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Student Engagement in Engineering Education Through Video Learning and Virtual Learning Objects

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Abstract– Student engagement remains a critical challenge in engineering education, particularly in courses that require strong conceptual understanding and sustained cognitive effort. This study examines engineering students' perceptions of engagement following the implementation of a structured instructional intervention integrating Video Learning and Virtual Learning Objects (VLOs) in a mechanics course. The intervention was organized around a three-phase learning sequence that combined short, segmented instructional videos with interactive digital activities designed to support autonomous and reflective learning. A quantitative, non-experimental descriptive approach was employed using the Student Engagement Questionnaire (SEQ) to assess five engagement dimensions: Intellectual Abilities, Teamwork, Teaching Methods, Teacher–Student Relationship, and Student–Student Relationship. Data were collected through a self-report survey administered to undergraduate engineering students after the intervention. The results indicate positive student perceptions across all engagement dimensions, with particularly strong responses related to cognitive engagement and instructional clarity. The integration of Video Learning and VLOs supported self-directed learning, conceptual understanding, and perceived effectiveness of teaching methods. In contrast, the Student–Student Relationship dimension received comparatively lower ratings, suggesting that social engagement was constrained by the individual-focused instructional design. These findings underscore the importance of intentional pedagogical design when integrating digital resources into engineering courses. While Video Learning and VLOs can effectively enhance cognitive and instructional engagement, fostering social interaction requires the deliberate inclusion of collaborative learning strategies. This study provides baseline evidence to inform the design of technology-enhanced learning environments in engineering education.

Keywords-- Educational Innovation, Higher Education, Engineering Education, Virtual Learning Objects, Video Learning.

I. INTRODUCTION

Student participation in educational activities proves difficult to achieve but it represents a critical factor for developing professionals who will tackle present-day requirements. Academic and professional success requires students to maintain both involvement and motivation, which defines the concept of engagement [1].

Student engagement benefits from video learning because it combines educational content delivery with improved student understanding and confidence development [2]. Through Virtual Learning Objects (VLOs) students gain independence to study topics individually, especially when subjects need extended learning beyond traditional classroom environments [3].

VLOs serve as useful educational tools because they offer high-quality learning resources to students regardless of their location and internet connectivity status [4]. Previous studies have shown that student results improve through VLOs only when the resources are designed properly and remain accessible to students and interactive for their learning needs [5].

This research investigates how students perceive their academic participation and learning environment after using VLOs and Video Learning during their course. The Student Engagement Questionnaire (SEQ) was used to assess students' academic engagement. The validated instrument demonstrated excellent internal consistency (α = 0.94), ensuring reliability for use in higher education research [6].

Student engagement is commonly described as a multidimensional construct that integrates cognitive, behavioral, and social components of learning [1], [7]. In engineering education, engagement goes beyond attendance or task completion and involves students' ability to regulate their learning processes, apply conceptual knowledge, and interact meaningfully with instructional environments.

Within this framework, Video Learning and Virtual Learning Objects (VLOs) operate as complementary instructional strategies. Short, segmented video resources primarily support cognitive engagement by facilitating conceptual understanding, self-paced learning, and reflective processing [8], [9]. In contrast, interactive VLOs—such as quizzes, conceptual exercises, or formative assessments—encourage active participation and learning autonomy through immediate feedback and iterative engagement with content [4], [5].

This pedagogical alignment suggests a direct relationship between the design of Video Learning and VLOs and specific dimensions of the Student Engagement Questionnaire (SEQ). Cognitive-oriented activities are expected to influence the Intellectual Abilities dimension, while structured digital tasks and instructor mediation relate more closely to Teaching Methods and Teacher–Student Relationship [6], [10]. Conversely, when learning activities are designed primarily for individual progression, their impact on the Student–Student Relationship dimension may be limited [11].

Based on this conceptual alignment, the present study examines students' perceptions of engagement after a structured three-phase intervention integrating Video Learning and VLOs in an engineering mechanics course, using the SEQ as the primary assessment instrument.

This paper is organized as follows. Section II presents the background. Section III describes the methodology. Section IV reports the results. Section V discusses the findings.

Finally, Sections VI and VII present the conclusions and future work.

II. BACKGROUND

Academic engagement means students both achieve their course requirements and develop autonomous learning methods and apply classroom knowledge outside academic settings [1], [12]. Research indicates that academic engagement produces two main effects, boosting both student achievement and the development of leadership and employability skill [13]. The actual learning process engagement requires more from students than class attendance and assignment submission because they need to take an active role in their education.

In this context, digital learning tools such as VLOs and Video Learning have emerged as effective strategies to foster academic engagement by promoting autonomy, motivation, and conceptual understanding among student [2], [4], [14]. Likewise, the flipped classroom approach has shown comparable benefits by combining pre-class video materials with in-class collaborative activities. This methodology significantly enhanced students' argumentative skills, academic performance, and participation levels in engineering courses [15]. These learning objects have shown effectiveness in teaching complex hematology topics which need additional educational support after traditional classroom instruction [16]. However, simply providing access to VLOs does not automatically result in improved learning outcomes; their effectiveness depends on accessibility, interactivity and adaptation to the learning environment [5].

Over time, VLOs have evolved from being merely complementary digital resources to becoming powerful tools that expand learning opportunities and accessibility in diverse educational contexts. VLOs have made it possible to deliver high-quality content to rural areas and other hard-to-reach locations which create educational possibilities for communities that previously lacked access to learning [4].

