Building Interest and Engagement in Engineering Students through Interactive Lecture Demonstrations

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Abstract— **Building student interest is a challenge every teacher encounters, and competing demands from society can make engagement difficult to sustain. In this study, I describe how I developed my higher education teaching by combining traditional lectures with active learning strategies to create a more engaging learning environment. This approach is grounded in the principles of active learning, aiming to engage students cognitively and encourage meaningful connections between theoretical concepts and practical applications. I introduced Interactive Lecture Demonstrations (ILDs) into the lectures of a first-cycle course for Fire Safety Engineering students at Lund University.**

This study investigates how the introduction of ILDs affects student motivation and engagement within a university-level course on Building Materials. Both quantitative and qualitative analyses were conducted. A student survey was used to examine motivation and engagement. In addition, a quantitative statistical analysis was also carried out, in which exam questions were categorised according to the intended learning outcomes (ILO), allowing assessment of student performance in relation to the ILOs.

The introduction of ILDs led to higher engagement, more lively interactions during breaks, and a noticeably more dynamic dialogue during and between lectures. While the quantitative data indicated enhanced motivation and engagement, the statistical analysis of learning outcomes was less conclusive, suggesting that the impact of ILDs on exam performance may be subtle or influenced by other factors. These findings indicate that incorporating ILDs into traditional lectures can effectively promote engagement and active learning in STEM education.

Index Terms— **Student motivation, student performance, Interactive Lecture Demonstrations, CEQ**

I. Introduction

Interactive lecture demonstrations (ILD) is a teaching method that can be applied to enhance conceptual learning in any subject, especially in STEM teaching. When investigating this strategy to enhance student learning, I found evidence from Sokoloff and Thornton [1], who reported strong evidence for a significant improvement in learning and retention of fundamental concepts among students who attend in ILDs. ILDs are often employed in physics [1-3] but may also be used in other disciplines like chemistry [4] and mechanics [5, 6]. Students in the mandatory first cycle course Building Materials (VBMA25), Fire Safety Engineering programme, are facing difficulties in transferring theory of building materials structure properties to the practical context in application based exercises. This challenge is sometimes observed during supervised exercise classes. To overcome these difficulties, I introduced ILDs in my teaching in Building materials, as this course shares many of the theories from disciplines like physics, chemistry and mechanics.

This study investigates the implementation of ILDs within a university-level course on Building Materials, VBMA25, aiming to evaluate their impact on student perception and performance. Using a combination of quantitative and qualitative data from the Course Experience Questionnaire (CEQ) [7] and statistical analysis of normalised examination scores, the study compares examination performance across student cohorts prior to and following the implementation of ILDs. The quantitative data from the CEQ consisted of two questions of student perception of ILDs. By assessing both theoretical and applied components of the course, this research seeks to determine whether ILDs contribute to improved learning and engagement, and to identify any potential limitations in their effectiveness when applied to VBMA25. This study therefore addresses two research questions:

(1) How do students perceive the impact of ILDs on their learning and engagement, as explored through a CEQ questionnaire?

(2) Does the integration of multiple ILDs improve normalised examination scores in VBMA25, as evaluated by statistical analysis of examination data?

II. Interactive Lecture Demonstrations in VBMA25

In the 2024 VBMA25 course, Interactive Learning Demonstrations (ILDs) were integrated into seven of ten lectures. The remaining three lacked suitable content for ILDs. Students were informed at the start that brief ILDs would be used to link theory with practice in Fire Safety Engineering.

One ILD, presented in a lecture on dimensional stability, demonstrated the effect of temperature on materials by evaluating the coefficient of linear thermal expansion. Using a digital calliper, liquid nitrogen, a steel rod (50 × 10 × 10 mm), a thermometer (+50°C to −200°C), and a suitable container, students measured the rod's length at room temperature, then after cooling in liquid nitrogen.

During the demonstration, students discussed the theoretical and mathematical basis of one-dimensional

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thermal expansion, identified key parameters, and predicted material behaviour. The activity effectively bridged theoretical concepts with hands-on understanding, illustrating how experiments can be used to evaluate and model material properties.

