Flipped Learning with Interactive Videos

João Fonseca
Instituto Superior Técnico
Lisboa, Portugal

ABSTRACT

The use of interactive videos in flipped learning, an active learning methodology, has proved to be a valuable tool to boost student engagement and communication between students and teachers. A systematic literature review was conducted to research the types of video interaction currently employed in flipped learning and their impact. The findings revealed that the most employed video interaction tools were instructor and student annotations and in-video quizzes. The most reported benefits were increased student participation and improved student assessment, and its most significant challenges were increased time and effort spent by professors and students. A subsequent participant-observer case study research was conducted to analyze the impact of videos in flipped learning in a real-life course. This analysis was performed in a curricular unit in Instituto Superior Técnico which implemented interactive materials in preparation and home activities. Students were asked through questionnaires about their experience and opinions regarding the implementation of these materials, and their interaction data was also consulted and analyzed. Student feedback was by and large very positive. The role of the interactive materials in stimulating their thought and attention was recognized, while also providing opportunities to discuss their topics with colleagues. Despite this fact, some students chose to not engage with these materials, and the higher quantities of student annotations per video was also a reported issue.

KEYWORDS

Flipped learning; Interactive videos; Active learning; Case study research; Participant observer.

1 Introduction

Flipped learning is a learning model that aims to balance better how to distribute activities between class time and the student's individual time. It accomplishes this by favoring more challenging and practical tasks during classes (where the instructor can provide more comprehensive support) and more introductory and less challenging tasks to be done in preparation for those classes [1].

This learning model is a subset of a more extensive model named active learning. Active learning is a learning model that favors implementing activities in the classroom to incentivize student reflection, cooperation with one another to solve problems, and discussion of topics among themselves to learn from one another and further their understanding [2]. Flipped learning, being an active learning model itself, follows the same principles [3].

The flipped learning model has often been combined with video lectures to introduce and prepare students for the more demanding content, and tasks during the classes [4]. However, the preparation the pre-class videos are intended to provide can only be adequate if the students are motivated enough to watch the videos in due time [5] and are concentrated while doing so [6]. Moreover, the videos alone can only provide theoretical knowledge about a given subject without the student being able to put them into practice without using an external platform or tool [7].

Recent technologies of video interaction, where both students and instructors may communicate through embedded messages and discussions in the videos, or where instructors may create embedded questions to be answered throughout the video's watch time, can help to mitigate these issues [8]. With them, the students can immediately test their knowledge after it is introduced in practical examples. In other cases, students can also communicate and discuss the contents with peers as a form of collaborative learning, turning what would otherwise be a more individual and solitary pre-class preparation into a more social endeavor [9].

1.1 Objectives

This report aims to provide a theoretical background on active learning, flipped learning, and interactive videos, presenting and discussing its impact on the courses it is implemented in. The report will accomplish this by performing a preliminary research into two curricular units in a higher education context, a Systematic Literature Review (SLR), and a case study in a real-world higher education implementation of these learning models.

The preliminary research will present two distinct implementations of flipped learning with interactive videos, analyze both implementations, and compare them. The SLR will provide a broader overview of existing research on flipped learning with interactive videos, detailing existing interaction methods and their pros and cons. Finally, the case study will cover the impact of flipped learning with interactive videos on student engagement and collaboration in a real-world scenario and discuss its positives and negatives.

2 Theoretical Background

2.1 Active Learning

Active learning is a learning model that differentiates itself from the traditional learning model by introducing activities in the classroom to motivate student engagement with learning materials and the course as a whole [2]. By being student-centered, it aims to incentivize discussion among students and develop problem-solving skills to improve their learning [10].

In a passive classroom lecture, without any interaction or engaging activities, the student's interest and attention will inevitably wane as the lecture progresses, with attention lapses becoming more prolonged and more frequent if the students are not engaged [11].

The introduction of practical tasks in the classroom to challenge the students and engage them with the contents being taught also has the advantage of increasing their attention span. By presenting the students with activities to reflect on and discuss the course's topics, they can develop their critical thinking skills, expand their understanding of the course's contents, and improve their long-term information retention. These factors usually result in a substantial increase in student performance [12].