Technology proves beneficial when used strategically as an effective ally for educational success. Recent studies highlight that when digital activities are designed with interactivity, structure, and clear pedagogical purpose, they significantly improve student engagement and academic performance in online environments where motivation often decreases due to lack of challenge or feedback opportunities [14].

Research shows that video learning becomes more effective when videos adjust to individual learning preferences and speeds of each student [8]. Previous classrooms observations indicate that brief educational videos work better than extended boring content at keeping students engaged and enhancing their comprehension. The recording and uploading of classes serve as a starting point for educational video content development which must include segmented segments for student explanation and information processing [9].

The cultural backgrounds of students strongly influence digital learning environments. All students possess different life experiences along with varying resource availability which requires designing inclusive strategies to promote equal participation for all students [11]. Students show better motivation and engagement when teachers provide them with clear consistent feedback about their performance [10]. A short well-directed comment from our experience demonstrates how it transforms students from disengaged to engaged learners. Science reveals that engagement exists as a complex system which includes cognitive and behavioral components alongside emotional aspects Wang [7]. Any approach to enhance engagement requires simultaneous attention to cognitive and behavioral and emotional aspects.

Despite these advantages, certain challenges persist when students engage with video-based materials. Video learning can also result in passive information processing when students simply watch without intentional focus or cognitive regulation [17].

Research studies along with teaching practice demonstrate that external factors work as barriers to student engagement. Video game overuse functions as an evident example of how excessive usage negatively impacts concentration and executive functioning which in turn harms academic performance [18].

This research provides an opportunity to examine how students perceive their engagement through VLOs and Video Learning, enabling the identification of strengths and weaknesses in these educational approaches. Building on this evidence, the present study integrates these principles by combining interactive VLOs and segmented videos designed to promote autonomy, reflection, and conceptual understanding in an engineering contest. Unlike previous studies that analyze engagement in general online courses, this research focuses on a discipline specific application in engineering mechanics, using a validated instrument to explore how interactive videos and VLOs influence students' engagement dimensions.

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III. METHODOLOGY

A. *Educational intervention*

The educational intervention aimed to enhance independent learning through the combination of Video Learning and VLO to promote academic engagement. The educational intervention comprised of three phases and four VLO activities, integrating short videos, with embedded questions, an interactive crossword, and a conceptual quiz, which provided interactive resources and progress-based assessments for students to advance individually, as shown in Fig. 1.

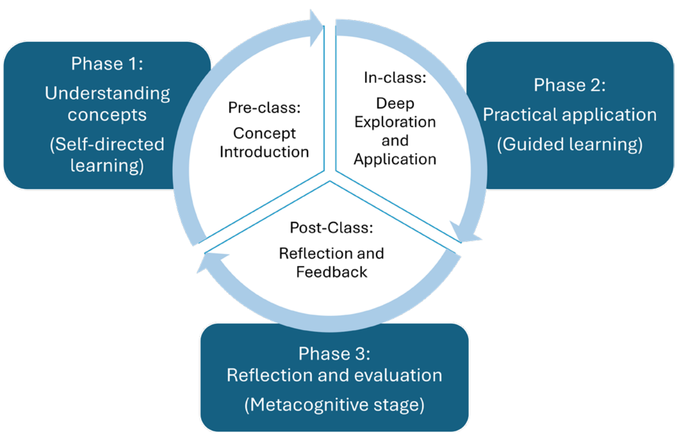

Fig. 1. Sequence of three phases in educational intervention.

During the first phase, conducted before the in-class sessions, students began by studying basic concepts about center of mass and centroid through educational video content. The process included two formative VLOs that allowed students to verify their understanding before attending class, as shown in Fig. 2.

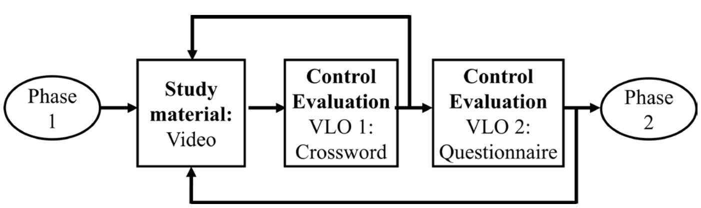

Fig. 2. Sequence of activities implemented in Phase 1.

After watching the video, students needed to finish an interactive crossword puzzle serving as VLO to measure their comprehension level. The activity enabled students to determine weak points in their understanding so they could watch the video again before attempting the crossword puzzle for a second time. Students who finished the crossword puzzle correctly could proceed to a second assessment through a VLO which featured a final quiz about the essential topics. Students who provided correct answers could continue to the following phase. The digital learning environment used during this Phase 1 is illustrated in Fig. 3.

