

# Introduction to the Learning Sciences

## Final Project - Design Critique

### **Learning Goals:**

In this design critique report, we try to analyze the course “Introduction to the learning sciences” which we took in this semester. We try to analyze the course design based on different learning theories and models. Following are the learning goals of the course:

1. To compare and contrast learning theories: Students will be able to gain a comprehensive understanding of various learning theories such as constructivism, constructionism, situated learning and sociocultural theories and will be able to identify the similarities and differences to understand their contributions to the learning community.
2. Core principles that influence learning: Here the students will be able to understand foundational concepts such as scaffolding, cognitive load, metacognition, motivation and cultural processes and their influence on learning.
3. Examine Learning Approaches: The goal here is to familiarize the students on various perspectives that are adopted towards learning like problem- and project-based learning, inquiry-based learning, productive failure, preparation for future learning, collaborative learning, and embodied learning.
4. Application of different theories and approaches to the real world environment: Using the concepts imbibed to analyze a learning scenario.
5. Presenting critique of a learning environment: Analysing the features and design of a learning environment, evaluating it based on its design and application of theory, and proposing an alternate learning environment.

### **II. Learning Design and Features:**

The course is designed in a manner where there are two lecture classes every week. The expert steers every lecture in a direction that fosters discussion and viewpoints on the different learning concepts. The lectures include in class activities where the students are made to think about the topic taught and apply it to a real world situation. A significant amount of time is also spent on every lecture to revise the concepts that are learnt in the previous week. Precluding

every lecture, a reading material is provided that would familiarize the students about concepts that would be discussed. The students are provided with scaffolds to help them interpret the readings and the students are required to articulate their understanding through weekly reflections. The instructor guides the lectures and improves the learning experience through structuring and problematizing scaffolds in the form of video materials, group activities, debrief sessions and drawing a parallel between the in class activity and the concept that is taught. The features are elucidated in detail below:

1. Classroom Instruction: Here the instructor relays knowledge and concepts through lectures and presentation slides that contain key points that act as scaffolds to aid the student in correlating the keypoint to the ongoing discussion of the concept. The several lectures that spanned the semester involved laying the groundwork for first understanding the field of research in learning sciences, followed by learning theories and gradually steered towards designing and improving learning environments. The lectures were enriched with signs like the use of conceptual vocabulary for instance, ‘productive failure’, ‘embodied cognition’ and theoretical frameworks such as ‘Constructivism’, ‘Situated learning’ to internalize during the process of meaning making.
2. Use of video modules and simulations: Sometimes the lectures are supported through youtube videos involving a learning experiment. Students are then allowed to ponder about the relevance of the video to the concept taught or that would be taught. Simulations are used to aid the students in reflecting about their use in the process of learning. These are important scaffolds when combined with instructor prompts to help bridge the gap between the video/simulation to the abstract theories. An instance where this enhanced our learning was watching a video on embodied learning in class. Discussions on what could be the learning mechanism , directed our trail of thought towards the concepts of embodied learning.
3. In class group activities: Most of the lectures follow a very brief introduction to the day’s core concept to be taught, an in class activity is conducted. Here students in pairs or in a group of three, are first encouraged to think about a case study that is pertinent to a learning theory or an approach and note down their observations individually. They are next asked to discuss their findings and perspectives with their groups/partners that includes counter arguments, support, explanation of their viewpoint upon which their stance is further refined. The group then tries to find a common ground that they share with the class. During the course of the activity, the instructor moves between groups, offering guidance to those who may be stuck, or struggling to grasp the task’s objectives. Ideas and clarifications are provided during the activity to facilitate progress and to ensure that the class is engaged with the activity’s goals. Some activities are also designed in a manner where the students support their understanding/ argument through drawings, concept maps or flow charts. The students here become accustomed to the norms of the activity that include active participation, respectful collaboration, attention and focus as well as important progress to be made within the timeframe of the activity. Every activity is followed by a class discussion where all the groups present their findings. Other students are encouraged to support or critique the same. Every

discussion consists of two components where one is in favor of a stance and the other finds a loophole in it. The entire activity and its relevance is brought into a full circle where the instructor connects the class discussion to a learning theory/ an approach.