III. Method

Participants and intervention - This study involved two instructional groups: pre-intervention students (2021–2023 cohorts, n=158) taught prior to ILDs, and post-intervention students (2024 cohort, n=56) taught with multiple ILDs. A single ILD was piloted earlier but did not represent a systematic change; full implementation occurred in 2024.

Student Perception - Student perceptions of ILDs were evaluated using two CEQ questions on their learning added value and on motivation, and engagement, answered on a 5-point Likert-type scale. Qualitative responses to an open-ended question further explored themes of motivation and engagement.

The survey consisted of three questions incorporated into the faculty's regular CEQ for VBMA25. Responses were registered on a 5-point Likert-type scale, ranging from "Strongly disagree" (-100) to "Strongly agree" (100).

The questions addressed to ILDs were as follows:

CEQ 1.I found the ILD to be a valuable part of the course and they supported my learning.

CEQ 2.The ILDs increased my motivation to learn more about the course subject.

CEQ3. What do you think was the best thing about this course?

The first two questions focused on self-reported perception on support of learning and motivation and the responses to the open-ended question further explored themes of motivation and engagement.

Student performance - was assessed using theory-based questions mapped to ILO 2 which covers the material structure, manufacturing processes, and properties of building materials and ILO 4, which covers mechanisms related to heat transfer, moisture behaviour, mechanical properties, durability, and material performance at elevated temperatures. Normalised scores (0–1) were calculated for each student.

The dataset comprised 40 examination questions, of which 26 corresponded to ILO 2 and 14 to ILO 4. Across cohorts, approximately 73% of ILO 2 questions and 71% of ILO 4 questions were administered prior to the intervention, with the remaining 27% and 29% administered post-intervention, respectively.

For each student, normalised scores (NS, range 0–1) were calculated for each ILO by aggregating the results of all relevant theory questions.

Statistical Analysis - Differences between Pre- and Post-intervention groups were analysed using one-way analysis of variance (ANOVA) for ILO 2 and ILO 4, with a significance set at $p < 0.05$. Examination formats remained consistent across cohorts to ensure comparability.

IV. Results

Student perception - The responses of each statement/question were grouped into three categories: negative (selecting -100 or -50), indifferent (selecting 0), and positive selecting (50 or 100). The responses of CEQ1, the perceived value of the ILDs in supporting their learning, are shown in Figure 1.

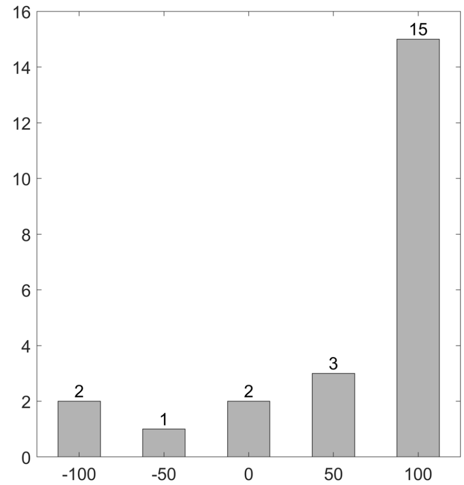

Figure 1. Distribution of student responses to CEQ 1: *"I found the ILD to be a valuable part of the course and supportive of my learning."*

A total of 18 students (75%) responded positively, indicating agreement or strong agreement. Two students (8%) indicated a neutral or indifferent stance. Three students (12%) responded negatively, indicating disagreement or strong disagreement. This distribution suggests that the majority of students viewed the ILDs as a valuable component of the course and that they supported their learning.

A total of 19 students (79%) responded positively, indicating agreement or strong agreement. Three students (13%) indicated a neutral or indifferent stance. One student (4%) responded negatively, indicating strong disagreement. These results suggest that the ILDs were perceived by most students as positively contributing to their motivation.

Pre- and post-intervention examples of answers to CEQ 3 (Translated from Swedish).

Pre-intervention:

"A passionate lecturer who is truly dedicated to his work and subject. The laboratory sessions provided a good break from all the reading."

