can be characterized as either active or passive based on the approach instructors take, the methods and instruments they employ, as well as the attitude of the students. The nature of learning reflects how students learn. The absorptive connection supports students in acquiring

information, concepts, and theories. The other type immerses them in theory-practice learning settings to acquire tacit knowledge via practices of complex problems and real-world applications. These two dimensions classify learning experience into four types (L, O, V, E).

Taking on the role of a learner entails a student's active participation, but only with teacher-created content. Passive experiences are also produced on teacher-based content for the observer role. Similarly, the visitor position is passive, but the conditions are unusual and students might become immersed in the experience that the instructor hasn't fully prepared. Experimenter roles are both active and immersive, allowing students to utilize their own knowledge and abilities to contribute and shape the experience. By enabling students to execute the four roles (LOVE), students are molded into a researcher role (Hussadintorn Na Ayutthaya & Koomsap, 2018), which fosters the transformation from knowledge consumers to knowledge producers (Lovitts, 2005; Gardner, 2008). In addition, more active and immersive methods are recommended (Prince, 2004; Freeman et al., 2014) to attain the best result of the method combination.

3. SLJM presentation

3.1. SLJM design toolkit

In order to realize the proposed concept, SLJM design toolkit (Figure 3) has been developed to provide a working space for designing and visualizing a designing journey. It was built on the PowerPoint template for ease of accessibility and usage. The template consists of three major sections: (1) course learning outcomes and assessment tool on the left, (2) journey design in the center, and (3) design component on the right. The left areas give spaces to display the data extracted from a syllabus and aid in developing alignments between the designing journey with the identified course learning outcomes. Before advancing to the journey design process, it is noted that the syllabus developed using the backward design approach is an ideal initial step. The middle area is where the journey will be designing with the assistance of design components provided right next to it.

Table 1 summarizes the functionality of all design components. They are enabled by the SLJM process, which is described in the next section. Through the use of the SLJM design toolkit, where all components are always visualized, instructors can easily and quickly predict the impacts of specific activities on student learning and identify the strengths and weaknesses of all features embedded into a designed journey.
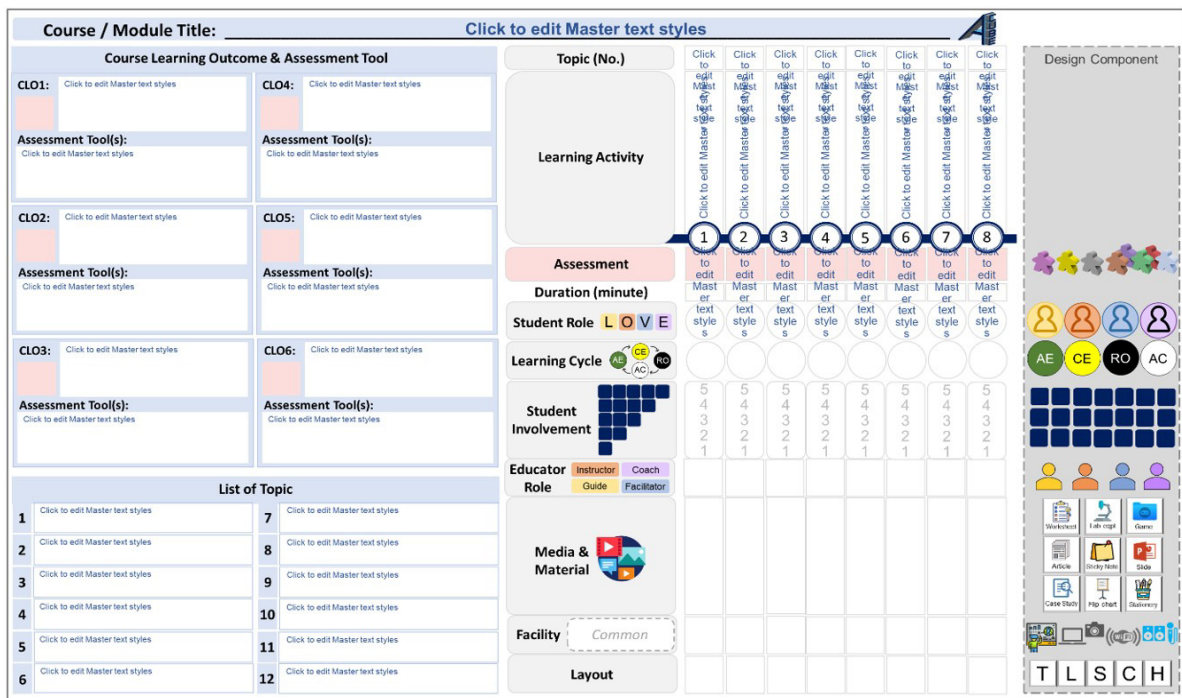

Figure 3. SLJM design toolkit.

