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Exploring the Impact of Educational Videos on Higher Education: Insights from the b-Mat@plicada Course

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The increasing use of educational videos in Higher Education, particularly in Mathematics, has been driven by the technological advancements and the shift to online learning caused by the pandemic. Educational videos offer flexibility, allowing students to learn at their own speed and accommodate different learning preferences. Despite challenges like technical issues and concerns about reduced interaction, videos offer numerous benefits, including enhanced understanding, motivation, and accessibility. The b-Mat@plicada course, developed at a Portuguese Higher Education institution, comprises 38 educational videos created to improve both student satisfaction and learning outcomes and to address typical challenges faced by the teachers. Feedback from surveys has indicated a high student appreciation of the course, a growing demand for educational videos, and improved perceptions post-pandemic. Additionally, classroom experiments have demonstrated the effectiveness of the b-Mat@plicada videos in achieving the learning objectives, with students approving their visual and audio quality. In this study, 73 students from Business Sciences and Informatics Engineering participated by watching the b-Mat@plicada video on the Laplace Expansion Theorem, followed by a post-test and a questionnaire. The video, designed through an algorithmic approach to improve understanding, was evaluated to determine its effects on learning outcomes and student perceptions. The results of this current study were compared to those of a similar experiment conducted in 2018 with a different group of students. Findings indicated a general increase in the use and perceived quality of educational videos from 2018 to 2024, partly due to the COVID-19 pandemic's influence on online learning. However, post-test scores showed a decline over time, highlighting potential challenges in remote learning as well as varying impacts across academic course areas.

Keywords: Educational videos, Higher Education, Mathematics, Students perceptions, Learning Outcomes.

1. Introduction

The use of videos in Higher Education (HE) has surged in recent years, driven by the rapid advancement of Internet and mobile technologies, as well as the unprecedented shift to online learning caused by the COVID-19 pandemic [1], [2]. In particular, Mathematics has seen a

significant increase in video usage, addressing the difficulties many students face in the subject [3], [4]. Videos offer a flexible and captivating way to present complex concepts, gaining popularity among both teachers and students.

The evolution of technology has played a crucial role in the proliferation of educational videos. The availability of high-speed Internet and the widespread adoption of smartphones, coupled with advanced video production tools, have simplified the creation and distribution of educational videos. During the COVID-19 pandemic, when in-person classes were suspended, videos became an essential tool of remote learning [5]. They allowed educators to continue delivering content and provided students with the flexibility to learn at their own pace and revisit materials as needed [6].

Videos offer several advantages in the educational context. They use visual aids and provide step-by-step explanations that can be paused and replayed as necessary. This multimodal approach accommodates diverse learning styles and can improve understanding and retention. Moreover, videos can overcome time and space constraints by allowing students to access learning materials anytime and anywhere [7]. Studies have shown that educational videos can increase motivation, improve learning performance, and enhance student satisfaction [8], [9].

Despite their benefits, educational videos also face limitations, including technical challenges like large file sizes and Internet connectivity issues [10]. There is also a concern that videos might reduce face-to-face interaction and the spontaneous exchange of ideas that occur in a traditional face-to-face classroom [11]. Additionally, the quality of educational videos can vary significantly, with poorly produced content potentially leading to confusion rather than clarity. Despite these challenges, the benefits of well-designed educational videos generally outweigh the weaknesses, particularly when they are used as supplement tools of traditional face-to-face classes [8].

Students often struggle with Mathematics due to abstract reasoning, problem-solving demands, and the subject's cumulative nature [12]. These challenges can lead to anxiety and disengagement. Videos can help address these issues by providing clear, visual explanations and allowing students to learn at their own pace [13]. For example, worked-example videos showing step-by-step solutions can help students develop problem-solving skills and build confidence [14]. Furthermore, videos can be paused and replayed, allowing students to repeatedly review challenging concepts, which is especially helpful for those with different levels of prior knowledge [15].

In summary, the increasing use of videos in HE, accelerated by the technological advancements and the COVID-19 pandemic, has transformed the way Mathematics is taught and learned. Despite the challenges, educational videos offer significant advantages in overcoming the difficulties that students often encounter in Mathematics.

The b-Mat@plicada course was developed at a Portuguese HE institution with the aim of addressing the challenges of teaching Mathematics in a blended learning environment. Comprising 38 explanatory videos on key topics in Mathematics like differential calculus, integration methods, and matrix calculus, the b-Mat@plicada course is accessible via the institution's Moodle platform. It aims to offer a flexible learning option that can either substitute or complement traditional face-to-face classes, allowing students to review and

reinforce their understanding of complex mathematical concepts. The course was created using a detailed five-step methodology, ensuring the production of high-quality and effective educational videos. Its objectives include enhancing student satisfaction and learning performance, simplifying the production of instructional materials for teachers by reducing the required time and technical expertise, and minimizing equipment costs.

Initial feedback from students, gathered through satisfaction surveys, has indicated high appreciation for the b-Mat@plicada course. Students valued the ability to control their learning pace, revisit complex concepts, and access materials at their convenience [16]. This flexibility proved particularly valuable during the COVID-19 pandemic when traditional face-to-face instruction was interrupted. In 2020, 78 HE students highlighted the critical role of these resources in their learning during the absence of in-person classes [17]. More recently, the responses of 104 HE students to a satisfaction survey regarding the use of learning videos, as well as the quality and usefulness of the b-Mat@plicada videos, were compared with results obtained in 2015 [18]. The findings indicate an increase in demand for b-Mat@plicada educational videos and online videos in general. Students have noted an improvement in video quality since the pre-pandemic period and now find online videos more useful. Despite this increased appreciation, students still view them as supplementary rather than primary learning sources.

In addition to studying students' perceptions, learning performance was also investigated through classroom experiments, which consistently demonstrated the effectiveness of b-Mat@plicada videos in achieving the learning objectives. In a first study, 49 HE students watched a video on matrix multiplication and then solved an exercise without additional support. The results indicated that the video effectively facilitated learning, with students praising the quality of visuals and audio, the video's length, and its usefulness [19]. Later, a similar experiment was performed using the b-Mat@plicada video on the Laplace Expansion Theorem [18]. Despite the increased difficulty of this topic, the 63 participating students successfully applied the theorem after watching the video, emphasizing the content's effectiveness in meeting the learning objectives. Similar to the previous study, students rated the video highly in terms of usefulness, visual, and audio quality. The need for video content in teaching was also highlighted, primarily for clarifying doubts and reinforcing material. However, all students agreed that videos cannot replace traditional face-to-face classrooms, emphasizing the crucial role of teacher-student interaction.

In this study, the experiment with the b-Mat@plicada video on the Laplace Expansion Theorem, initially conducted in 2018 with 63 HE students from the Business Sciences degree, was repeated in 2024 with a sample of 73 students from both the Business Sciences and Informatics Engineering courses. The main differences between the two groups included the academic course area and the 2024 students' experience with online classes during the COVID-19 pandemic, which may have affected their foundational knowledge and attitudes towards video-based learning. The results of both experiments were compared, enabling conclusions about the impact of the academic course area and the effects of the pandemic-induced shift to online learning.

2. Research Methods

Participants

The student sample was selected from a HE institution in Portugal and consisted of 73 students of the Business Sciences degree (N = 33, 45%) and Informatics Engineering (N = 40, 55%). Despite the limited number of participants, which resulted from the controlled conditions of the experiment (the video was watched once, and the exercise was completed individually without assistance), this study aims to offer valuable insights into the video's quality and its effectiveness in achieving the learning objectives.

The selected b-Mat@plicada video

The video selected for this experiment, titled "Laplace Expansion Theorem" (refer to Table I), followed the instructional principles established in earlier research [19]. The Laplace Expansion Theorem is a fundamental property of determinants that expresses the determinant of a matrix as a linear combination of its minors. Typically, the theorem and definitions are illustrated with examples, but this method can cause misunderstandings, particularly about the linear combination of minors. To address these issues, a more effective teaching strategy involves using an algorithmic approach, which simplifies the learning process by providing a step-by-step procedure [20]. Classroom experiences showed that this approach improved understanding and increased the use of the Laplace Theorem in the assessments of the students. As a result, the algorithmic approach was incorporated into the instructional video on the Laplace Expansion Theorem.

Table I. The selected video for the experiment.

b-Mat@plicada video: "Laplace Expansion Theorem"	
Mathematics Topic	Laplace Expansion Theorem
Link	https://youtu.be/vk5U6rbJRAU
Language	Portuguese (Portugal)
Video Quality	High Definition (HD)
Video Length	8 minutes and 28 seconds
Education Level	Higher Education
Prior Knowledge	Basic operations; Second-order determinants.

Procedure and Instruments

The experiment was conducted in a classroom, with students participating voluntarily and anonymously. Students watched the b-Mat@plicada video on the Laplace Expansion Theorem and then performed a post-test. Subsequently, they completed a post-questionnaire to provide feedback on the video's effectiveness and their views on using videos for learning (see Fig. 1).

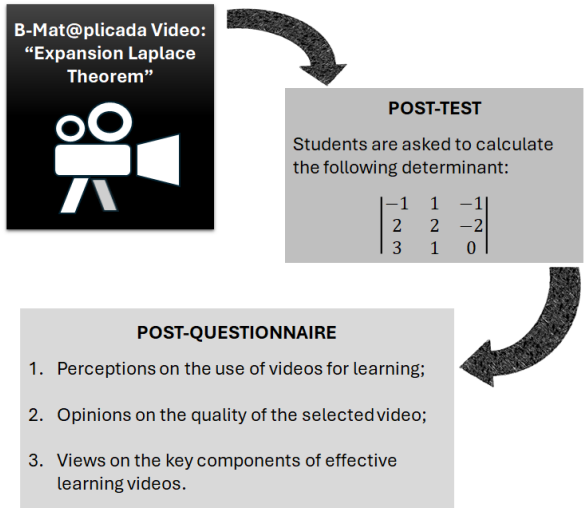

Fig. 1. Experimental Procedure for Evaluating the b-Mat@plicada Video

In the post-test, students were asked to calculate a third-order determinant by using the Laplace Expansion Theorem. Scores on the post-test ranged from 0 to 4 points, where 4 indicated a perfect score and 0 signified an unresolved response. Details on the test scores can be observed in Fig. 2.

The post-questionnaire included nine multiple-choice items designed to gauge students' attitudes and perceptions regarding the use of videos for learning, particularly in Mathematics. Additionally, it is also composed of ten items on a 5-point Likert scale, ranging from 1 (strongly agree) to 5 (strongly disagree), with the aim of assessing students' opinions on the specific quality of the video used in this experiment.

Level 0	The student did not the exercise or did not write correctly the Laplace expansion	
Level 1	The student wrote correctly the Laplace expansion	$\begin{vmatrix} -1 & 1 & -1 \\ 2 & 2 & -2 \\ 3 & 1 & 0 \end{vmatrix} = a_{31}A_{31} + a_{32}A_{32} + a_{33}A_{33}$
Level 2	The student replaced the minors and the entries of the matrix A by the correct values	$= 3 \times (-1)^{3+1} \times \begin{vmatrix} 1 & -1 \\ 2 & -2 \end{vmatrix} + 1 \times (-1)^{3+2} \times \begin{vmatrix} -1 & -1 \\ 2 & -2 \end{vmatrix} + 0$
Level 3	The student calculated correctly the second-order determinants	$= 3 \times 0 + (-1) \times 4$
Level 4	The student applied correctly the Laplace expansion and deduced the correct value of determinant	$= -4$

Fig. 2. Score Levels for the post-test.

Data Analysis

Descriptive statistics will be employed to investigate the responses of the students. This method is used to clearly summarize the data, highlighting central tendencies and overall patterns in student responses. Descriptive statistics also allow for easy comparison between the 2018 and 2024 datasets, helping to analyze changes or trends. This analysis will show how factors like academic course area and the shift to online learning during the COVID-19 pandemic have influenced student perceptions and learning outcomes.

Research Questions

In order to explore the impact and effectiveness of the b-Mat@plicada course, four research questions were formulated. These questions aim to investigate the relationship between student characteristics and their engagement with the videos, as well as to assess the impact of these educational tools on learning outcomes and satisfaction levels:

1. How have student attitudes and perceptions regarding the use of online explanatory videos for learning changed from 2018 to 2024, and what factors, including the COVID-19 pandemic, have contributed to these changes?

2. What changes have occurred in student perceptions of the quality of the selected video on the Laplace Expansion Theorem from 2018 to 2024, and what are the contributing factors?

3. How have student opinions on the key components of effective learning videos shifted from 2018 to 2024, and what factors have driven these shifts?

4. In what ways have student learning outcomes varied from 2018 to 2024, and how have factors such as the COVID-19 pandemic and academic discipline affected these outcomes?

3. Results and Discussion

Student Attitudes and Perceptions on the Use of Online Videos for Learning

Fig. 3 presents the students' responses regarding their use of explanatory videos available on the Internet (for example, on YouTube) to understand or review content taught in classes. The data reveals a significant increase in the use of online videos for reviewing class content, with the percentage of students using them frequently rising from 22% in 2018 to 40% in 2024. Conversely, the proportion of non-users decreased from 14% to 7%. This shift underscores an increasing dependence on digital learning tools, underscoring the necessity for educators to incorporate this type of content into their teaching strategies. The surge in online video usage can be partly attributed to the COVID-19 pandemic in 2020, which cause a widespread shift to online education. This transition acquainted students with digital learning materials, augmenting their reliance on these resources. Even post-pandemic, students continued to utilize online videos for supplementary learning and revision, underscoring the enduring impact of pandemic-induced changes in study habits.

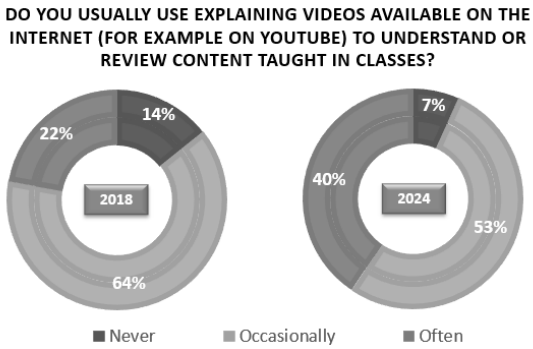

Fig. 3. Students' use of online explanatory videos for class content review (2018 vs. 2024).

Fig. 4 illustrates the perspectives of students regarding the quality of available videos. In 2018, 38% of respondents found videos to be diverse and clear, declining to 31% by 2024, while those who believed quality depended on the theme rose from 46% to 65% during the same period. Notably, no respondents in 2024 considered videos rarely of good quality, suggesting a more optimistic view. Additionally, the proportion of those never look for videos decreased from 14% in 2018 to 4% in 2024. This indicates a growing awareness and discernment regarding video quality, with themes playing a more significant role in perceptions, while the perception of videos being rarely of good quality has diminished. The rapid growth of technology, the Internet, and smartphones has greatly influenced this change in student opinions. Additionally, the pandemic, which led to widespread lockdowns and remote work, caused a surge in online content consumption, including videos. This increased exposure likely made viewers more discerning, raising their expectations for quality as they encountered a wide range of video topics during the pandemic. As a result, the rise in video consumption during the pandemic probably played a role in shaping the more critical views and changing opinions about video quality seen in 2024.

Comparing the results regarding the usefulness of explanatory videos in teaching (see Table II), we observe a consistent consensus in both years. In 2018, nearly all respondents (98%) agreed that explanatory videos were beneficial to student learning, with a small minority (2%) expressing no opinion. In 2024, the percentage of respondents who found explanatory videos useful increased slightly to 99%, with only 1% expressing no opinion. Notably, no respondents disagreed with this statement in either year. This consistent high level of agreement across both years underscores a strong belief in the educational effectiveness of explanatory videos, with opinions remaining stable over time.

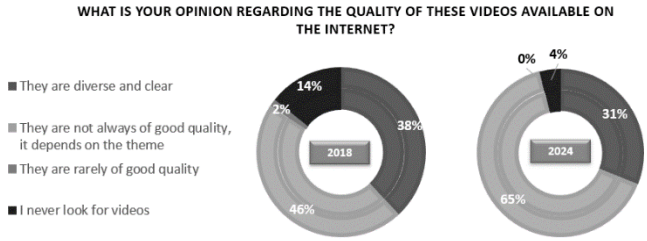

Fig. 4. Students' opinions on the quality of educational videos available online (2018 vs. 2024).

Table II. Perceptions of the usefulness of explanatory videos in teaching: 2018 vs. 2024.

In teaching in general, do you consider that explanatory videos can be useful and beneficial to student learning?	2018 (N = 63)		2024 (N = 74)	
	n	%	n	%
Yes	62	98,4	73	98,6
No	0	0,0	0	0,0
No opinion	1	1,6	1	1,4

Table III compares the perceived impact of videos on learning and educational practices between 2018 and 2024, revealing consistent recognition of their benefits. In 2018, 17,9% of respondents noted that videos helped alleviate the effects of missing classes, a figure that rose

to 24,6% by 2024. Furthermore, significant proportions in both years, 41% in 2018 and 33,3% in 2024, highlighted the videos' role in clarifying doubts, emphasizing their value as supplementary educational tools.

The comparison between the responses from 2018 and 2024 regarding the use of explanatory videos in Mathematics provides interesting insights, especially considering the context of the pandemic (see Fig. 5). In 2018, all respondents (100%) believed that explanatory videos complement traditional face-to-face classrooms, indicating a unanimous recognition of their supplementary role in learning. However, in 2024, while the majority (93%) still maintained that explanatory videos complement traditional classrooms, a notable shift occurred with 7% believing that videos could replace traditional face-to-face instruction. This change suggests a slight evolution in perspectives, potentially influenced by the experiences during the pandemic. The widespread adoption of online learning during the pandemic might have led some individuals to reconsider the role of traditional classroom settings, acknowledging the potential of videos to serve as primary educational tools. However, it is crucial to consider another factor that could explain these results. The five students who considered in 2024 that videos can replace traditional face-to-face classes are all enrolled in the Informatics course, while in 2018, all students were enrolled in Business Sciences. This difference in academic course might indicate that students in Informatics, who are likely more familiar with and receptive to technology, have a different perspective on the use of explanatory videos compared to their peers in Business Sciences. Therefore, while the pandemic certainly played a role in changing educational practices and perceptions, this shift in opinion might also be attributed to the course area. More studies would be necessary to fully understand this phenomenon, but it underscores the importance of considering the academic context when analyzing changes in educational perspectives.

Table III. Advantages of Learning Videos: 2018 vs. 2024.

Item	2018 (N = 117)		2024 (N = 138)	
	n	%	n	%
The videos allow me to not be so affected if I miss classes	21	17,9	34	24,6
The videos allow me to clarify doubts	48	41,0	46	33,3
The videos allow me to remember contents	38	32,5	43	31,2
The videos help modernize education	10	8,5	12	8,7
Other	0	0,0	3	2,2

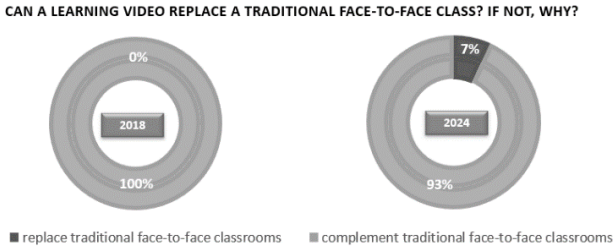

Fig. 5. Students' use of online educational videos (2018 vs. 2024).

Fig. 6 shows the reasons why videos cannot replace face-to-face classrooms, selected by the students in 2018 and 2024. In 2018, 37% of students highlighted the importance of the dialogue between students and teachers, a sentiment that remained almost unchanged in 2024 (36%). This consistency shows how much students value direct interaction for their learning. The importance of interactions with colleagues also grew, from 20% in 2018 to 28% in 2024, indicating a rising recognition of peer interactions in learning, possibly due to challenges faced during remote learning. There was a significant increase in acknowledging the need for self-discipline while studying with videos, rising from 12% in 2018 to 24% in 2024. This shift may reflect students becoming more aware of the demands of self-directed learning, influenced by their experiences during the pandemic period. Interestingly, the percentage of students who found face-to-face classes more motivating than studying with videos alone decreased slightly from 15% in 2018 to 12% in 2024. This suggests a gradual adjustment to digital learning environments, though most students still prefer traditional classrooms for motivation. In 2018, a small fraction of students (3%) disliked using digital technologies for studying, a sentiment that disappeared entirely by 2024, which indicates an increased familiarity and comfort with digital tools as they became more integrated into education.

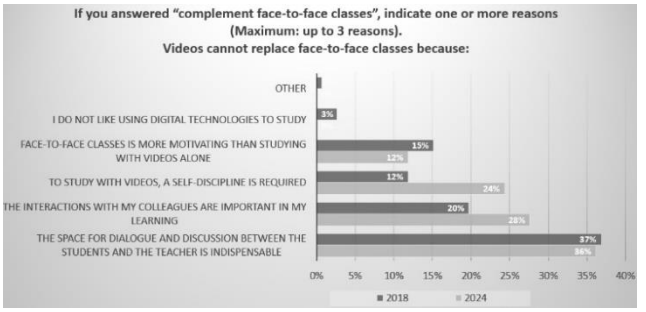

Fig. 6. Reasons why videos cannot replace face-to-face classrooms (2018 vs. 2024).

Student Perspectives on Video Quality

Fig. 7 shows the students' opinions on the quality of the selected video, collected in 2018 and 2024. In terms of clarity, the video consistently received high ratings, scoring 4.8 in 2018 and 4.7 in 2024, showing that students found it clear and easy to understand. Although there was a slight decrease in the mean score, it still indicates strong clarity overall. The attractiveness of the video improved slightly, from 4.2 in 2018 to 4.3 in 2024. Students consistently rated the video highly for its helpfulness in understanding the subject, scoring 4.6 in both years, demonstrating its continued effectiveness in aiding comprehension. There was a notable increase in appreciation for the inclusion of music at the beginning of the video, with the score rising from 3.2 in 2018 to 3.7 in 2024, suggesting enhanced enjoyment or perceived enhancement of the viewing experience. The quality of both image and sound remained consistently high, scoring 4.5 and 4.3 respectively in 2018, and 4.5 and 4.4 in 2024, indicating sustained excellence in technical aspects of video production. The video's suitability for studying received very high ratings, scoring 4.7 in both years, indicating its effectiveness as a study aid. Similarly, the appropriateness of the examples used in the video received consistently high ratings of 4.7 in both years. The perceived adequacy of the video length increased slightly from 4.5 in 2018 to 4.6 in 2024, suggesting that students in 2024 found the

video length slightly more suitable for their needs. Lastly, students' enjoyment of effects and animations in the video improved, scoring 4.0 in 2018 and 4.2 in 2024, suggesting a growing appeal that could enhance the educational experience. Overall, these results show a consistently positive perception of the educational video with slight improvements in certain areas, reflecting evolving student preferences and expectations.

Table IV compares student opinions on the white background used in b-Mat@plicada videos, collected in 2018 and 2024. In 2018, most students (79.4%) found the white background adequate, though 19% felt it made no difference to their viewing. By 2024, 68.9% still deemed the background adequate, with a slight decrease in this view. Meanwhile, 28.4% felt the background did not affect their experience, indicating growing indifference. Few students in both years (1.6% in 2018 and 2.7% in 2024) believed a different background could enhance video attractiveness, showing general acceptance of the current choice. Overall, while most students find the white background adequate, some are indifferent or see potential for improvement with a different background.

Fig. 7. Comparing video quality perception: 2018 vs. 2024.

Table IV. Perceptions on the selected white and clean background commonly used in the b-Mat@plicada videos: 2018 vs. 2024.

Which is your opinion on the white and clean background generally used in the b-Mat@plicada videos?				
	2018 (N = 63)		2024 (N = 74)	
	n	%	n	%
The white and clean background does not make difference	12	19,0	21	28,4
A different background could make the videos more attractive.	1	1,6	2	2,7
The white and clean background is adequate	50	79,4	51	68,9

Key Components of Effective Learning Videos

Fig. 8 compares students' views on key features in effective learning videos from 2018 to 2024. Both years emphasized image quality at 25%, and sound quality increased slightly from 20% to 24% over this period. Notably, importance placed on animations and aesthetics rose

marginally, suggesting growing appreciation for visual appeal in engaging learners. Video length also gained importance, up from 12% in 2018 to 13% in 2024, indicating a preference for concise content. However, there were shifts: speech quality decreased from 28% to 25%, suggesting a shift in focus within video content. Similarly, emphasis on the timbre of voice dropped from 7% to 3%, indicating less focus on specific voice attributes. Overall, these findings underscore evolving student preferences in educational videos, highlighting nuanced changes in priorities like animation, video length, and verbal delivery alongside consistent values in image and sound quality.

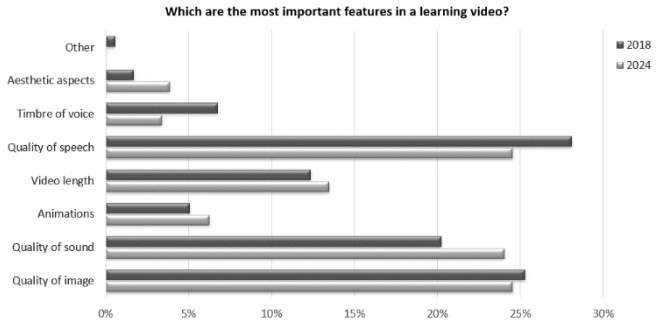

Fig. 8. Student Views: Educational Video Features 2018 vs. 2024.

Student Learning Outcomes

Fig. 9 displays the absolute frequencies for the various score levels, while Table V presents the mean score levels across different years and academic courses. Results from post-tests indicate a decline in student performance from 2018 to 2024. In 2018, 86% of students scored the highest (4), averaging 3.76. By 2024, only 64% achieved this top score, with an average of 3.22. In 2024, Informatics students scored higher (average 3.49) than Business Sciences students (average 2.79), suggesting varying preparation and response to video instruction across disciplines. One significant factor contributing to the overall decline in performance is likely the impact of the COVID-19 pandemic. Students who experienced online classes during their secondary education may have faced challenges that hindered their mathematics learning. The transition to remote learning often led to reduced engagement, limited interaction, and potential gaps in foundational knowledge and skills. These factors could have contributed to the lower performance observed in the 2024 group. Another consideration is that the effectiveness of instructional videos may depend on the individual student and the specific academic course. While the video helped achieve high performance in the 2018 cohort, the 2024 group showed more variability in outcomes, with performance varying significantly by academic course. This suggests that the video can aid learning, but its impact might be influenced by students' backgrounds, engagement levels, and the particular academic course. In conclusion, the data indicate a decline in post-test scores from 2018 to 2024, likely influenced by the educational disruptions caused by the pandemic. Additionally, the effectiveness of the instructional video seems to vary depending on the student group and academic course. Addressing these gaps and improving instructional methods, particularly for students affected by online learning during the pandemic, will be crucial for enhancing future learning outcomes. Tailoring video content to better meet the needs of different academic courses and individual students may also improve its effectiveness.

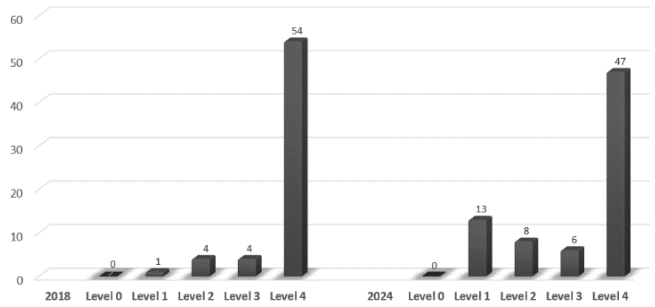

Fig. 9. Absolute frequencies of Score Levels: 2018 vs. 2024.

Table V. Mean Post-Test Score Levels

Experiment	Academic course	Mean
2018	Business Sciences (N = 63)	3,76
2024	Business Sciences and Informatics Engineering (N = 73)	3,22
2024	Informatics Engineering (N = 40)	3,49
2024	Business Sciences (N = 33)	2,79

4. Conclusions

In conclusion, the b-Mat@plicada course exemplifies the potential of video podcasts to improve the learning experience in HE. By providing high-quality and accessible educational content, the course helps students overcome the challenges of learning Mathematics. The positive reception and effectiveness of the course highlight the critical role of well-designed e-Learning resources in modern education, offering valuable insights and guidelines for educators seeking to develop similar initiatives.

An experiment comparing student responses from 2018 to 2024 highlights the impact of academic course area and the online learning shift on perceptions and outcomes. The findings show how education is changing, with more reliance on online videos and changing views on their quality and role in learning. While students still find explanatory videos useful, they are more critical of their quality, highlighting the need for better content production and delivery. The drop in post-test scores also indicates a need for focused efforts to address learning gaps caused by the pandemic and improve how instructional videos work across different academic settings. As education changes, teachers must adjust their methods to meet students' evolving needs and use technology effectively to improve learning in both online and traditional classrooms.

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