4. Weekly reflections: Every week the students are provided with reading material that is composed of literature from the field of learning sciences discussing the various theories, pedagogical models and different experiments conducted by several researchers supporting the fundamental theories or development of new tools or signs that have shown to influence learners. The papers also describe in detail the different learning environments and the control variables of the study conducted. These however consist of concepts that the students are unfamiliar with, and that would be the central theme of discussion in the following class. Following every reading the students are encouraged to reflect upon what they have understood and answer a few questions to aid them to test their grasp on the concept. These include - identifying the key features of the reading, how the experiments correlate to the various learning theories as well as how the approaches adopted by the researchers reinforce or deviate from the fundamental theories. Some reflections force the students to think critically and beyond the context asking them to apply them to their real life. The readings are integral tools that provide diverse perspectives of theoretical concepts like cognitive load and collaborative learning.
5. Assessment: Two assessments are conducted through the course to test the overall understanding of the content learned in the classes. The first assessment required a submission of a report that required the students to describe a case of a personally significant learning that they have recently experienced. The goal of the assessment was to reflect on the processes of their own learning and connect it to the theories from the readings and classroom lectures and discussions. The second assessment was a pair activity that aimed on helping the students reflect on an online course or a class that they had both undertaken. The key idea being to reflect on the course design and whether the design aligned with the pedagogical models studied in class and how the structure could be improved to achieve the learning goals. The clear assessment guidelines as well as the rubrics provided a structure for the students to focus their reflections. The first task that required the students to connect to personal experiences served as a cognitive conflict to apply abstract concepts to concrete scenarios. The pair activity of collaborative nature enables the students to co-construct knowledge through shared reflection and experiences.
6. Social and community rules: The course also had certain rules that the learners needed to follow. First was that classroom participation was necessary. Students were expected to ask questions and give their inputs during the teaching-learning sessions. Students were expected to participate in group and pair activities throughout the course. In the group activities, students were required to listen to the inputs given by each and every member of their group. They had to listen to them and counter their group/members. By convincing each other with appropriate reasoning, they had to come up with a combined representation and solutions. During classroom discussions, every group had to give

their collective inputs in the discussion. While one group is presenting, the others had to listen to them attentively and counter them for further elaboration or examples to support their hypothesis. Students were given weekly readings and were expected to write their reflections. They were provided with certain articles which were compulsory to read and some optional articles as well to enhance their understanding. Students were expected to complete a certain minimum requirement of weekly reflections.

### **III. Learning Theories or Pedagogical Models Used:**

The overall design of the course based on the features mentioned above is guided by the Problem solving and delayed Instruction (PS-I) model. The in-class group activities are designed in such a manner that they present either a case-study to the students or a design question where students have to design a learning environment for learners of a particular age group on a specific topic. Initially, students are presented with a case of a learning episode/process or a design question. They first have to individually identify the features of the learning theories being dealt with in that particular case/design question. These features are tied to either the learning theory which students have already read or are going to read. This initial phase is the prior knowledge activation phase where they have to use the knowledge they have in the existing schema related to the target concept (in this case a learning science theory/concept).

In the second phase, students work in a group/pair where they present their identified features to their peers with appropriate reasoning. The other student(s) is/are expected to counter the presenter or ask for further elaboration to ascertain a claim. This process helps them to come up with the most critical features of the learning theory or most appropriate design. In this phase, students get ample opportunity to explain and elaborate their reasoning to each other.

In the third phase, all the groups submit their analysis of the case/learning design to the instructor and present it to the entire class. These submissions are in the form of a concept map, diagram, flow chart, or steps. In this phase, the role of the instructor is to ask the individual group to explain their analysis/design by elaborating it in detail or giving examples. The instructor helps the entire class to focus on the similarities or differences in the analysis/designs presented by the individual groups by writing them on the slides.

In the fourth and final phase, the instructor explains about the actual features of the learning science theory with a debriefing session. The instructor highlights the features that were common with the students' submission and explains about the features that were different in detail. This phase is the one where the instructor introduces students with the canonical representation and solution method (RSM) of the target concept.

The above described PS-I model can be supported by an activity which was done in the class on “Legitimate peripheral participation” (LPP). We were given a case study of engineering students who learnt to make drones in a social learning environment. As a group activity, we had to come up with a learning mechanism describing the reflective practices, identity, meaning and participation of engineering students of different years. By discussion in the group we came up

with our own RSM in the form of diagrams which consisted of concentric circles with texts and arrows to show connections between the text. This was the part of the first and second phase of the PS-I model as described above. In the third phase, we submitted our RSM to the instructor which were then shown to the entire class and were compared to highlight similarities and differences. Then in the fourth phase, the instructor showed a canonical RSM and debriefed about the actual learning mechanism involved in the given case study.

Along with the PS-I model, Vygotsky's theory of social learning also describes the design of this course. Vygotsky states that scaffolding is required to help students to move across their zone of proximal development (ZPD). In other words, to help a student to learn the knowledge and skills which she/he hasn't acquired yet, the facilitator or the more knowledgeable teacher has to use certain scaffolding. As described in the above section of learning design and features, weekly reflections were an important part of our course "Introduction to learning sciences". Students were provided with weekly readings along with some key questions to reflect upon. These key questions were part of the scaffolding provided in the form of "structuring". As the readings were new and complex for us to understand, these key questions served as prompts.

