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BOARD # 179: Implementing a Lecture-Free Learning Framework: Advancing Experiential Education through Interactive Problem Solving

Dr. Seyed Hamid Reza Sanei, Pennsylvania State University, Behrend College

Dr. Sanei is an associate professor of mechanical engineering at Penn State University with teaching experience expanding three universities and research experience in composite and additive manfacturing.

Implementing a Lecture-Free Learning Framework (LFM): Advancing Experiential Education through Interactive Problem Solving

Abstract:

This paper introduces the development and implementation of a **Lecture-Free Learning Framework** rooted in the principles of experiential learning. Departing from traditional lecture-based instruction, this innovative pedagogical approach engages students directly in interactive problem-solving activities without prior lectures or examples. Encapsulated by the ethos, "Don't explain the game to me; let's just play it," the framework immerses students in the learning process from the outset, fostering deeper understanding and retention.

The Lecture-Free Learning Framework draws inspiration from and extends various student-centered teaching methodologies such as project-based learning, flipped classroom models, and peer learning. By **eliminating pre-lecture content entirely**, it places emphasis on learning through direct engagement with complex, real-world problems. Students collaborate in teams to explore concepts and develop solutions, promoting peer-to-peer learning and collective knowledge construction. The instructor assumes the role of a facilitator, guiding discussions and providing support as needed, rather than delivering conventional lectures.

Preliminary implementation in undergraduate engineering courses such as machine design and system dynamics has demonstrated increased student engagement, enhanced motivation, and positive feedback regarding the learning experience. Assessments indicate improved problem-solving skills, deeper conceptual understanding, and the ability to apply knowledge in practical contexts. This paper discusses the theoretical underpinnings of the framework, practical aspects of its implementation, and evaluates its effectiveness through limited initial data.

By shifting the instructional paradigm, this work contributes to the ongoing discourse on pedagogical innovation in engineering education. It offers insights into alternative teaching strategies that prioritize experiential learning, active participation, and peer collaboration. The Lecture-Free Learning Framework aims to have higher retention, so students have deeper understanding of the topics, a summary of important points is offered at the end of the learning session as a reference page during problem solving, but no full lecture is ever delivered.

2. Introduction:

The landscape of engineering education is undergoing a transformative shift, driven by the need for approaches that prioritize active engagement, critical thinking, and practical application of knowledge. Traditional lecture-based instruction, while foundational, often limits opportunities for students to actively participate in the learning process, leading to gaps in conceptual understanding and retention. In response, innovative pedagogies such as the flipped classroom, project-based learning (PBL), Kolb Experiential Learning Theory (ELT) and peer learning have emerged, each offering unique advantages in fostering student-centered learning.

The flipped classroom model emphasizes pre-class preparation, requiring students to engage with instructional material, such as videos or readings, before attending class. Class time is then dedicated to active problem-solving and the application of concepts [1]. While effective in promoting higher-order thinking, this approach relies heavily on students' self-discipline and access to resources outside the classroom, leading to inconsistent engagement and learning outcomes [2]. Project-based learning immerses students in real-world challenges, allowing them to apply theoretical knowledge in practical contexts [3]. Similarly, Kolb's Experiential Learning Theory (ELT) provides a foundational model for learning through experience, structured around a cyclical process of Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation [4]. While ELT fosters deep understanding through hands-on engagement and reflection, its implementation often requires significant institutional support, infrastructure, and funding to create controlled environments for experimentation. This dependency makes large-scale adoption challenging, as it extends beyond an individual instructors control, limiting its feasibility in many educational settings. Additionally, peer learning leverages collaborative efforts among students, fostering shared knowledge construction and communication skills [5]. All methodologies are instrumental in enhancing engagement but often require a foundational understanding of the subject matter, which may still be delivered via lectures or pre-class assignments.

This paper introduces the Lecture-Free Learning Framework, a novel approach that diverges from these established methods by entirely eliminating pre-class preparation and traditional lectures. Rooted in the principles of experiential learning [4], this framework immerses students directly into problem-solving activities without prior explanation or examples. The ethos, "Don't explain the game to me; let's just play it," encapsulates the framework's core philosophy: learning occurs most effectively when students grapple with examples from the outset.