Post-intervention:

"The lecturer we had was very good and pedagogical and really helped with the course."

Collectively, the post-intervention comments highlight stronger perceptions of engagement, support, and course relevance, suggesting that the ILD approach had a positive impact on students' learning experiences.

Student performance - Table 1 summarises the distribution of student performance for the pre and post intervention groups across each analysed component, along with the corresponding p-values (p) from one-way ANOVA. For each component, the 25th percentile (25%), median (50%), and 75th percentile (75%) are reported.

Table 1. Distribution of student performance across pre- and post-intervention groups.

	Pre			Post			
	25%	50%	75%	25%	50%	75%	p
ILO2	.48	.64	.74	.48	.62	.71	.98
ILO4	.50	.74	.92	.42	.58	.67	.002

For ILO 2, there was no significant difference between pre- and post-intervention groups ($p = 0.98$), with medians of 0.64 and 0.62, respectively. In contrast, ILO 4 showed a significant decrease post-intervention ($p = 0.002$), with the median falling from 0.74 pre-intervention to 0.58 post-intervention.

Overall, the table indicates that the teaching intervention had a significant impact on ILO 4 but not in ILO 2. The interquartile ranges suggest that variability in student performance was similar across pre- and post-intervention groups.

V. Discussion

Following the large-scale introduction of Interactive Learning Demonstrations (ILDs), 75% of students reported that the method supported their learning. This likely stemmed from increased dialogue and discussion during and between lectures. Students' questions shifted from focusing on isolated facts to showing deeper reasoning and conceptual connections, suggesting a move from surface to deeper learning. Many also became more active during breaks, continuing discussions with peers and showing sustained engagement beyond lectures. The atmosphere resembled the curiosity and energy typical of laboratory sessions. These findings are consistent with those reported by Cuong et al. [3], who also observed enhanced student interest and engagement following the implementation of ILDs.

Self-reported motivation and engagement also increased, with 79% of respondents agreeing that ILDs enhanced both. Although many students were primarily interested in fire-related topics, ILDs appeared to bridge this gap by connecting abstract concepts to practical, applied demonstrations.

In contrast to findings by Sokoloff and Thornton [7], no significant improvements in examination performance were found between pre- and post-intervention groups. In fact, scores related to ILO 4 were slightly lower after ILD implementation. This may reflect differences between student cohorts or the possibility that the applied, experiential nature of ILDs shifted focus away from theoretical understanding. Without explicit connections to underlying principles, students may have perceived the demonstrations as stand-alone experiences rather than tools to reinforce theory. The limited duration of the intervention may also have constrained its impact.

Despite the lack of measurable performance gains, students consistently reported positive learning experiences and increased engagement. These outcomes suggest that ILDs effectively fostered motivation and participation, even if not yet reflected in examination results. Future work should focus on strengthening the link between ILDs and theoretical content through structured reflection and explicit conceptual integration. Overall, while statistical outcomes were inconclusive, both qualitative and quantitative feedback point to ILDs as a promising method for enhancing engagement and supporting deeper learning.

VI. Conclusion

The findings from this study present a nuanced picture of the impact of ILDs on student learning. While student feedback via the CEQ was overwhelmingly positive—indicating that the majority perceived the ILDs as supporting their learning and improving their motivation and engagement—the statistical analysis of learning outcomes offers a more complex interpretation. ILO 2 showed no measurable effect from the ILDs, and ILO 4, notably, exhibited a statistically significant moderate decline in performance following the intervention.

Taken together, these results suggest that while students value the ILDs and report perceived benefits, the measurable impact on academic performance is limited and, in some cases, slightly negative. These findings highlight the importance of combining student perception data with objective performance measures when evaluating pedagogical innovations and of refining ILD design to more strongly link active engagement with theoretical understanding.

Nevertheless, the study demonstrates that even modest pedagogical adjustments, such as incorporating ILDs, can meaningfully enhance the learning atmosphere and lay the groundwork for more interactive and effective teaching practices in higher education.

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