The constructivist approach was also inherent in the PS-I model of learning. In the first phase of the model, while analyzing the case study or working with a design question, we had to use our prior knowledge either about the learning theories that we had learnt in previous classes or our own learning experiences. While working with the case studies and design questions, we also encountered cognitive conflict when our peers countered our hypothesis or claims. This sometimes created a disequilibrium in our existing models of understanding and pushed us to accommodate our schema based on the new information and perspective presented by our peers.

#### **IV. Assessment of learning theory or pedagogical model:**

The PS-I learning model being adopted to accomplish the first three learning goals was appropriate to develop a comprehensive understanding of the learning theories (like constructivism, situated learning, cognitive apprenticeship, Vygotsky's social learning theory and so on.), models (productive failure, collaborative learning, and so on.), and principles (like cognitive conflict, zone of proximal development, etc.). In one of the classes, there was a pair activity which was based on the theory of "collaborative learning". The activity was divided into two parts. In the first part, we had to read a text on utilitarianism and write a 50 word summary. Here, both the partners mostly focused on the key points and paraphrased it to write a summary. In the second part of the activity, we were given another text on transcendental realism and again asked to write a 50 word summary. However, this time there were some rules to follow while working in pairs. The rules were that first we had to read the text individually. Then the first partner had to explain her understanding to the other. The other partner had to challenge it by asking a question. Then we had to repeat the same task by switching the roles. Then at the end, we both had to contribute 2 points each to form the summary. The second part of the activity was more interactive in a sense that it had the elements of sharing understanding, turn-taking, constructive dialogue, and reasoning. It helped us to understand how scaffolding

the instruction with rules helps in productive social interaction in a collaborative learning environment.

The course integrates various prompts in the form of key questions being provided with the weekly reading to write our reflections. These questions helped us to pay attention to the important aspects and arguments presented in the reading and guided us in connecting different theories, finding similarities and differences between the theories, and thinking about different scenarios where the theories will be effective. For example, during the reflective reading on collaborative learning, one question stated “Is collaboration always good for learning? Why or why not? Give an example of both situations, when collaboration can be effective and when it can be counter-productive.” These questions pushed us one step further to think about the implementation of a learning approach in different cases and analyze when an approach proves to be effective and under what conditions it might not lead to effective learning.

Learning goals 4 and 5 are based on the assessment of students' learning. Goal 4 is broadly based on assessing the learning of an individual learner. Hence, it is more oriented towards a cognitivist approach to learning. Here, we as individual learners had to analyze our own significant learning experience with a framework of different learning theories that we learnt in the first half of the semester. The assignment was a great opportunity to use different cognitive functions like memory, recall, reasoning, analysis, and representation of our understanding. On the other hand, goal 5 is broadly based on collaborative learning, hence comes under the realm of socio-cultural approach to learning. In this, we were expected to work in pairs and write a design critique of any one course. This assignment helped us to interact with our partner. This interaction helped us to reach a common ground in terms of the arguments to be presented in the report. During the discussion session, justifications were provided to present certain claims using the in-class activities of the course, the readings and the theories read in the course.

## **V. Evaluation of Learning Design:**

From the perspective of learning sciences, the course is thoughtfully structured to provide students with opportunities to explore a new domain while nurturing their curiosity and encouraging a desire for deep learning. It effectively incorporates the essence of learning science principles, to create an engaging educational experience by following a balanced approach of analyzing the theoretical depth of the field blended with practical application and personal reflection.

The in class activities and debrief sessions were crucial in examining different learning theories and their applications in the real world. For instance, there was an activity, where students utilized the design principles to create an effective learning environment to help explain the concept of Photosynthesis. Here, the students were given an opportunity to comprehensively integrate their newfound knowledge of their understandings of the course by proposing their own design. An example learning design that was proposed was an open ended exploration with focused effort (problematization) coupled with guided instruction (structuring). The use of scaffolds was unanimously proposed to be included in the learning design. The concepts helped

analyze a learning scenario and provided a link between the application of the course contents to real world experiences.

The assessments were a crucial juncture where students realized the highly practical relevance of learning sciences. Through the lens of constructivist approach, students relied on their existing schemas to navigate the rubrics. The inclusion of reference examples such as the 'good' and 'average' essays served as scaffolds in refining their approach. Assessment 2, designed as a pair activity, aligned closely with Vygotsky's theory, highlighting the importance of collaborative reflections in learning. These assessments provided students an opportunity to engage and internalize the course objectives while also empowering them to link these scientific principles to real world contexts effectively.