Table 1. Design components and their functions.

Component	Function
Topic (No.)	Refers to the listed topic.
	Notifies topics that are missing, switching, or unconnected.
Learning activity	Describes a teaching and learning method utilized in an activity.
Assessment	References to the applicable assessment tools to evaluate the attainment of certain course learning outcomes.
	Notifies unconnected course learning outcomes.
Duration	Indicates minutes used to complete an activity.
	Notifies prolong and cut-down classes that reduce student interest and engagement.
Student role	Identifies a student role when participating in an activity based on the LOVE model.
	Notifies the diversity and redundancy of learning experiences and activities.
Learning cycle	Identifies possible learning cycles that students have progressed through after completing an activity, based on Kolb's Experiential Learning Cycle.
	Notifies the complete and incomplete closures of particular learning cycles.
Student involvement	Indicates the level of student involvement when participating in an activity.
	Notifies of unfavorable instances in which the overall involvement is too low/high.
Educator role	Identifies an appropriate role for instructor to deliver and manage an activity.
	Notifies ill-suited roles that impede student learning.
Media and material	Identifies appropriate collections of teaching and learning materials.
	Notifies of insufficient and inappropriate teaching and learning materials.
Facility	Identifies a list of necessary equipment for the execution of a designed activity.
	Notifies of missing and insufficient equipment.
Layout	Identifies a suited layout supporting the execution of a designed activity.
	Notifies the incompatibility of the layout for a designed activity.

3.2. SLJM process

The steps outlined below will assist instructors in visualizing the current learning journey of their course and enhancing the learning experiences of the journey.

1. Extract the data from a course syllabus (course title, course learning outcomes – CLOs, assessment tools, list of topics) and insert them into blocks on the left.
2. Provide a short description and determine the duration of all activities used to deliver the topics.
3. Place meeples in the assessment spaces where the assessment tools can be applied to evaluate the attainment of certain course learning outcomes (different colors for different CLOs).
4. Analyze the method used for each activity to identify the following components.
   a. The student role (by consulting with Figure 2) (Hussadintorn Na Ayutthaya & Koomsap, 2017, 2019): Learner (L), Observer (O), Visitor (V), Experimenter (E)

   It is to remark that figure 2 does not include all methods; however, through analysis, the student role in all of these methods can be identified.
   b. The learning stage of Kolb's Experiential Learning Cycle (Kolb, 1984): Active Experiment (AE), Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC)
   c. The level of student involvement: giving attention (1) – fully participate and have a direct impact on the result of the activity (5)
   d. The educator role in order to deliver and manage the activity (adapted from Katsidis et al., 2008): instructor (specified learning activities controlled by teacher), coach (specified learning activities managed by learner), guide (open-ended/strategic learning activities controlled by teacher), facilitator (open-ended/strategic learning activities managed by learner)
5. Finish the rest of the design with the following design components. If necessary, additional components can be added.
   a. Media and material: Worksheet, Lab equipment, Game, Article, Sticky note, Slide, Case study, Flip chart, Stationery
   b. Facility: Digital whiteboard, Laptop, Camera, Wi-Fi, Sound system
   c. Layout: Theatre (T), Lecture (L), Stadium (S), Clusters (C), Horseshoe-shape (H)

6. Identify the current journey's strengths and weaknesses by consulting with the appropriate scenarios for the design components (Table 2).
7. Remove the unmatched and improper components that impede student learning to eliminate the weaknesses.
8. Incorporate more methods with the proper arrangement to enrich learning experiences and assist students in completing the learning cycle for all topics.
9. Adjust other components accordingly.

Table 2. Appropriate scenarios for the design components.

Component	Appropriate scenario
Assessment	There are enough activities to assess the achievements of CLO(s) for all individual topics.
Duration	The time allotted is adequate to complete the activities. A prolonged lecture is avoided.
Student role	Students play all four roles along a journey.
Learning cycle	The learning cycle is completed at least once for all individual topics.
Student involvement	The level of student involvement varies throughout a journey.
Educator role	An educator plays an appropriate role in supporting students' roles and guiding them through the learning cycle.
Media and material	Media and materials are expansive, of high quality, useful and appealing.
Facility	Facilities are of quality and always function as expected. They contribute to creating comfortable classroom environments and facilitating class interactions and engagements in all planned activities.
Layout	The layouts make it easier for students to interact and participate in all planned activities.