This proposed method should not be confused with the conventional flipped classroom. The Lecture-Free Learning Framework requires no prior engagement with instructional material, where compliance has been one of the challenges for its successful implementation. It also extends beyond project-based learning by embedding problem-solving as the central mode of instruction, rather than as an application of previously learned content [6].

Research shows that students often achieve a better understanding of topics when examples are actively solved. However, within the constraints of limited classroom time, examples are frequently relegated to the end of the session, often rushed or inadequately addressed, while the majority of time is consumed by delivering a lecture [7]. This can give instructors a false sense of accomplishment, as they may perceive a well-prepared lecture complete with detailed explanations and examples as sufficient for effective learning. Yet, the reality is that the most effective lecture may be the one that doesn't exist [8]. Lectures are inherently passive, and while embedding discussions within a lecture can foster critical thinking, the need to cover necessary content often diminishes the active, engaging portion of the session [9].

The author acknowledges that this paper introduces the concept, outlines the framework, and shares its early implementation alongside initial observations of its success. As a work in progress, this study does not yet include comprehensive data from controlled group comparisons or extensive longitudinal investigations. Future efforts are aimed at securing funding for a large-scale study involving multiple instructors, diverse courses, and varied student groups. Such an investigation would enable a thorough evaluation of the approach's impact on short-term, intermediate, and long-term retention. Nevertheless, the preliminary implementation of this framework in undergraduate engineering courses has shown promising outcomes, including increased student engagement, enhanced problem-solving abilities, and deeper conceptual understanding. By detailing the theoretical foundations, practical implementation, and anecdotal findings, this paper aims to contribute to the ongoing discourse on innovative pedagogical strategies in engineering education.

3. Framework Description

Implementing the lecture-free method may initially feel daunting, as starting a class with an example without any prior explanation or description challenges traditional teaching norms. However, educators are encouraged to experiment with this approach to observe its immediate impact on student engagement and understanding. A phased implementation, limited to a few sessions initially, can help instructors gauge student responses and refine their approach before applying it to an entire course.

This method is particularly well-suited for problem-solving courses such as statics, dynamics, and strength of materials. While concept-based courses like finite element analysis (FEA), vibrations, or composites present additional challenges, the lecture-free framework remains applicable. In these cases, the design of examples and worksheets requires extra attention to ensure that key concepts are adequately covered. Structured and well-sequenced examples are critical, with each example building on prior knowledge to introduce multiple concepts progressively.

4. Framework Implementation

The recommended strategy begins with the instructor solving the initial examples to set the stage, followed by assigning additional problems for students to work on independently for a few minutes before solutions are discussed. For smaller classes (fewer than 30 students), instructors can enhance the learning experience by circulating the room and providing individualized guidance during problem-solving sessions.

Example: Introducing First-Order Systems in a System Dynamics Class

To illustrate the Lecture-Free Learning Framework (LFM), consider the introduction of first-order systems in a System Dynamics class. By this stage, students have already learned how to convert differential equations into the Laplace domain and determine the time-domain response of a system. They are also familiar with common input types—such as step, impulse, and ramp functions—and have experience deriving transfer functions for various mechanical and electrical systems. This foundational knowledge allows them to engage directly with first-order system behavior through problem-solving

Example 1: First-Order Transfer Function

A first-order transfer function with a constant $\boldsymbol{a}$ and time constant $\boldsymbol{\tau}$ is given by:

$TF = \frac{a}{\tau s+1}$ for a step input of magnitude b,

a. Use the final value theorem to determine the steady-state response of the system.

b. Determine the complete response of the system using Laplace transformation.

c. Calculate how close the system's response is to the steady-state value at times $t=\tau$ and t=4τ. Express the response as a percentage of the steady-state value.

In this problem, students engage directly with the mathematical representation of a first-order system without prior lecture-based instruction. Instead of being told the exponential time response or its key properties in advance, they discover the significance of the time constant (τ) by computing the system's response at t = τ (63%) and t = 4τ (98%). This hands-on approach allows students to internalize fundamental principles organically through problem-solving, rather than passively receiving explanations.