However, there are some areas and aspects of the course that require some improvement and rearrangement.

The Problem Solving and Delayed Instruction (PS-1) was an intelligent strategy that was adopted that encouraged students to initially engage with the problem using their existing knowledge. By encountering roadblocks in the process, the cognitive conflict was heightened creating a fertile ground for learning. Subsequent instruction, following this ensured that students were able to identify the critical features that distinguished each theory from the other for example - inquiry based learning, embodied learning and application of the different theories to the real world. However, the PSI model may not be the most effective during the initial phases of learning, such as activating and differentiating prior knowledge into distinct concepts. For students who are new to learning science and lack prior experience in reflecting on its applications, the problems may not be well-structured enough to guide their learning or thinking processes. While relying on intuition can be a holistic approach, which can be valuable, it often leads to erroneous results if not supported by proper guidance and scaffolding. This can lead to a larger perceived knowledge gap, due to the inadequate activation of the prior knowledge. This kind of failure to solve the problem ineffective as the student is unaware and unable to reflect over it thus reducing the potential to learning,

The design of the weekly readings in the initial parts of the course posed challenges that impacted our learning process. The absence of timely evaluation and feedback on our reflections further added to the uncertainty regarding the direction and depth of our understanding. The relative inexperience in the subject domain led to roadblocks in comprehending the materials, particularly the readings on Learning pathways, Mind and Society by Vygotsky and role of metaphors in learning. The relevance of these texts was unclear until corresponding class instruction. This gap we believe can be bridged through better scaffolding and clearer guidance to navigate the complex tasks.

Another challenge faced during the teaching-learning process was that although Vygotsky's social theory works at several points of the course through the group and pair activities, there is a relative gap in the communication between the student groups (social groups) from the Humanities and Social sciences background and those from an engineering background. The interests and the meaning that each of these social groups derive also differs on the ground level.

There is a difference in the approach to the problem that each social group adopts, resulting in a mismatch and no concrete concept building that takes place through the interactions. There is no true metric of evaluation to check whether a true connection to the objective of the goal is met through social interaction. This is a case of expansive learning paradigm where there is a conflict between two social groups coming from different educational backgrounds. The methodology and theoretical concepts used in their respective domains are different. Hence, their approach to solve a particular learning problem will be different. This requires opportunities for both the groups to interact more with each other in order to understand their different perspectives on solving a problem and reach some common objectives and come up with some new model of learning.

## **VI. Redesign Features :**

Based on the assessment and evaluation of the learning approaches and design of the course, we found that the course was able to meet its objectives. However, certain gap areas as described in the above section (evaluation of learning design), could be filled by integrating following learning features:

**Instruction before reflection :** In the initial part of the semester when we were introduced with the readings on different learning theories, many learners faced difficulty with the readings as they were new to them. To help students build a theoretical understanding about the subject area, before the mid-semester exam, the course could have an instruction first approach, followed by readings, and reflections (Fig.1) . And in every subsequent class, students could be given the opportunity to discuss their reflections in the classroom with their peers and instructor to work on any cognitive conflict which they experienced while reflecting and consolidating their understanding. The efficiency of this approach could be tested based on how students perform in the mid semester assignment. If students are able to build a good understanding of the learning theories with this approach, then in the other half of the semester, the approach can be reversed, giving readings and reflection first, followed by the instructions. This approach also ensures that students have sufficient exposure and prior knowledge that they can activate while attempting their assignments as well as their understanding of the future concepts after the mid-semester to which the PSI model can be applied.



*Fig 1. Proposed design strategy of the course before mid semester*

Interaction opportunities: To counter the social group problem - A weekly reflection submitted in pairs , of the combination of two different disciplines. This would motivate interdisciplinary work and expose the students of the different social groups to try and solve a problem by incorporating both their views. Any instance of conflict that is not resolved amongst them can be later addressed by weekly reflections in the class as well as their submissions of the readings. The aim of giving pair weekly reflection is that students from different disciplines get the opportunity to interact with each other and resolve contradictions. They would be able to reflect on how a particular learning theory or model is implemented or could be implemented in their own respective domain and would also be able to understand how it is implemented in their partner's discipline. They would try to analyze the strengths and weaknesses of that particular learning theory/model in each other's disciplines. Along with this, they would also be given a task to together devise a model to highlight how that theory/model could be implemented in a new learning situation.

We believe that through the incorporation of the PS-I model in the initial phase coupled with the interdisciplinary approach to the reflective assignments and regular evaluation in addition to the existing features that work well, the course would be able to meet its goals more effectively and comprehensively.

Contribution: