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RESEARCH ARTICLE

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Enhancing self-regulated learning in engineering education with lightboard videos as a support tool

Rafael R. Sola-Guirado | **Francisco Comino** | **Rafael Castro-Triguero**

Department of Mechanics, University of Córdoba, Campus Rabanales, Córdoba, Spain

Correspondence
Rafael R. Sola-Guirado, Department of Mechanics. University of Córdoba, Campus Rabanales, Córdoba 14014, Spain.
Email: ir2sogur@uco.es

Funding information
Universidad de Córdoba

Abstract

Background: For engineering students, a lack of motivation and continuous study are common issues that lie in low academic performance. Active teaching with audio-visual systems, on the one hand, and self-regulated learning methodologies, on the other, have shown to have a high potential in these aspects.

Purpose: Assessing a proposal based on a self-assessment and integrating it into a traditional teaching process to improve student engagement and performance.

Design/Method: When once explanation of a thematic block was complete, we set a series of exercises encompassing key concepts for students to solve at home within a limited time. Students then had to upload their solutions to an e-Learning platform and subsequently received dynamic videos, created using a lightboard studio, showing solutions to the exercises to assess their level of learning through self-evaluation.

Results: The activity was highly valued by the students. They were more motivated in their studies than the control group, which is reflected in increased participation in the course and in the number of students who sat for the exams. However, according to the metrics of the videos and their responses to the questionnaires, students did not fully utilise the available resources. This is likely due to the extrinsic motivation facilitated or failure to treat the self-assessments as exam simulations. This resulted in academic performance that is very similar to that of the control group.

Conclusions: The results obtained demonstrate the usefulness of the teaching proposal for the purpose of this work, although it requires some improvements.

KEYWORDS

academic performance, evaluation, lightboard, self-regulated learning (SRL), student motivation

1 | INTRODUCTION

In engineering education, especially in foundational subjects in the early years, it is common to use lectures with problem-solving and computer-based practical exercises. However, if teaching methods in challenging subjects fail to capture students' attention, aid in content comprehension, and motivate students, student learning outcomes may not be achieved [2]. Students are more likely to persist when they perceive themselves as capable of succeeding (expectancy) and the tasks as interesting, important, and useful (values) or less costly in terms of effort, missed opportunities, and psychological stress (perceived costs) [18]. Furthermore, dropout or transfer to other university degrees mainly occurs during the first year of study [1, 15]. Therefore, it is very important to understand how the motivation of first-year engineering students operates to predict success during their initial exposure to engineering content. The future time perspective (FTP) of industrial engineering undergraduate students differs with the use of self-regulated learning (SRL) strategies [8, 26] and leads to greater academic success, resulting in higher graduation rates.

Active teaching involves the use of multimedia resources, in-class discussions, group work, and periodic assessment quizzes [25]. Recent research on engineering education has found better learning outcomes when instructors actively engage students (e.g., through practice problems) rather than passively (e.g., in lectures) [40], with results indicating increased cognitive engagement in introductory-level engineering courses. However, these methodologies may be insufficient if they continue to use a traditional assessment approach, where the student earns marks and is given no direction about how to revise. This lack of guidance can represent a challenge for the student when interpreting their own performance and understanding the extent of their assimilation of the subject matter [21]. Therefore, it is highly recommendable that students be aware of their learning status to adapt their study, and this is an area that SRL theory explores [35, 43]. The theory is based on the idea that learning is an active, dynamic process in which students should be responsible for their own learning. Learners who are self-regulated achieve better academic performance than those who are not [13]. Furthermore, if instructors obtain direct feedback on this learning progress, they will be able to identify the discrepancies between a student's current performance and their desired learning goals [29]. Feedback is a powerful, essential tool for learning and assessment, particularly when it provides the necessary information to bridge the gap between actual performance levels and reference standards [11]. These authors conclude that a student needs feedback to learn effectively, so they recommend that instructors consistently provide reflections that include explicit indications as feedback throughout the course.

The use of summative assessments, which include unit tests, exams, presentations, or projects, is common when implementing an SRL procedure, but they represent a heavy workload for instructors and often only serve to determine grades. This type of evaluation rarely provides useful feedback to students. However, if self-assessment techniques are integrated into a summative assessment methodology, it could lighten the teaching burden and also enable students to track their progress. Self-assessment is a fundamental skill for SRL that is present in each of its phases [41] and has been demonstrated to have a positive relation with academic achievement. Rubrics or other procedures can be used to enable students to perform self-assessments [28], which can include providing solved exercises to the students. On the other hand, despite the potential benefits of SRL, its implementation in a course requires students to both devote extra time and make a sustained effort, which can be challenging for them. Therefore, it can be very interesting to propose some form of reward to the student as a moderate form of extrinsic motivation [30] to engage them in carrying out these practices.

Self-assessment exercises can be much more appealing when solved using technology and digital media [3, 33] (Rashid & Asghar, 2016); hence, the use of videos in the context of university learning has been the subject of numerous studies in recent years [27]. The availability of digital resources is transforming how students access and process information, but it is the responsibility of educators to adapt and provide these media appropriately for learning. Specifically, the concept of a lightboard studio offers significant advantages over the use of videos created on traditional or more advanced electronic whiteboards or using narrated slides [20, 39]. Several recent studies have analysed the positive effects of videos created with a lightboard in biotechnology [5], mechanical engineering [39], and chemistry [36]. Students demonstrated positive performance with this teaching and learning approach, which led to improved subject performance.

This study examines self-regulated learning, driven or supported by the use of video generated by a lightboard studio, and its effect on engagement and performance in engineering students. Our aim is to elucidate the effectiveness of integrating audiovisual resources into self-assessment and independent study practices, thereby providing a definitive trajectory towards enhancing self-regulated learning with technological support. The proposed methodology encompasses the execution of a series of thematic exercises throughout the course, which students are tasked to solve independently at home; these exercises are subsequently elucidated in videos created using a lightboard to facilitate self-assessment.

2 | TEACHING PROPOSAL

A teaching proposal called Videos with Lightboard for Self-Regulatory Learning (VL4SRL) was implemented over two academic years (2022 and 2023) at a large public university in the south of Spain in the subject of machine and mechanism, which has six ECTS credits and is commonly taken in most industrial engineering degree programmes. We studied two groups of students with different teaching approaches: a control group (121 enrolled students) which followed a traditional, classic teaching procedure, and an experimental group (104 enrolled students) using the same procedure (identical content, instructors, teaching techniques, and courses) but with the addition of the teaching proposal described in this paper. At the end of each academic year, several parameters were analysed in both groups.

2.1 | Traditional teaching

The course lasts for 12 instructional weeks (February–May), with five class hours per week divided into 3 h of theory and problem-solving and 2 h of computer-based practical sessions. The course covers six thematic blocks, summarised as follows: (1) Types and parts of mechanisms and their mobility determination; (2) relative motion of kinematic chains; (3) numerical methods for kinematic analysis of mechanisms; (4) analysis of mechanisms using Newton–Euler methods; (5) dynamic analysis using energy-based methods; and (6) vibration in single-degree-of-freedom mechanisms. Upon completing the course, students have the opportunity to take an assessment in three official examination periods (June, July, and September). In each of these examination periods, the evaluation consists of three tests. The overall grade will be an average of these three tests:

- Theoretical part: conceptual exercises exam, lasting 0.5 h, and accounting for 20% of the final grade.
- Execution part: mechanism calculation problem-solving exam, lasting 2 h, and accounting for 60% of the final grade.
- Practical part: computer-based mechanism behaviour simulation exam, using Matlab software, lasting 1.5 h hours, and accounting for 20% of the final grade.

2.2 | Traditional teaching + VL4SRL

During the traditional course, when a thematic block is completed, an exercise related to that block is set (six exercises during the course), which will become visible 1 week later on a Moodle platform. The created exercises were highly conceptual, similar to those proposed in conventional exams, and consisted of six different sections. The exercise had to be solved by the students at home within a 1-h time limit. In the available hour, a student has to complete a multiple-choice test on the platform itself. Each test question has 6 possible answers, and a student can either choose an option (receiving 1/6 points if they answer correctly and −1/12 if they answer incorrectly) or not select an answer, in which case no points are added or deducted. When the allotted time for solving the exercise and submitting their answers expires, a video with the solutions created by the instructors becomes available. The videos were recorded using a lightboard studio system, which we will discuss later.

This activity was introduced at the beginning of the course as optional, allowing the students who wished to participate to obtain their final grade without the need for a single end-of-course exam. This way, it was possible to assess extrinsic motivation and determine their level of continuous study throughout the course. It should be noted that students were advised to complete the exercises individually, without using any instructional materials, simulating an in-person exam. They were also advised to view the video as many times as necessary for self-assessment, thus being able to gauge their real learning progress.

2.3 | Development of the lightboard studio and video recording

A homemade lightboard studio system (Figure 1) was developed on the university premises. The system consists of a structure with a glass surface, bordered by adjustable LED strips, a Canon camera, a computer with a wireless mouse, keyboard, and microphone, a 55” TV, and a structure with black fabric [7]. The camera and the TV are connected to the computer to view the recording in real-time and use the Open Broadcast Software (OBS) video recording and editing software. This software rotates the image for proper viewing and allows for overlaying various visual effects, such as images, videos, and so on. High-contrast liquid glass markers are used for proper visibility. After completing the recording, the videos were edited, including headers, frame cropping, and quality adjustment.

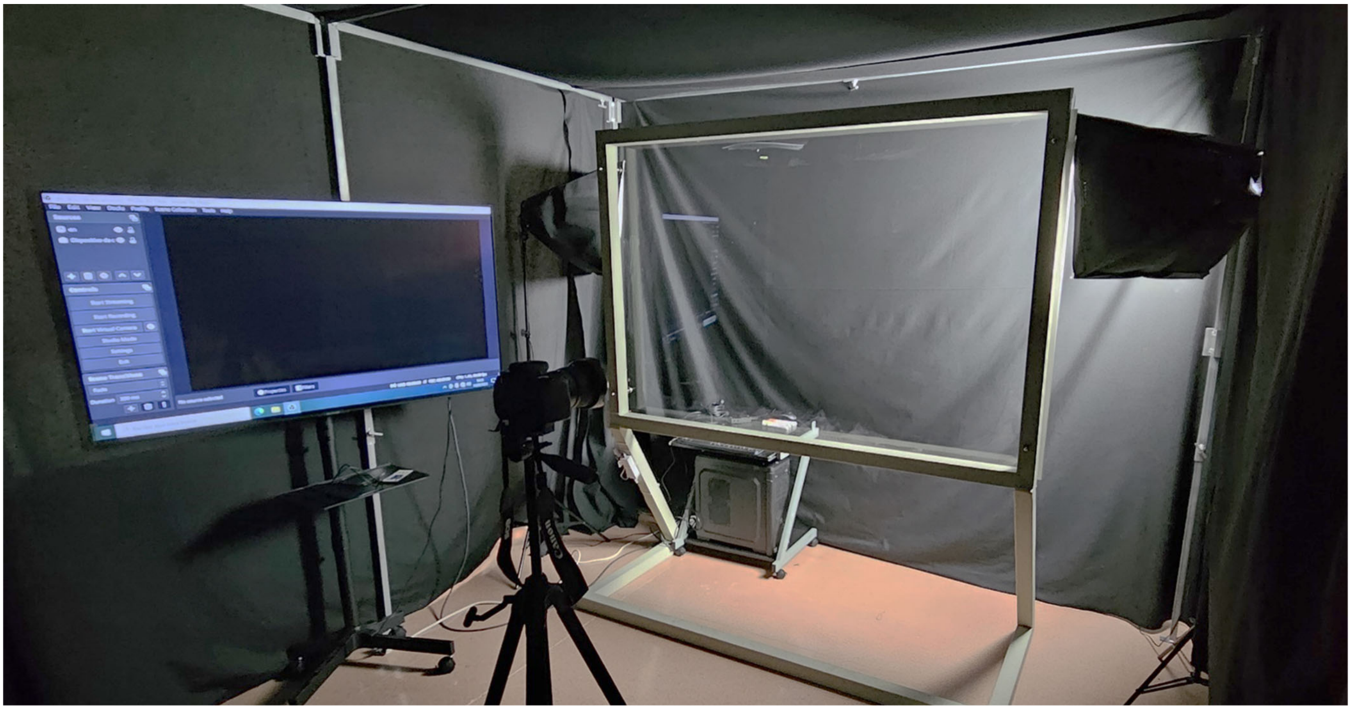

FIGURE 1 Home-made lightboard studio used for the video recording.

The methodology employed focused on the incorporation of lightboard video solving exercises within the engineering curriculum, allowing students to access educational material that complemented their autonomous learning. Each of the suggested exercises proposes several sections in which the concepts studied in the subject are to be calculated in a very simple way. For example, in the topic 'Dynamic analysis using energy-based methods', a mechanism is proposed in which its kinetic energy, potential energy, equation of motion, equilibrium position and reduced moment of inertia must be calculated, and all this is solved in about 9 min (Figure 2, up). All videos suggest this structure and were specifically uploaded to the YouTube platform and classified as 'private' (Figure 2, down).

The links to these videos were mass-sent to all students in the course, 1 day after they completed the proposed activity, so students could view them at their convenience, as many times as they wished, and pause them as needed.

These videos, in addition to presenting relevant academic content, also included interactive and reflective elements designed to promote learning autonomy. For example, some videos incorporated self-assessment questions and pause moments that encouraged students to reflect on their understanding of the material, thus, evaluating their progress and areas for improvement. This practice could improve content understanding as well as develop critical thinking and self-assessment skills. This integration of audiovisual resources was intended not only to facilitate self-regulated learning but also to increase student motivation and engagement with the study material.

2.4 | Evaluation of the teaching proposal

To closely align the study variables with the objective of this work, an evaluation was conducted focusing on three key indicator areas: (i) usefulness of regulated learning assisted with lightboard videos, (ii) student engagement, and (iii) academic performance (Table 1). Each variable was measured using specific methods such as anonymous questionnaires, metrics on video interaction, activity participation and outcome comparisons between control and experimental groups. This approach ensured that this research effectively assessed the core of how videos generated in a lightboard studio influence self-regulated learning. Thus, Table 1 summarises the indicators used to determine the feasibility with which the proposed methodology achieves its objectives. The indicators were obtained from the control group, experimental group, or both. Of the total 104 students in the experimental group, 49 responded to the questionnaires, whereas 25 students of the total 121 students in the control group answered the questionnaires, which were sent automatically at the end of the academic courses. Different resources were used to quantify the

FIGURE 2 An example of one of the structure exercises (down) and part of the list of videos uploaded to YouTube (up).

mentioned parameters. On the one hand, at the end of the course, a questionnaire was administered to students in both groups. Some questions were included exclusively for the experimental group regarding the proposed activity. We also collected metrics from the statistics obtained from the YouTube studio videos. On the other hand, factors such as class attendance, participation in exams, and academic results were measured. Finally, other subjective factors, such as the opinion of the faculty from previous years (when the discussed teaching proposal had not been implemented) compared to the current year, were determined.

TABLE 1 Indicators and parameters used to evaluate the teaching proposal.

Indicator	Parameter	Mode of assessment
Adequacy of the self-assessment method as an SRL enhancer *(only experimental group)*	No. of video views and percentage of the video duration	YouTube metrics
	Time in which the videos were viewed	YouTube metrics
	How did you do the exercise at home?	Questionnaire: (always, often, sometimes, never) – With someone – Using material (books, notes, internet…) – Consulting chats
	Quality and content of the videos used to assimilate the concepts used	Questionnaire: 1 (very poor) to 10 (very appropriate)
	Duration of the video that students prefer	Questionnaire: Choose the right duration
	Number of exercises the students prefer to do	Questionnaire: Choose the right number
	Time when the students prefer to do questionnaire	Questionnaire: morning (7–9 h), evening (18–20 h), night (20–22 h)/during the week or weekend
	Type of material the students prefer to use	Questionnaire: – Videos Lightboard – Videos with slides or traditional blackboard – Text file – Masterclass
Motivation and continuous study *(control and experimental group)*	Level of student motivation	Questionnaire:1 (very low) to 10 (very high)
	Class attendance	Weekly count
	Use of resources to study	Questionnaire: – Class notes – Complementary bibliography – Notes from other students or courses – General Internet – Private lessons – Others
	Student participation in classes and tutoring	Teaching staff opinion
	Distribution of study time	Questionnaire. Number of hours per month spent on the study
Academic performance *(control and experimental group)*	No. of students who sat the exams	Count
	Student score	Correction by the teaching staff

3 | RESULTS AND DISCUSSION OF THE EXPERIENCE

This section presents the results of the various evaluated indicators.

3.1 | Adequacy of the self-assessment method as an SRL enhancer

The results show that 74.5% of students from the experimental group participated in the proposed activity by completing the exercises during the course. The average number of views of the video was 73.2 ± 26.0 for a total of 104 students, indicating that not all participating students watched the videos. Additionally, in the questionnaire, 60% of students reported needing to watch the videos twice for a full understanding of their resolution. On the other hand, it is worth noting that 48.8 ± 24.3% (mean ± SD) of the visits occurred during the week in which the video was activated after completing the exercise, and 32.1 ± 17.9% of the visits were in the week before the final exam. This highlights that despite the suitability of this self-assessment activity after completing a thematic block, a high percentage of students procrastinate and do not watch the videos until days before the exam when they do not have an adequate response margin to adjust their study in case of deficiencies.

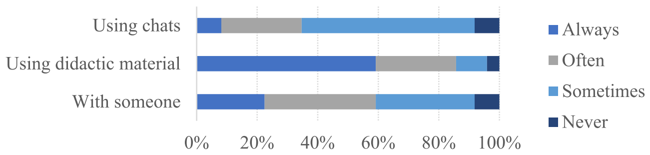

FIGURE 3 Frequency with which the participating students performed the proposed exercises.

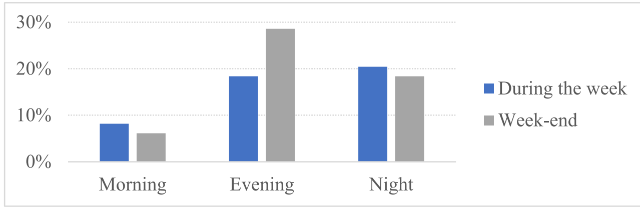

FIGURE 4 Student preference (in percentage of those surveyed) for when to carry out the activity outside the classroom.

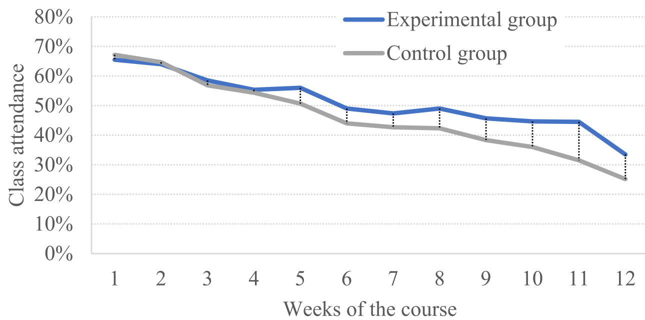

FIGURE 5 Average percentages of class attendance among the control group.

Figure 3 illustrates how students completed the proposed exercises based on their questionnaire responses. We observe that a very small percentage of students completed the exercises as recommended on their own without using materials in order to gauge the progress of their learning as a final exam simulation. It is noteworthy that more than 80% of participating students used instructional materials regularly or always and that more than 50% of them frequently or always worked on the exercises with other classmates. It is also striking that a high percentage of students resorted to using chats to check their answers.

Students indicated that the ideal average duration of the videos was around 9.1 min, and the optimal frequency for proposing exercises was 5.1 times in a 12-week course. This suggests that the timing followed (six exercises) and the duration of the videos produced (10.4 min) were very much in line with what the students preferred.

Indeed, the quality and content of the videos created to enhance understanding of the thematic block received a rating of 7.6 out of 10, indicating that they were very suitable for learning the subject. Of the surveyed students, 65.3% indicated a preference for the type of material used in this activity (videos generated using a lightboard system), while 8.2% and 10.2% preferred other types of videos or solved PDF files, respectively. Only 16.3% of the students prefer real-time exercise resolution. On the other hand, there was disagreement among students regarding the preferred time range for completing the out-of-class activity, although late evening or night hours were predominant (Figure 4).

3.2 | Motivation and continuous study

The questionnaires indicate that students who had traditional teaching rated their motivation level for this subject during the course with a score of 5.7 ± 0.4 out of 10, whereas students who participated in the proposed teaching activity rated it with a score of 7.4 ± 0.9 out of 10. This indicates a significant improvement in motivation (Student's t-test, $p < .05$), which was reflected in other factors, such as increased class attendance (Figure 5), the use of a greater number of supplementary resources alongside their class notes (Figure 6), and more active participation during classes, as well as increased use of tutoring services (data not quantified). Finally, Figure 7 shows that the students in the experimental group studied more consistently throughout the course compared to the control group, meaning the former started studying earlier and left less material for the end of the course, although these differences were not significant (Student's t-test, $p > .05$). In addition, the average total number of hours spent studying outside class by the experimental group was 101.2 h compared to the 99.2 h shown in the control group.

3.3 | Academic performance

The percentage of students who took the final exam in the experimental group in the June, July, and September sessions was 57.7%, 60.0%, and 12.7%, respectively, compared to 48.8%, 29.6%, and 19.8% in the control group. This indicates higher participation by the experimental group compared to the control group in June and July. In September, there was higher participation in the control group, probably because this group contained more students who had previously failed. A total of 53.8% of students in the experimental group passed the course, compared to 41.3% in the control group, indicating better

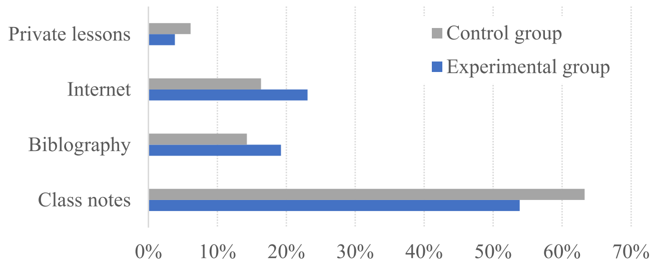

FIGURE 6 Average distribution (in percentage) of the use of resources employed to study the subject among the control group.

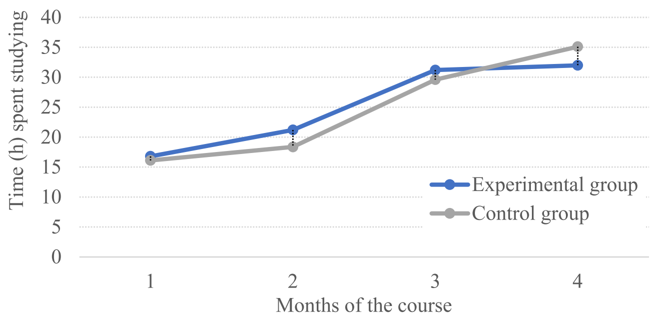

FIGURE 7 Average number of hours per student and month of the course devoted to studying the subject among the control group.

TABLE 2 Students' academic grades. The number in parentheses indicates the percentage of enrolled students.

No. students...	Control group	Experimental group
Enrolled	121	104
Pass (score: 5–6.9)	36 (29.7%)	41 (39.4%)
Good (score: 7–8.9)	12 (9.9%)	15 (14.4%)
Merit (score: 9–10)	2 (1.7)	0 (0%)

academic results for the experimental group. Table 2 shows the distribution of scores in each group. There was a direct correlation between class attendance and academic performance (Pearson coefficient = 0.78; $p < .05$).

4 | DISCUSSION

The results of this study show that the vast majority of students took advantage of the activity and used the videos for self-assessment, enabling visual, auditory, and reading-based learning, with the positive cognitive effects that this entails [4], compared to solely reading-based learning, as was the case with the control group. Currently, the majority of information we receive comes to us visually, so videos are a common channel for processing new knowledge, and when combined with audio, note-taking, and so on, they can activate different regions of the brain to enhance processing [44]. However, the overall goal of achieving continuous study was not reached for some students because, even though they completed the exercises, they did not watch the videos after completing the activity and thus were not able to identify their strengths or weaknesses.

This is a negative aspect that should be addressed with future improvements to the current methodology because procrastination in studying is a proven indicator of lower academic performance and higher levels of stress among university students [32, 38]. Nevertheless, students were able to watch the videos on multiple occasions and at a personal pace (pause, rewind, or change the speed), which has been shown to be more beneficial for learning than mere text readings [24]. However, if not used properly, it could lead to distraction and lower content retention [14]. Therefore, it is important to consider the design and structure of videos to promote attention and content retention.

Most students used teaching materials or chatted with other peers to solve the exercises, while only a small percentage did not use any kind of material. This goes against the recommendations of the instructors at the beginning of the course, the aim of which was for students to complete the exercises as a simulation of the final exam and so gauge their level of understanding. There appear to be various motivations for copying results, such as the desire to achieve better grades with less effort, competition with other students, expectations from family members, or peer pressure [23]. Furthermore, students may be tempted to copy if they perceive that the benefits outweigh the risks of being detected, as may be the case here since students knew that achieving adequate grades would exempt them from taking the final theory exam without realising that a solid understanding of the theoretical content is necessary to perform well in the practical part due to their close relationship. Therefore, preventing copying or using teaching materials should also be considered in future improvements to this methodology, either through promoting ethics and integrity, raising awareness of the connection between theoretical and practical content, or adopting technological tools. However, even if the activities were completed collectively and/or using teaching materials, and even if students watched the videos several days after the activity, the use of this material in each thematic block unconsciously increases their study hours and diversifies the habitual resources they use (notes, books, slides, etc.).

The students have shown a preference for short-duration videos of around 10 min. These results align with previous studies that found video duration to be a key factor in whether students watch the videos [22, 37]. Additionally, based on the scores obtained, it can be concluded that students are discerning, not only about the content of the videos but also about their quality. The design and production of the videos have a significant causal effect on students' perceived learning [34]. Dynamic videos provide a visual and sequential representation that can facilitate the construction of relationships and a deep understanding of content. Regarding student preferences for completing activities at home, there is a disparity of opinions. In fact, at the beginning of the course, students were asked about their availability for the activity, but due to a lack of clear consensus, the instructors decided to schedule it on Fridays from 7:00 PM to 8:00 PM. In this regard, there are no studies that address student preference regarding the time of the week for studying, as there is as much diversity as there are student chronotypes and types of personal responsibilities.

The results indicate a significant improvement in student's ability to self-regulate their learning, evidenced by an increase in participation in independent study activities and an improvement in their academic outcomes. This study underscores the importance of integrating educational technologies, such as lightboard videos, to assist and enhance self-regulated learning in engineering education. The implementation of these technological tools not only facilitates more interactive and visual learning but also promotes self-assessment and critical reflection among students, which are the key components of self-regulated learning. This improvement aligns with the findings of numerous studies that use digital systems integrated into classes [16, 31]. Videos are a resource with high engagement potential and significant benefits in the teaching and learning process [6, 19]. When students are motivated, they are more willing to actively participate in the teaching and learning process, which was also the case in the experimental group. Evidence of this is the increased attendance of experimental group students throughout the course compared to that of the control group, so this approach encouraged students to stay engaged with the subject. Various scientific studies support the importance of class attendance in improving academic performance [10]. Attendance not only provides direct exposure to content and teacher instructions but also fosters interaction and the building of support networks. The results of this study also show that students who followed the experimental methodology prepared earlier than those following the traditional methodology. This led to a reduction in the number of hours dedicated to study at the end of the course and an increase in attendance at tutoring sessions. Kornell and Bjork [17] pointed out that spaced practice and interleaved practice were among the most effective strategies for improving academic performance. All of this suggests that the teaching practice implemented is useful for enhancing the quality of students' study habits. They exhibited higher motivation throughout the course, attended classes more regularly, and distributed their study efforts more evenly over the academic year.

Finally, the academic performance results of the experimental group improved compared to those of the control group, possibly due to all the factors discussed earlier: a greater number and diversity of resources, more study time, better time management, higher motivation, and participation. Generally, educational videos tend to yield very positive results in the university setting [16]. However, while empirical evidence shows these positive effects, the improvements in academic performance were not statistically significant, which is in line with the findings of Zhang and Zhou [42]. Instructive videos have proven their effectiveness as supplementary materials in traditional face-to-face classes [12]; however, caution should be exercised if this activity were conducted during class time due to the potential for distraction [9]. This effect did not occur with the methodology used in this study, as the videos were viewed at home, not for learning something new but for self-assessment of their knowledge. Given that there is substantial scientific evidence that the use of self-assessment techniques has a positive effect on academic performance [41], the combination of using such techniques supported by dynamic videos has proven to be beneficial in improving the performance of university engineering students.

5 | CONCLUSIONS

There is a variety of scientific evidence that shows that both the use of educational videos and self-regulated study techniques have very positive effects on learning in higher education. This study introduces the novelty of combining both resources in a methodology that allows for student self-assessment of their progress using videos created with a lightboard studio. Our study evaluated this proposal over several courses, into which it was integrated, with more than a 100 mechanical engineering students compared to a traditional teaching methodology. The activity, which was optional to complete, was highly utilised, and the videos had high viewing metrics. The quality, content, and duration of the videos received very positive feedback. There was a slight increase in study spacing throughout the course in most cases, as well as an increase in the use of study resources. Student motivation, participation, and class attendance also improved. Academic results improved slightly, possibly as a consequence of all of the above.

Self-assessment has proven to be a powerful strategy for enhancing awareness of one's own learning process, which, in turn, can improve metacognition and strategic planning. Videos can facilitate self-assessment by allowing students to review their own performance and compare their answers or solutions with the correct ones. This provides them with the opportunity to identify and correct errors, strengthen their understanding, adjust their study strategies, and also promotes a sense of empowerment and autonomy. Overall, the results obtained from this experience indicate its usefulness. However, certain actions are required to ensure that students truly take advantage of the proposed system as a continuous self-assessment tool throughout the course and avoid procrastination. In this regard, while extrinsic motivation can provide an initial stimulus, it is important to recognise that it may not be sufficient to ensure long-term commitment and optimal performance, so intrinsic motivation should be reinforced. Another potential area for improvement could involve formative feedback through the creation of new videos that include clear explanations and comments on common errors. This would enable students to understand their strengths and weaknesses more effectively.

In summary, the integration of videos generated through a lightboard studio within the engineering curriculum represented an innovative methodology that fosters self-regulated learning through self-assessment and enhances active engagement with the study material and students' performance in working on critical skills for their future careers. Future research should explore the application of this methodology in a wider variety of educational contexts to validate its effectiveness and adaptability.

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DATA AVAILABILITY STATEMENT

Research data are not shared.

ORCID

Rafael R. Sola-Guirado http://orcid.org/0000-0002-2004-8023

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AUTHOR BIOGRAPHIES

Dr. Rafael R. Sola-Guirado, PhD in Industrial Engineering. He is associate professor at the Department of Mechanics of the University of Córdoba. Its research progress focuses on the development of machinery, smart machines and technologies to improve the mechanization of fruit crops. In addition, he teaches mechanical engineers by combining active learning methodologies that integrate self-regulated learning systems.

Dr. Francisco Comino is an assistant professor in the Area of Materials Sciences and Metallurgical Engineering of the Department of Mechanics of the University of Córdoba (Spain). He earned his PhD in Industrial Engineering from University of Cordoba. His research is related to the field of Indirect Evaporative Cooling Systems, Desiccant Systems and Development of Prototypes using Composite Materials. In addition, he has carried out teaching improvement projects in engineering degrees.

Dr. Rafael Castro-Triguero, PhD in Civil Engineering graduated from the University of Granada (Spain). Since 2003, he has been working in academia at the Department of Mechanics of the University of Córdoba, where he currently holds a full professorship. His research focuses on "Smart Structural Health Monitoring for High-Speed Bridges" and -Bridge Life Extension: Towards Long-Term Sustainable Structural Monitoring." Additionally, he integrates innovative teaching approaches, leveraging new technologies such as the Lightboard, to enhance the teaching of structural mechanics.

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