Importantly, the Lecture-Free Learning Framework does not equate to an "explanation-free" method. The instructor remains an active facilitator, providing situational explanations where necessary—such as clarifying the universality of these time response properties across all first-order systems—but only after students have engaged with the problem. This ensures that learning occurs through discovery first, with instructor guidance reinforcing key takeaways at the right moment, rather than through lengthy upfront lectures covering all scenarios.

The second example will built on their knowledge of first order system and time constant, they find out the time constant can take many values with different interpretations.

Example 2: For each of the following models, obtain the time response and the time constant, if any.

a. $16\,\dot{x} + 14\,x = 0, x(0) = 6$
b. $12\,\dot{x} + 5\,x = 15,\ x(0) = 3$
c. $7\,\dot{x} - 5\,x = 0,\ x(0) = 9$

In this problem, students analyze first-order differential equations without prior lecture on the behavior of time constants. Instead of being directly taught how time constants vary, they discover it through problem-solving:

In the first equation, they will find a positive time constant, confirming the standard exponential decay behavior.

In the second equation, the solution yields a constant response, leading to the realization that the time constant is effectively zero since no transient behavior exists.

In the third equation, students encounter an unstable system, where the solution grows exponentially due to a negative time constant. They recognize that for systems with poles on the positive *jw*-axis, the concept of a time constant is not defined since the response increases without bound.

Rather than being lectured on all possible cases upfront, students actively engage with the mathematical results and naturally begin questioning the implications of zero or negative time constants. This process of **discovery-based** learning, where students first encounter unexpected outcomes and then seek to understand them, leads to higher retention and deeper conceptual understanding compared to traditional lecture-driven instruction. The instructor can intervene as needed to guide discussions and clarify insights, reinforcing the universal principles of time response behavior only after students have explored the problem themselves.

Building on the insights gained from the previous examples, this problem reinforces key concepts while introducing the impact of initial conditions and input changes on time constant and steady-state response.

Example 3: For the model $2\,\dot{x} + x = 10f(t)$,

a. How long does it take before 98% of the difference between $x(0)$ and x_{ss} is eliminated.
b. Repeat part (a) with a different initial condition, $x(0) = 5$ Will changing the initial condition change the steady state or time constant?
c. Repeat part (a) with $x(0) = 0$ and $f(t) = 20\,u_s(t)$. Will changing the input change the steady state or time constant?

In part (a), students reinforce their understanding of the time constant by recalling from Example 1 that it takes 4τ for the system to reach 98% of the steady-state value. In part (b), they compare results with part (a) to discover that changing the initial condition does not affect the steady-state response or the time constant, reinforcing the principle that transient behavior depends on initial conditions, but system characteristics remain unchanged. In part (c), they explore how input changes affect the steady-state response but not the time constant, developing an intuitive understanding of system behavior under different forcing functions. Subsequent examples build sequentially on the previous one, mirroring the natural learning process that would have traditionally been covered through lectures. However, rather than presenting these concepts in a passive format, the Lecture-Free Learning Framework ensures students discover them through problem-solving, fostering an engaging class environment.

A total of nine examples will be assigned for this topic, spread across two 115-minute sessions. For the sake of brevity, subsequent examples are not detailed here; however, each follows a structured progression—

building on previously acquired knowledge while seamlessly introducing new concepts through hands-on problem-solving, rather than traditional lecture-based instruction.

For conceptual topics that do not involve direct problem-solving, class activities can be structured around discussions to maintain active engagement. One effective approach is the "discuss with your neighbor" activity, where students collaborate in small groups to analyze or debate specific aspects of a topic. For example, instead of delivering a lecture on the advantages of fine versus coarse gear teeth, students can be asked to compare and discuss the two options in terms of strength, vibration, ease of manufacturing, durability, resistance to dirt, and noise level.

This method prompts students to actively think about the topic and draw from their prior knowledge, fostering deeper understanding and immediate engagement. It also prevents the passive learning often associated with traditional lectures, where students may become disengaged or distracted. After the group discussions, the instructor can address any misconceptions and clarify key points, ensuring students leave with a correct and comprehensive understanding. This approach not only reinforces active participation but also makes the learning experience more interactive and memorable.

To support students, a summary of notes can be provided at the end of each session as a reference guide. This document serves as a concise, comprehensive resource for clarification and review, similar to a rule book in a game. Depending on the course, the textbook itself may also serve as an appropriate reference. Importantly, these summary notes should not be confused with a lecture; they are delivered only after the problem-solving activities to supplement learning without disrupting the active and experiential nature of the framework.

In the LFM, the role of homework is significantly enhanced to reinforce conceptual understanding, critical thinking, and independent discovery. Since traditional lectures are absent, HW assignments focus on conceptual questions rather than rote exercises, requiring students to extract and apply principles from in-class problem-solving sessions rather than referring to pre-delivered notes or textbook explanations.

Students cannot simply locate a corresponding lecture section and reproduce an answer; instead, they must analyze the in-class examples, identify the underlying concepts, and effectively synthesize their own explanations—essentially constructing the "lecture" retrospectively from the problem-solving process.

To facilitate this, HW problems include concept-driven reflection questions, such as:

Why was a particular approach used over another?

How do different solution methods compare in efficiency and applicability?

What would change if system parameters were modified?

These types of questions reverse-engineer the learning process, prompting students to actively deduce theoretical insights from applied examples. Additionally, because students have already encountered basic procedural examples in class, Homework problems can delve into deeper analytical and conceptual explorations. Simple plug-and-solve exercises are largely unnecessary, allowing homework to focus on more complex variations, extensions of in-class problems, and new problem-solving scenarios that introduce subtle variations or new constraints, reinforcing adaptive thinking.

In my experience, when students are given a problem to solve in class before I present the solution, they often hesitate to attempt it independently. They fear making mistakes, assuming they will have to erase their work and rewrite the correct solution. To address this, I have designed a structured problem statement handout with three columns: Your Attempt, Instructor Solution, and Reflection. The Your Attempt column encourages students to engage with the problem without the pressure of perfection, while the Instructor Solution provides a reference for comparison. The Reflection column prompts students to analyze their approach, noting what they would do differently. To reinforce the idea of learning through iteration, the Your Attempt section can be color-coded in light gray, subtly signaling a draft mentality. Additionally, before revealing the instructor’s solution, students discuss their approaches in pairs, fostering peer learning and confidence in problem-solving.

Homework in LFM serves as a natural extension of classroom learning, transforming it from a mere practice tool into an integral part of the discovery process, ensuring students engage with material actively and contextually rather than mechanically.

5. **Preliminary Observations**

While this study does not yet include comprehensive data from controlled group comparisons or extensive longitudinal investigations, the author would like to share some anecdotal observations from implementation of the method to different course settings. The LFM method was implemented in part or in whole in plethora of courses, namely Machine Design, System dynamics, Statics and Dynamics. The success of the method was noticed through both immediate and semester long assessments. In addition to conventional problems, I have incorporated many conceptual questions in the exams and the result of LFM is overwhelmingly positive with higher averages than previous years. Such approach has even contributed to better performance in semester long project where improvements in students' abilities to tackle complex, real-world problems.

While not the primary objective of the Lecture-Free Learning Framework (LFM), one notable outcome has been significantly higher student ratings of teaching effectiveness compared to conventional instructional settings. Students frequently report that their retention of class content is substantially improved, and they perceive exam questions as extensions of class activities, thanks to the extensive practice and engagement provided during the course. Factors contributing to these improved ratings may include reduced confusion, increased confidence, exposure to a diverse range of problems before exams, and the highly interactive and engaging environment fostered during class sessions. These elements collectively create a positive learning experience, reinforcing the value of the LFM approach.

An additional observation pertains to student engagement during class sessions. In traditional lecture-based settings, students often resort to using their cell phones to alleviate boredom during prolonged periods of passive listening. However, within the LFM students are consistently engaged in active problem-solving and collaborative discussions, leaving little opportunity or inclination to divert their attention to mobile devices. This continuous engagement not only enhances learning but also naturally diminishes the need to enforce strict no-cellphone policies, as students remain focused on the tasks at hand. Active learning environments can reduce distractions by keeping students involved in the learning process, thereby decreasing the likelihood of off-task behavior such as cell phone use.

6. **Challenges and lessons learned**

Implementing the LFM presents several challenges, primarily related to preparation, time management, and perception of the learning process.