4. Case research on Innovative Product Design and Development course (PDD)

4.1. PDD

PDD is a graduate course developed as part of the European Commission-funded joint capacity-building project 'Reinforcing Non-University Sector at Tertiary Level in Engineering and Technology to Support Thailand Sustainable Smart Industry (ReCap 4.0)'. PDD is one of ten modules in the project's training program to enhance the capacity for the effective delivery of engineering and technology knowledge and skills related to Industry 4.0.

The objectives of PDD are to develop two competences: (1) putting the product design and development process into systematic practice and (2) collaborating with others in the design and development of a product.

PDD, like the other modules, is divided into two sessions: fifteen hours of in-person training and ninety hours of self-practice and online coaching. Figure 4 depicts only the training session's module learning outcomes and assessment tools to exemplify the toolkit.

Figure 4. Inputs from the course syllabus.

4.2. Design comparison

Below are explanations for the initial and new design of PDD's student learning journey. The visualization of the initial design (Figure 5) reveals that the journey comprises seventeen class activities arranged to offer the nine topics in order. Only three teaching and learning methods are applied across the journey. Nine of seventeen activities are formed by lecture, consuming about 80% of the total class hour. The other eight activities are formed by either case study or class discussion; however, they consume only 175 of 900 minutes (or around 20%) of the total class hour.
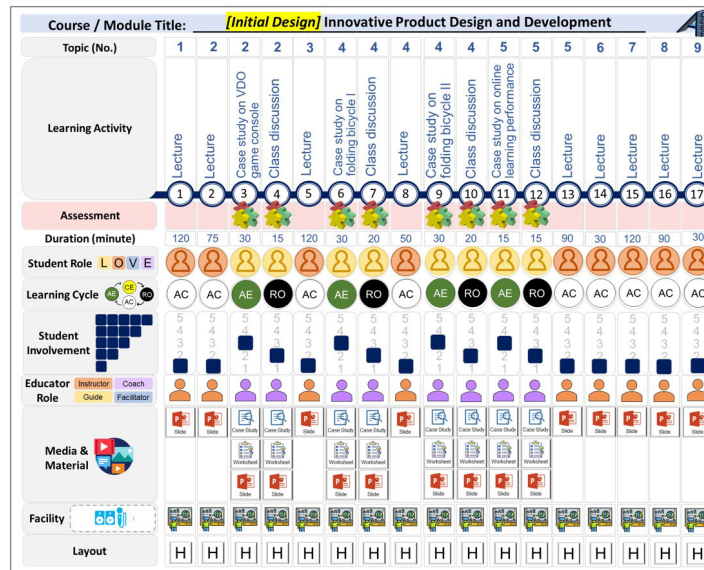

Figure 5. The initial design of PDD's student learning journey.

During the lecture hours, none of the assessment tools are applied to observe and assess learners' performance and learning progress. The assessment becomes possible when the case study and class discussion are implemented. As a result, the educator will not be able to notice any struggles and impediments of the class for most of the topics taught – topics 1, 3, 6-9 – unless s/he attempts to interact with the learners. According to that, the attainment of CLOs 1 and 2 cannot be fully assessed.

The lectures also limit the role of learners to the observers who passively engage in the class, which lessens their involvement to comparatively the lowest level. In addition, the lectures give full authority of the class to the educator, with the role of the instructor, s/he fully managing, controlling, and directing the learning. The authority is shared with the learners through their active engagement in the case study and class discussion activities, where the instructor's role is changed to coach, and the learners can manage the activities at a certain level.

The journey cannot progress individuals to complete any learning cycle for all nine topics. The most missing learning stage is the concrete experience (CE), which – if provided – would at least assist the learners in completing the learning cycle(s) for topics 2, 4, and 5. For the other topics, the cycle completion becomes impossible as the design can progress the learners to only the entry learning stage, abstract conceptualization (AC). As a result, the learners are disconnected from the process of knowledge internalization. In this case, the learners must attempt to close the learning cycles by themselves to be able to construct their knowledge and understanding of the learned topics.

The prepared media and materials, facility, and planned class layout support the currently designed activities. However, flip charts, stationery, personal electronic devices, and the availability of Wi-Fi should be added to foster individual learning during active learning activities.

Due to the shortcoming of the initial design, other teaching and learning methods – group work on a case study, group work on a design, gallery walk, and game-based learning – are employed to assist in transforming the lecture-dominated into an engaging and constructive learning journey. In addition, the methods are arranged for the completion of learning cycles for most of the topics.

The new design journey (Figure 6) provides more places for assessments and allows all assessment tools to be implemented. All three CLOs can be fully assessed. The lecture hours are reduced and replaced with active learning activities. Students can play all four roles in this journey. They are directed to close the learning cycle for all topics at least once, assisting them in developing their understanding of all topics.
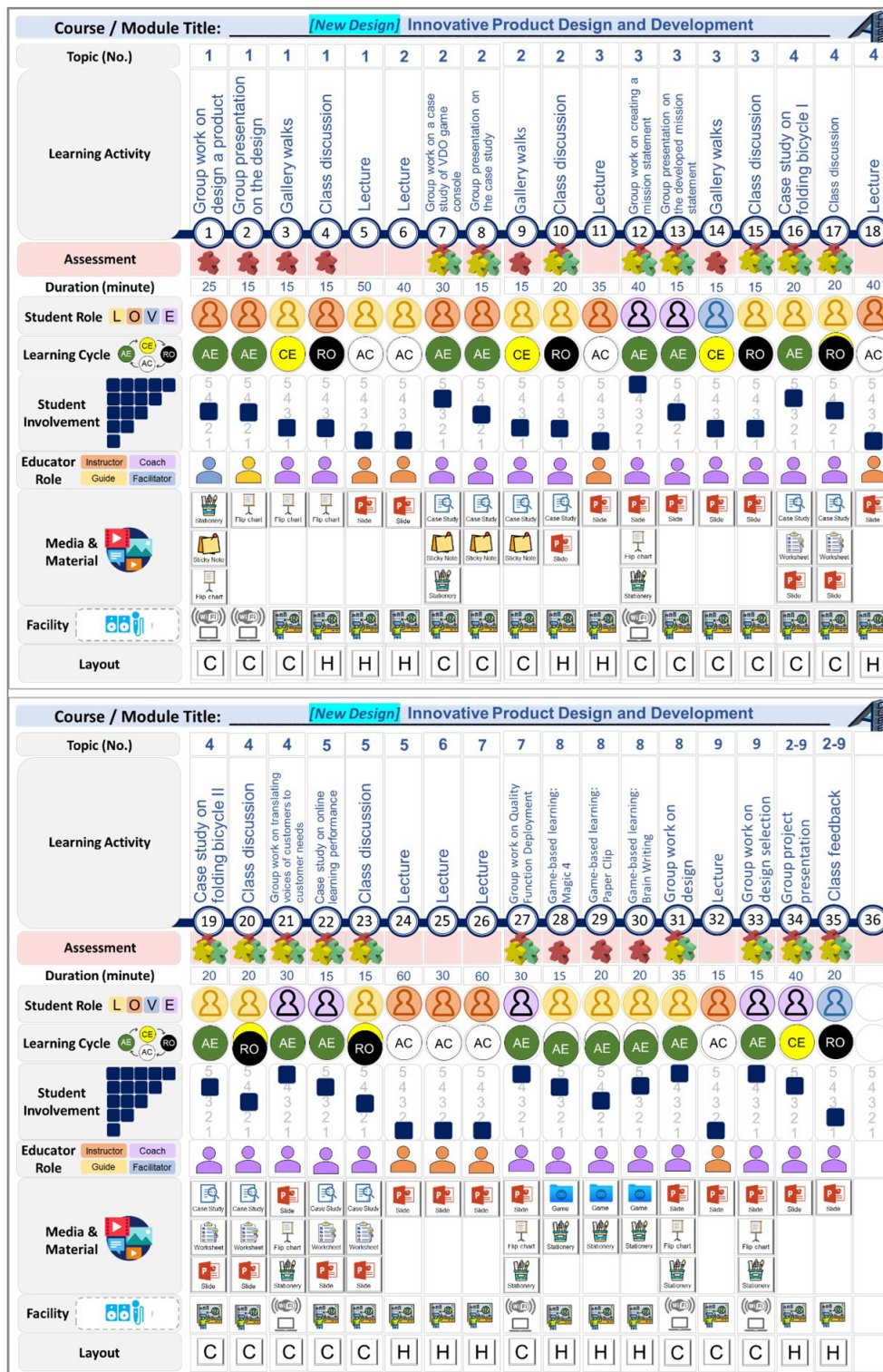
Figure 6. The new design of PDD's student learning journey.

Using topic 3 as an example, learners are exposed to the content and some examples of mission statement creation through lecture (activity 11). Then, they are asked to work in a team to apply the learned lesson to a real product proposed by their team (activity 12) and to prepare a few slides to present their rationale and developed mission statement to the class (activity 13). Their roles are changed to experimenters within the collaborative working environment on the real product. Each individual is progressing from the entry learning stage, abstract conceptualization (AC), where they attain new knowledge, to the active experimentation (AE) stage, where they apply the knowledge to a new, different case. They are directed to the concrete experience (CE) stage via the roles of visitors attending other group presentations (activity 14). In this stage, they see how others implemented

the concept into different real case products. Differences between theirs and other works and experiences on real-world complexity and issues are essential inputs for analysis and reflection, which will happen next in class discussion (activity 15). This activity arrives individuals to the final learning stage of the cycle, reflective observation (RO). The educator provides comments and suggestions, a summary of achievements and lessons learned he observed from all the teams, raises issues and misconceptions, and engages the class to discuss for clarification.

The overall involvement is increased and alternated. Instead of instructing, coaching plays a major role in delivering and managing the journey. Guiding and facilitating roles are also applied at the beginning of the journey, providing spaces for students to express their interests and share their knowledge in classes. Media and materials are in variety. The list of facilities and planned layouts facilitate the implementation of the designed activities.

4.3. Implementation

The designed journey was implemented. Figure 7 and Figure 8 present some examples of class ambiances offered in two different venues. There is little difference in the facility for the two venues: the number of front-of-classroom digital displays, table shape and size, and room size. However, the designed activities could be implemented as planned, and class engagements reached the expectation. To deliver the lectures, the educator wrote directly on the smart whiteboard or on his tablet, which was projected simultaneously on the three displays, allowing everyone at different seating to see the content clearly. The cluster layout was arranged appropriately to the different table shapes and sizes to facilitate interactions of both group and class activities. Each group utilized its digital display and whiteboard (or wall) to facilitate the discussions, visualize ideas, and present the works to the class during the gallery walk activities. The educator visited each group at times to observe obstructions and provide supervision. The sound system and lighting were checked and worked as expected. Wireless microphones were used by both parties for flexibility and to increase the voice volume. Wi-Fi was available, and needed equipment and materials were supplied.

Figure 7. Examples of class A's ambiances.

Figure 8. Examples of class B's ambiances.

4.4. Learner feedback

At the end of the training sessions, learners were asked to fill out a training evaluation form. According to the findings (Table 3), PDD received high scores in all dimensions. The trainer's effective approach is the statement that received the most agreement from the two classes. The dimensions of module relevance to their teaching practice and understanding received relatively low scores, indicating areas for improvement. According to their comments, PDD introduced completely new tools and techniques to them that required time to understand. Therefore, additional activities should be implemented to guide them to complete another learning cycle for some topics, especially QFD.

Table 3. Results of training evaluation.

	Class A		Class B	
	December 2021		*March 2022*	
Total Number of Class Participants	8		11	
Forms Received	7		11	
1. Demographic Profile				
	Male	**Female**	**Male**	**Female**
1.1) Gender	28%	72%	37%	63%
	Mean	**SD**	**Mean**	**SD**
1.2) Age	37.0	4.8	45.5	4.9
1.3) Years of Teaching Experience	8.7	3.8	14.6	6.8
2. Overall Feedback *(1: Totally Disagree, 3: I am not sure, 5: Totally Agree)*				
2.1) The themes / topics developed in the training were relevant for my teaching practice.	4.43	0.53	3.91	0.94
2.2) I understood the concepts presented in the training activities.	4.43	0.53	4.36	0.67
2.3) I had an active participation during the training activities.	4.57	0.53	4.45	0.52
2.4) The trainer(s) had an effective approach during the activities developed.	4.86	0.38	4.73	0.47
2.5) The training materials used were useful for the activities.	4.71	0.49	4.54	0.69
2.6) The training was valuable experience for professional growth.	4.71	0.49	4.64	0.50
2.7) I will recommend this training to somebody else.	4.86	0.38	4.54	0.69

5. Conclusions and future works

In order to facilitate some instructors, who face some challenges in utilizing the modern teaching and learning methods due to their specific implications and alignment to other course components, the Student Learning Journey Map (SLJM) has been developed. SLJM is an instructional design process and toolkit for enriching learning experiences by consciously designing and aligning all aspects of learning activities. Its power has been demonstrated through case research on the Innovative Product Design and Development (PDD) course in ReCap 4.0 program, an upskill and reskill program for faculty members in Engineering and Technology, higher class engagement, and the learners' positive feedback.

According to its practical aspect, it is believed that SLJM will be useful not only for Engineering courses but also for courses across disciplines. However, SLJM could achieve greater results by incorporating backward design and student-centered approach, including 'Learning Experience-Focused Course Design and Development (LEF-CDD) (Koomsap et al., 2019). This perspective is included in our future research to strengthen the SLJM capability. Besides, the plan also includes implementing the designed journey to other PDD classes and applying SLJM to other ReCap 4.0 training program modules for further analysis and development.

6. Acknowledgements

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