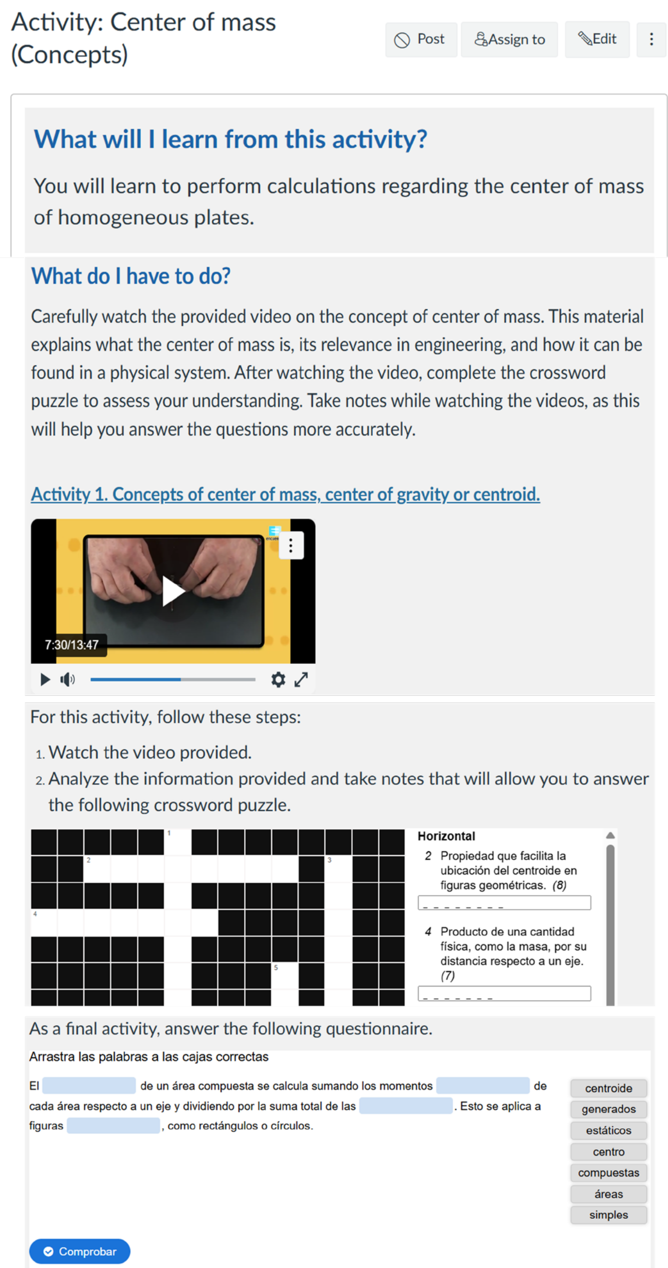

Fig. 3. Digital environment implemented in Canvas.

The second phase of learning took place during the in-class session and focused on a deeper exploration of the center of mass of composite figures, as illustrated in Fig. 4. Students engaged with a new video presented as a VLO that included interactive questions to reinforce their understanding. During this phase, the instructor facilitated discussion, clarified doubts, and guided students through problem-solving strategies to ensure conceptual accuracy.

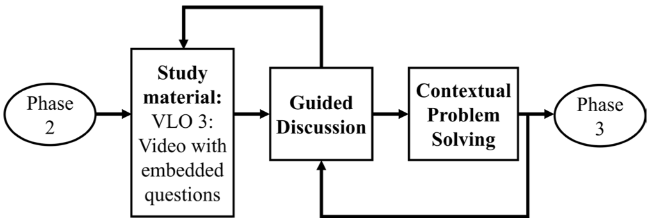

Fig. 4. In-class activities supported by the instructor as facilitator.

Students maintained the freedom to rewatch the video as needed, supporting their self-directed learning while receiving immediate feedback in class. They were then required to demonstrate conceptual understanding by completing a practical assessment, as illustrated in Fig. 5.

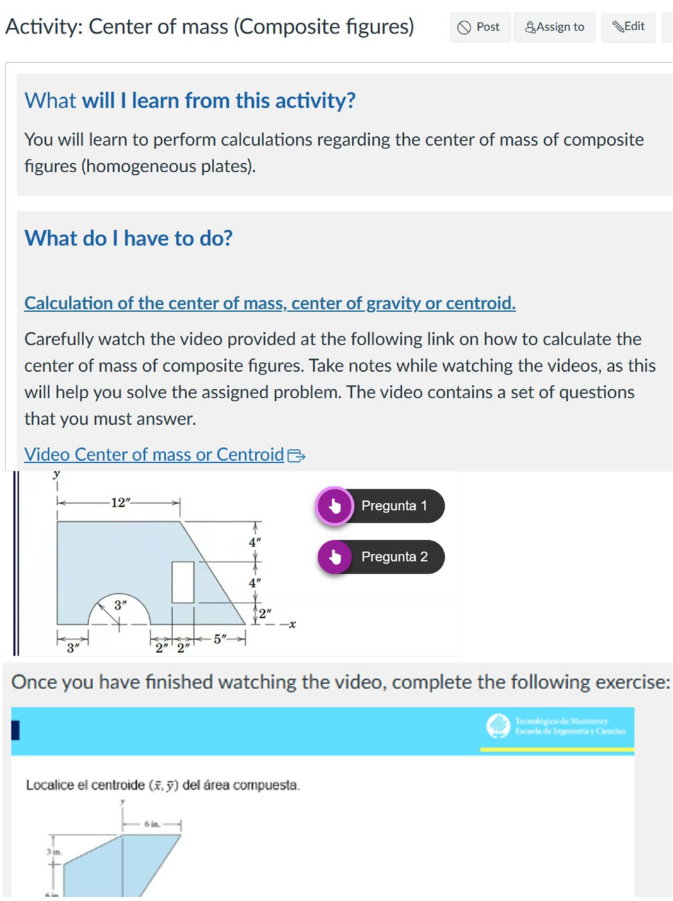

Fig. 5. Contextual problem-solving activity In-class.

This assessment involved calculating the center of mass of a composite figure. This activity allowed students to apply the learned concepts in contextualized way before advancing to the next phase of the intervention.

The third phase of the intervention took place after the inclass activities and focused on individual reflection. The final VLOs required students to reflect on their learning experience through an activity that asked them to describe what they had learned, identify encountered obstacles, and share their perspective about the educational approach. After completing this activity, students uploaded their reflections on Canvas and then completed the SEQ to assess their perceptions of engagement, as illustrated in Fig. 6.

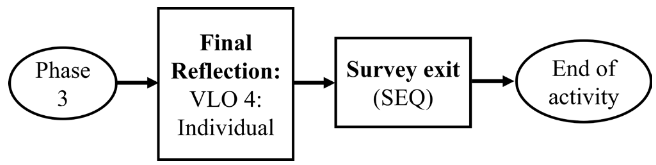

Fig. 6. Activities during Phase 3 (post-class reflection) and evaluation engagement questionnaire.

The digital environment for this final phase included the reflective VLO interface and SEQ survey, both accessible through Canvas. Fig. 7 shows the student view during this phase, where learners recorded their reflections, submitted their responses, and completed the engagement questionnaire to provide final feedback on the use of VLOs and Video Learning.

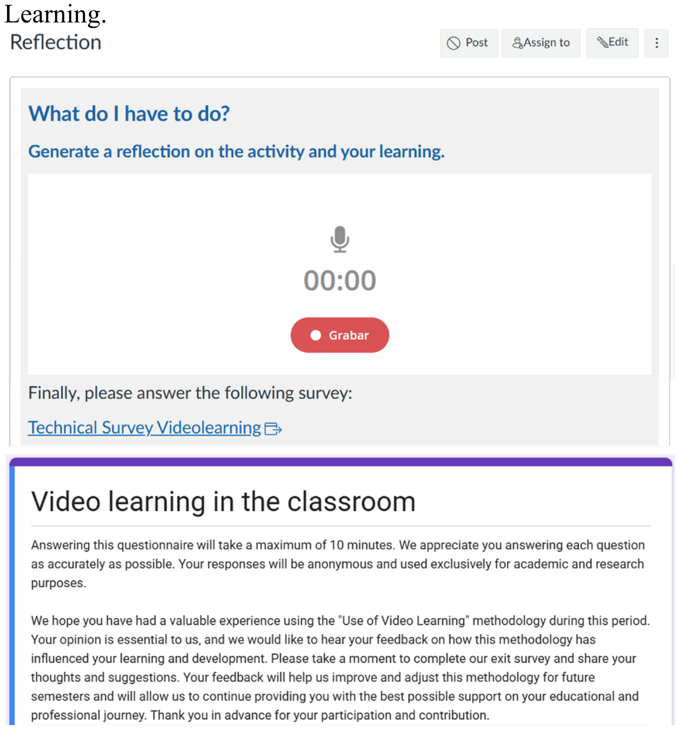

Fig. 7. Canvas interface showing the reflective VLO and engagement questionnaire.

B. Impact measurement

The SEQ served as the main evaluation tool to measure students' academic engagement, as it a validated and reliable instrument widely used in higher education context. According to Sayeg et al. [19], the questionnaire explores five key dimensions that affect student engagement: Intellectual Abilities, Teamwork, Teaching Methods, Teacher-Student Relationships, and Student-Student Relationships. The first two dimensions are related to students' capabilities, while the remaining three reflect aspect of the teaching-learning environment [19]. The validated instrument demonstrated excellent internal consistency (α = 0.94), confirming its reliability for use in university courses [6].

The SEQ statements corresponding to each dimension are presented in Table I, which served as the basis for the course assessment.

TABLE I
SEQ DIMENSIONS AND STATEMENTS

Dimension	Item
Intellectual Abilities	IC1. I have developed my ability to make judgements about alternative perspectives
	IC2. I have become more willing to consider different points of view
	IC3. I have been encouraged to use my own initiative
	IC4. I have been challenged to come up with new ideas
	IC5. I feel I can take responsibility for my own learning
	IC6. I have become more confident in my ability to pursue further learning
Teamwork	TW1. During my time at this course, I have learned how to be to be more adaptable
	TW2. I have become more willing to change my views and accept new ideas
	TW3. I have improved my ability to use knowledge to solve problems in my field of study
	TW4. I am able to bring information and different ideas to solve problems
	TW5. I have developed the ability to efficiently communicate with others
	TW6. In my time at this course, I have improved my ability to convey ideas
	TW7. I have learned to be an effective team or group member
	TW8. I feel confident about the way I deal with a wide range of people
	TW9. I feel confident in using computer applications when necessary
	TW10. I have learned more about using computers for presenting information
Teaching Methods	TM1. Our teacher uses a variety of teaching methods
	TM2. Students are given the chance to participate in classes
	TM3. The teacher tries hard to help us understand the course material
	TM4. The course design helps us to understand the course content
	TM5. When I have difficulty with learning materials, I find the explanations provided by the teacher useful
	TM6. I can see how courses fitted together to make a coherent course for my major
	TM7. The program of study for my course was well integrated
Teacher-Student Relationship	TS1. There is sufficient feedback on activities and assignments to ensure that we learn from the work we do
	TS2. The course uses a variety of assessment methods
	TS3. To do well in assessment in this course your need to have good analysis skills
	TS4. The assessment tested our understanding of key concepts in this course
	TS5. The communication between teacher and students is good
	TS6. I find the teacher helpful when asked questions
	TS7. I manage to complete the requirements of the course without feeling unduly stressed
	TS8. The amount of work we are expected to do is quite reasonable
Student-Student Relationship	SS1. I feel a strong sense of belonging to my class group
	SS2. I frequently work together with other in my classes
	SS3. I have frequently discussed ideas from courses with students out-of-class
	SS4. I have found that discussing course material with other students outside classes has helped me to reach a better understanding of the material

The SEQ consists of 35 statements that the students evaluate on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This instrument enables researchers to analyze multiple aspects of engagement and has proven effective in assessing academic engagement in university courses, providing significant insights into students' perceptions of their classroom experience [6], [19].

The responses obtained from the SEQ were analyzed using descriptive statistics to calculate means scores and standard deviations for each dimension. Additionally, 95% confidence intervals were computed to estimate the precision of the mean values. Correlation analysis using Pearson's coefficient was also conducted to examine the relationships among the five engagement dimensions and identify potential patterns of association within the data.

C. Population and informed consent

A total of 38 third-semester engineering students enrolled in the mechanics course participated in the study between August and December 2024, select through non-probabilistic convenience sampling. The intervention was implemented during the instructional module on the concept of "center of mass", which represented the main conceptual focus of the learning activities. All participants gave their voluntary consent before starting the intervention, and their responses remained anonymous throughout the process.

This study was conducted under institutional ethical guidelines. Participation was entirely voluntary, and students provided informed consent before completing the questionnaire. All responses were anonymized, and no personal or academic identifiers were used in the analysis. The intervention did not affect course grades or evaluation processes, ensuring that students' participation was free of coercion or bias.

IV. Results

Table II presents the descriptive statistics for the five dimensions of SEQ. The table summarizes the mean values, standard deviations, and 95% confidence intervals for each dimension, providing an overview of students' overall engagement after the implantation of VLOs and Video Learning.

TABLE II
Mean and Standard Deviation by SEQ Dimension (N=38)

Dimension	Mean	Standard Deviation	95% CI
Intellectual Abilities	4.61	0.62	4.40 – 4.81
Teamwork	4.53	0.75	4.29 – 4.78
Teaching Methods	4.57	0.80	4.31 – 4.84
Teacher-Student Relationship	4.43	0.97	4.11 – 4.75
Student-to-Student Relationship	4.26	1.03	3.92 – 4.60

The results of SEQ dimensions appear in Table II where Intellectual Abilities received the highest scores (Mean = 4.61, 95% CI [4.41, 4.81]) followed by Teaching Methods (Mean = 4.57, 95% CI [4.31, 4.84]) and Teamwork (Mean = 4.53, 95% CI [4.29, 4.78]). The educational intervention directly targeted these three dimensions by supporting student independence while utilizing digital resources and video content to grasp key concepts and develop problem-solving abilities.

The 95% confidence intervals provide a measure of precision around each mean, indicating that the true population mean is likely to fall within the reported range. The relatively arrow intervals across the five dimensions reflect consistent perceptions among students regarding the positive effects of the intervention.

While overall consistency was observed across dimensions, closer attention is warranted for the Teacher-Student Relationship dimension (Mean = 4.43, 95% CI [4.11, 4.75]) and Student-to-Student Relationship dimension (Mean = 4.26, 95% CI [3.92, 4.60]), which received lower scores than other dimensions but maintained positive overall ratings. The Studentto-Student Relationship dimension showed the largest standard deviation of 1.03 which indicated different opinions about group belonging and social dynamics.

To gain a deeper understanding of students' perceptions across each engagement dimension, five box-and-whisker plots were generated. This graphical approach allows identifying consistent patterns, areas of convergence, and aspects where perceptions were more diverse, offering a more nuanced view of how students experienced the intervention.

Fig. 8 displays the distribution of student responses for the Intellectual Abilities dimension. For all six items, the median value is 5, indicating that at least 50% of students selected the highest level of agreement. The interquartile range remains narrow and consistently between 4 and 5, meaning that 75% of responses fall within this upper interval across all items.

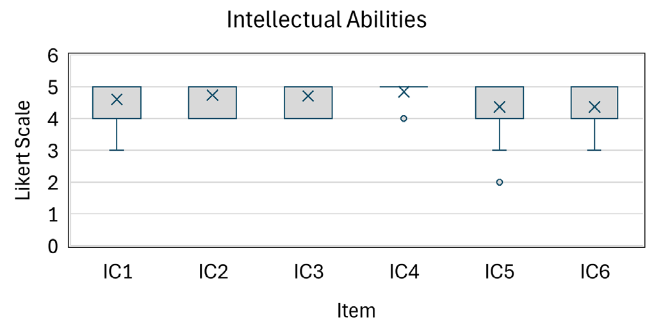

Fig. 8. Distribution of responses for Intellectual Abilities dimension on a 5-points Likert scale (1 = strongly disagree, 5 = strongly agree).

Mild variability appears in IC4 and IC5, where a small number of outliers fall below the main distribution; however, these do not alter the overall pattern of strong agreement. Overall, the quartile structure confirms highly consistent perceptions among students and indicates that the intervention strongly supported cognitive engagement and the development or reflective and independent thinking skills.

Fig. 9 presents the distribution of student responses for the Teamwork dimension. The median is consistently at 5, indicating that at least 50% of participants selected the highest level of agreement for teamwork-related statements, including collaboration, adaptability, and communication. The interquartile range remains narrow and positioned between 4 and 5 in nearly all items, meaning that 75% of responses fall within this upper range and reflect strong consensus among students.

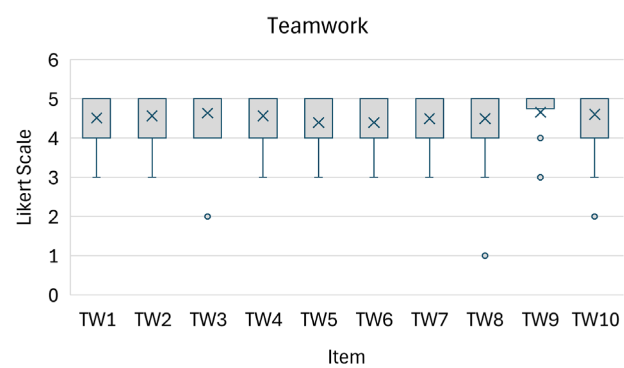

Fig. 9. Distribution of responses of the Teamwork dimension on a 5-points Likert scale (1 = strongly disagree, 5 = strongly agree).

Some mild variability is observed, particularly in TW3, TW8 and TW9, where a small number of outliers fall between

1 and 3. Despite these isolated values, the main distribution remains highly concentrated in the upper quartile, which confirms that students perceived Teamwork development positively.

Overall, the quartile pattern demonstrates stable and consistently favorable views of teamwork and indicates that the digital activities incorporated into the intervention effectively supported collaborative engagement and use of shared digital tools.

Fig. 10 presents the response distribution for Teaching Methods dimension. For most items (TM1.TM3 and TM5), the median is positions at 5, indicating that at least half of the students expressed the highest level of agreement regarding clarity, structure, and instructional support throughout the intervention. The interquartile range in these items remains narrow and concentrated between 4 and 5, suggesting that 75% of responses fall within this upper interval and reflect strong consistency in student perceptions.

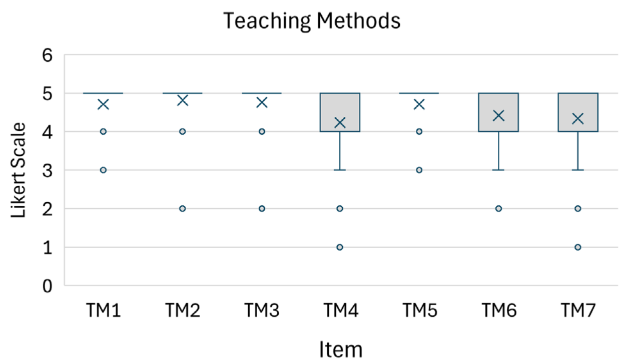

Fig. 10. Distribution of responses of the Teacher-Students Relationship dimension on a 5-points Likert scale (1 = strongly disagree, 5 = strongly agree).

In contrast, items TM4, TM6, and TM7 exhibit greater variability, with wider boxes and several lower outliers between 1 and 2. These patterns indicate that approximately 25% of students perceived lower coherence or alignment in specific instructional components, particularly those related to course integration and pacing. Despite this increased dispersion, the overall distribution remains strongly skewed toward positive rating, confirming favorable perceptions of the pedagogical organization and the effective integration of digital materials to support understanding.

Fig. 11 illustrates the results for the Teacher-Student Relationship dimension. Median scores remain high across most items, around 4 to 5 on the Likert scale, indicating that students perceived positive interaction, communication, and academic support from the instructor.

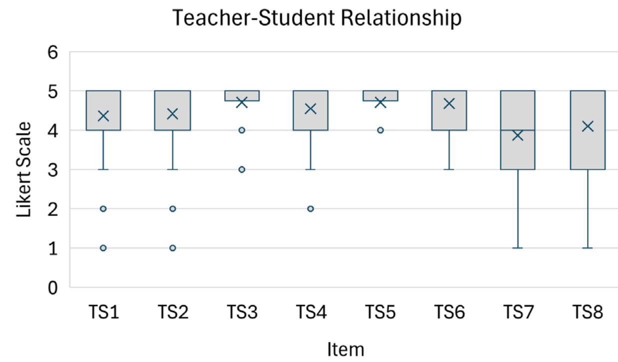

Fig. 11. Distribution of responses of the Teacher-Students Relationship dimension on a 5-points Likert scale (1 = strongly disagree, 5 = strongly agree).

Items TS1 through TS6 show relative compact ranges, suggesting that participants consistently valued the teacher's guidance and clarity during the intervention. The interquartile ranges for these items are relatively narrow and concentrated between 4 and 5, showing that 75% of responses reflect stable, positive perceptions.

However, items TS7 and TS8 exhibit greater dispersion and several low outliers, representing students who experienced higher workload stress or limited opportunities for individualized feedback. These results suggest that, while communication and instructional support were generally well rated, workload management and perceived academic pressure could be improved to further enhance the learning experience.

Fig. 12 presents the results for the Student-Student Relationship dimension. The median values of the four items range between 4 and 5, showing generally positive perceptions regarding peer interaction and collaboration. The interquartile ranges for these items extend from 3 to 5, showing that 75% of the responses fall within a moderately positive interval, although with greater dispersion compared to other SEQ dimension.

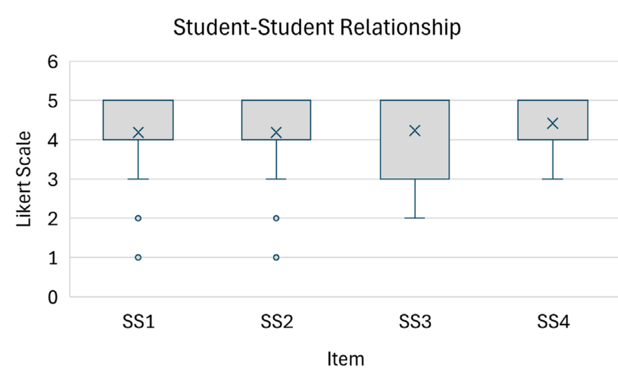

Fig. 12. Distribution of responses of the Students-Students Relationship dimension on a 5-points Likert scale (1 = strongly disagree, 5 = strongly agree).

However, compared to other dimensions, this one exhibit wider ranges and several lower outliers, especially in items SS1 and SS2, indicating that not all students experienced the same level of group cohesion or communication. Overall, the data reflects that while students maintained a favorable view of peer relations, there remains room for improvement in fostering a stronger sense of belonging and consistent teamwork among all participants.

The most popular aspects concentrate on self-directed learning and comprehension development, and students gave their highest ratings to "IC4. I have been challenged to think of new ideas" (Mean = 4.84) and "TM2. Students have the opportunity to participate in class" (Mean = 4.82). The intervention specifically focuses on these areas through VLOs and Video Learning.

The two lowest-rated aspects concern student perceptions of academic pressure and social relationships because students scored "TS7. I manage to complete course requirements without feeling excessively stressed" at 3.87 and "SS1. I feel a strong sense of belonging to my class group" at 4.18.

To complement the descriptive findings, Pearson correlation coefficients were calculated using the mean scores of the five SEQ dimensions, as shown in Table III.

TABLE III
PEARSON CORRELATION FOR SEQ DIMENSION (N=38)

Dimension	1	2	3	4	5
1. Intellectual Abilities	1.00	0.75	0.59	0.66	0.66
2. Teamwork		1.00	0.35	0.47	0.62
3. Teaching Methods			1.00	0.85	0.53
4. Teacher-Student				1.00	0.56
5. Student-to-Student					1.00

According to the interpretation proposed by Schober [20], coefficients between 0.70 and 0.89 indicate strong correlations, whereas values between 0.40 and 0.69 represent moderate correlations. The analysis revealed strong positive correlations between Intellectual Abilities and Teamwork (r = 0.75), and between Teaching Methods and Teacher-Student Relationship (r = 0.85). Moderate correlations were also found between Intellectual Abilities and Teacher-Student Relationship (r = 0.66) and between Teamwork and Student-Student Relationship (r = 0.62). These relationships indicate that effective teaching methods and active student engagement strengthen teamwork, cognitive development, and social connection, aligning with the overall goals of human-centered engineering education.

Overall, the results from the SEQ indicate that the intervention achieved its main objective of fostering engagement and conceptual understanding through VLOs and Video Learning. Students reported consistently high satisfaction levels in the dimensions related to cognitive and instructional processes, while slightly lower scores were observed in the social dimensions, particularly Student-Student Relationship. The combination of descriptive and correlational analyses demonstrates that learning autonomy and instructional clarity are strongly associated with teamwork and communication, emphasizing the interdependence between cognitive and social engagement within technology-enhanced environments.

These results provide the foundation for a deeper discussion of how each engagement dimension was influenced by the implementation of VLOs and Video Learning, and how these outcomes align with findings reported in previous research.

V. DISCUSSION

The results obtained from the SEQ indicate that students generally perceived the learning experience positively after the implementation of Video Learning and Virtual Learning Objects. Overall, the findings suggest that the intervention supported cognitive engagement, instructional clarity, and learning autonomy, while also revealing areas that require further attention, particularly in the social dimensions of engagement.

The Intellectual Abilities dimension obtained the highest overall scores among the five SEQ dimensions, indicating strong cognitive engagement. This result suggests that the combination of Video Learning and VLOs effectively supported reflective thinking, autonomy, and conceptual understanding. By allowing students to control their learning pace and revisit key concepts, the instructional design promoted deeper engagement with course content. These findings are consistent with previous research reporting that well-structured video-based learning activities enhance self-efficacy, higher-order thinking, and conceptual understanding in engineering education [2], [4], [21].

Students' perceptions of the Teamwork dimension were also positive, reflecting the development of problem-solving skills, adaptability, and confidence in the use of technological tools. Although collaboration was not the primary focus of the intervention, the structured use of digital resources and individual progress-based activities appears to have supported behavioral and cognitive engagement. This result aligns with studies indicating that technology-rich learning environments can foster teamwork-related competencies when digital tools are meaningfully integrated into learning tasks, even in the absence of explicit collaborative structures [7], [14].

Regarding Teaching Methods, students perceived the instructional approach as clear, coherent, and supportive of their learning process. The use of short, segmented video materials facilitated content comprehension and sustained attention, while the instructor's role as a facilitator contributed to guiding students through conceptual difficulties. These findings support prior evidence that pedagogically designed video content and intentional instructional mediation enhance engagement and understanding in higher education contexts [8], [9], [15].

The Teacher–Student Relationship dimension showed comparatively lower ratings than the cognitive and instructional dimensions, particularly in aspects related to workload management and perceived academic pressure. While communication and instructional support were positively valued, these results highlight the importance of balancing task demands and providing structured guidance to prevent overload. This observation is consistent with previous research emphasizing that feedback quality and workload regulation play a critical role in sustaining student engagement and perceived competence [7], [10].

The Student–Student Relationship dimension received the lowest ratings among the five SEQ dimensions (Mean = 4.26), although the overall score remained within a positive range. Students reported a weaker sense of belonging and fewer opportunities for peer interaction outside the classroom. Rather than indicating a limitation of Video Learning or Virtual Learning Objects themselves, this result can be interpreted as a consequence of the instructional design adopted in this intervention.

The learning activities were intentionally structured to promote self-directed learning and individual conceptual understanding, prioritizing autonomy, pacing control, and reflection. Prior studies have shown that digital learning environments tend to strengthen cognitive and behavioral engagement when autonomy and self-regulation are emphasized; however, social engagement does not emerge automatically unless collaborative structures are explicitly integrated into the instructional design [7]. In this study, opportunities for peer interaction were limited, and social engagement relied largely on informal or spontaneous collaboration rather than on planned collaborative tasks.

This finding aligns with previous research indicating that virtual and technology-enhanced learning environments often face challenges in fostering peer interaction and group cohesion when social activities are not intentionally scaffolded [11]. Similarly, interactive and gamified digital environments have demonstrated positive effects on collaboration and peer engagement only when teamwork-oriented tasks are deliberately embedded into the learning process [14].

From a design perspective, future implementations of VLOs could strengthen the social dimension of engagement by incorporating structured peer interaction strategies, such as small-group discussion prompts linked to video content, collaborative resolution of conceptual problems, or peer feedback on reflective activities. These additions could complement the existing focus on autonomy and cognitive engagement, contributing to a more balanced engagement profile across all SEQ dimensions.

Limitations

Despite the positive perceptions reported by students, this study presents several limitations that should be considered when interpreting the findings. First, the intervention was conducted with a relatively small sample from a single engineering course, using a non-probabilistic convenience sampling strategy. As a result, the findings cannot be generalized beyond the specific educational context in which the study was implemented.

Second, the study did not include a control group, which limits the ability to establish causal relationships between the use of Video Learning and VLOs and changes in student engagement. The results therefore reflect students' perceptions following the intervention rather than comparative evidence of effectiveness.

Additionally, student engagement was measured using a self-report instrument. While the Student Engagement Questionnaire (SEQ) is a validated and reliable tool, self-reported data may be influenced by response bias, social desirability, or students' subjective interpretations of their learning experience.

Finally, the instructor played an active role as a facilitator throughout the intervention, guiding discussions and providing feedback. This pedagogical involvement may have positively influenced students' perceptions of engagement, making it difficult to isolate the effects of the digital resources alone. Future studies should consider alternative designs that allow for a clearer distinction between instructional strategies and instructor-related factors.

VI. CONCLUSION

This study explored engineering students' perceptions of engagement after the implementation of a structured intervention integrating Video Learning and Virtual Learning Objects within a mechanics course. The findings suggest that thoughtfully designed digital resources can effectively support cognitive engagement, instructional clarity, and learning autonomy when aligned with clear pedagogical intentions.

Rather than simply confirming the usefulness of digital tools, this work highlights the importance of instructional design in shaping how students experience engagement. The combination of short, segmented videos and interactive VLOs supported reflective thinking and self-directed learning, reinforcing the idea that technology contributes to engagement not by its presence, but by how it is intentionally integrated into the learning process.

At the same time, the study underscores that social engagement does not emerge automatically in technology-enhanced environments. The comparatively lower perceptions related to student–student interaction point to the need for deliberate collaborative design strategies when the goal is to foster a stronger sense of belonging and peer connection. This insight is particularly relevant for instructors seeking to balance autonomy with social learning in blended or digital contexts.

Overall, the results provide baseline evidence that Video Learning and Virtual Learning Objects, when pedagogically structured, can enhance key dimensions of student engagement in engineering education. These findings contribute to ongoing discussions on human-centered instructional design and offer practical guidance for educators interested in integrating digital resources to support meaningful and sustainable learning experiences.

VII. FUTURE WORK

This study represents an initial phase of a broader research project focused on understanding how Video

Learning and Virtual Learning Objects can support student engagement in engineering education. Building on the findings and limitations identified in this work, future research will aim to strengthen both the methodological rigor and the scope of the intervention.

Subsequent studies will incorporate comparative research designs, including control groups and larger samples across different engineering courses, to allow for more robust analysis of the effects of Video Learning and VLOs on student engagement. These designs will help clarify the extent to which observed changes can be attributed to the instructional strategies rather than contextual or instructor-related factors.

Future implementations will also place greater emphasis on the social dimension of engagement by integrating structured collaborative activities into the digital learning environment. Planned strategies include peer discussion prompts linked to video content, collaborative problem-solving tasks, and peer-feedback mechanisms embedded within VLOs. These approaches aim to foster a stronger sense of belonging and more consistent student–student interaction while maintaining the benefits of self-directed learning. In addition, future work will explore mixed-methods approaches by combining quantitative instruments, such as SEQ, with qualitative data sources including student reflections, focus groups, or interviews. This triangulation will provide deeper insights into students' learning experiences and support a more nuanced understanding of engagement processes in technology-enhanced environments.

Finally, longitudinal studies are planned to examine the persistence of engagement and learning outcomes over time, both within and beyond a single course. Such analyses will contribute to a clearer understanding of how sustained exposure to structured digital learning experiences influences students' academic development throughout their engineering programs.

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