The preparation for this method requires significant effort, as each example must be meticulously designed to align with learning objectives. Moreover, the examples must be structured in a progressive sequence, ensuring that each subsequent problem builds upon the understanding developed in earlier exercises. This careful design is essential to cover the full scope of course content without relying on traditional lectures or pre-class materials.

Although solving examples is an effective pedagogical tool, it is inherently time-consuming. The "race against time" becomes a significant concern, especially in courses with dense syllabi. Despite this, the framework has been successfully implemented without sacrificing any critical topics, demonstrating its feasibility with strategic planning and well-crafted exercises.

Another challenge involves students' perceptions of learning. While students generally appreciate the increased focus on problem-solving over lectures, some may feel a lack of formal instruction, which could impact their sense of preparedness. This highlights the importance of clearly communicating the purpose and benefits of the framework to students at the outset, ensuring they understand the experiential learning philosophy and its long-term advantages.

Attendance also emerges as a critical factor. Since the learning process occurs entirely during class time, absences can significantly hinder student progress. The lack of pre-class materials or traditional lectures places greater emphasis on active participation in classroom activities, making consistent attendance essential for success.

Another challenge, though not directly related to student learning, is faculty adoption. Many colleagues are hesitant to remove traditional lectures, perceiving that students will be left to learn the material entirely on their own through examples. In reality, the LFM does not eliminate instruction but restructures it. Instead of delivering an entire lecture upfront, LFM breaks it into smaller, context-driven explanations provided after each example, ensuring that students engage with the material actively before receiving clarifications. In this approach, the key principles are reinforced through targeted explanations at the right moment. Importantly, LFM is not an explanation-free method—it simply shifts explanations to occur after problem engagement, when they are most meaningful and impactful.

These challenges underscore the need for thoughtful implementation, clear communication with students, and strategies to maximize engagement and time efficiency. While the approach demands a shift in both teaching and learning dynamics, the observed benefits—enhanced engagement, improved problem-solving skills, and deeper conceptual understanding—justify the effort required to overcome these obstacles.

7. Conclusion and Future Work

The preliminary implementation of the Lecture-Free Learning Framework (LFM) has demonstrated promising outcomes in enhancing student engagement, problem-solving skills, and conceptual understanding. A list of conclusions is listed here:

- **Enhanced Student Engagement:** The LFM significantly increased student engagement by immersing them in problem-solving activities from the outset, fostering active participation and collaboration.
- **Improved Problem-Solving Skills:** Students demonstrated enhanced ability to tackle complex, real-world problems through repeated exposure to diverse examples and active learning.
- **Deeper Conceptual Understanding:** By focusing on experiential learning, students retained knowledge better and were able to apply concepts effectively in exams and projects.
- **Positive Student Feedback:** High teaching effectiveness ratings reflected students' appreciation for the interactive and practical nature of the learning environment.
- **Effective Integration into Curricula:** Despite the absence of traditional lectures, the framework successfully covered all course content without compromising depth or breadth.
- **Feasibility of execution:** Unlike experimental learning or Kolb’s method, LFM approach can be implemented at the discretion of the instructor without immense institutional support and requires minimum to none budget and infrastructure.

Future work will focus on systematically evaluating the Lecture-Free Learning Framework (LFM) through structured quantitative and qualitative studies to assess its impact on student learning outcomes, engagement, and long-term retention. Controlled comparisons of exam performance, assignment scores, and project outcomes between LFM-based and traditional courses will quantify learning gains, while longitudinal assessments will track knowledge retention in subsequent coursework.

Student perception and engagement will be analyzed through pre- and post-course surveys, focus groups, and course evaluations to assess adaptation to the LFM model and identify areas for refinement. To address faculty adoption challenges, efforts will focus on developing structured problem sets, scaffolding techniques, and instructor support resources to streamline implementation and reduce preparation time.

LFM will also be expanded to additional engineering and STEM courses to evaluate its adaptability across disciplines. Finally, industry-aligned assessments will measure real-world problem-solving skills, ensuring LFM's effectiveness in preparing students for professional applications. These targeted research efforts will establish an empirical foundation for refining and scaling LFM in experiential engineering education.

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