The active learning tasks differ from "homework" and other assignments due to being conducted in the classroom, engaging students in the learning process [12]. Active learning activities can have the students connect newly acquired knowledge with their own previous ideas [13], as well as foster a collaborative environment where students discuss the topics givens, arrive at a solution through an exchange of ideas, and allow them to engage with one another [10].

However, incorporating active learning opportunities alongside lectures is in and of itself a significant challenge due to time constraints. Allocating more time to active learning tasks can imply that the exposition of new contents will have to be done in less time, while the opposite can also happen [14].

Flipped learning, an active learning model, was developed to minimize this problem of time constraints. It allows more time for activities and discussions by changing the way the classes and courses are structured [3], which will be covered in greater detail in the following section.

2.2 Flipped Learning

Flipped learning (or flipped classroom, or inverted classroom, as it is also often called) is a learning model that aims to invert the activities that are usually performed during lectures with the ones usually performed individually by the students between lectures [15].

Therefore, the flipped learning model intends to contrast with the traditional learning model in which classes are usually used to present new concepts to the students through lectures. Consequent tasks are also assigned to the students to be performed outside of the class, during their study time, to apply the concepts taught in the classroom [16].

This traditional model, however, has several pitfalls which have been often pointed out [1]:

- The most challenging work, which involves applying the concepts learned in lectures, is performed individually, without instructors readily available to provide support.

- The least challenging work (the exposition of new concepts) is mostly done with the aid of instructors.

- The class time is usually almost wholly dedicated to explaining new concepts, leaving very little class time to apply them.

- Students become dependent on the lecturers and find themselves unable to learn and progress without them.

These issues are some of the motivators for adopting the flipped learning model throughout several courses. By delivering new concepts and performing less challenging tasks during the students' individual space, the class is freed up to perform more challenging activities, during which the instructors can actively engage with the students to support them [17].

The flipped learning model has also seen subsequent adoption due to rapid technological developments and widespread usage of media sharing. The increasingly streamlined creation of media content and its distribution through the web makes it so that presenting or creating new learning materials is ever more straightforward [14].

2.3 Videos in Flipped Learning

In a flipped learning context, the exposition of new concepts in the students' individual space can be done using various materials, such as texts or videos [4]. The latter, however, has seen the most usage in flipped learning iterations [18]. This widespread adoption of videos in flipped learning can be attributed to, when compared to other methods (such as reading tasks), helping the students better understand and retain the concepts presented, as well as boosting the students' interest, concentration, and motivation [19].

Despite being the most popular teaching method in pre-class activities, video lectures are not without issues. Motivating students to watch the videos to prepare for the classes ahead is still a commonly reported challenge by instructors [18]. Additionally, the videos alone are not very interactive, leading students to adopt a passive role in pre-class learning [8]. Moreover, students have also found it difficult to maintain concentration during the video lectures and were thus easily distracted from them [20].

Several strategies have been attempted to solve or mitigate these issues. Usage of videos generated by instructors themselves has proved to be more motivating and captivating than videos produced by third parties, as the active participation of the instructors in the video lectures provided a more personal learning experience which deepened the bond between them and the

students [1]. The length of the videos was also deemed a determining factor in increasing or decreasing student motivation, as the large majority of students were much more motivated and concentrated while watching shorter videos as opposed to longer ones [21]. Furthermore, the usage of interactive videos has also been employed as an attempt to hold the students' attention and motivation [17].

3   Research Methodology

3.1   Preliminary Research

A preliminary research was conducted on flipped learning and interactive videos to study how students react and interact with these learning models.

This research comprised three questionnaires performed at different stages of a higher education course. The final questionnaire was done for two courses with different implementations of video interaction in a flipped learning environment. The data from these questionnaires was later analyzed to conclude the students' perceptions of this learning model. Additionally, the data from the final questionnaire also allowed for a comparison of the two implementations regarding students' usage and stance regarding the video interaction tool used.

3.2   Systematic Literature Review

An SLR is a systematic way to perform a literature review to identify, evaluate, and interpret the available research pertinent to a research topic or question. This method enabled the summarization of the existing research regarding the topic of this report, providing the necessary information for further investigation and research activities [22].

The SLR performed in this work used the guidelines provided by Kitchenham's Procedures for Performing Systematic Reviews [22], which introduces the concept of SLR, details its importance and advantages, and most importantly, presents a procedure to perform the said SLR. This procedure provides three stages for this process: Planning; Conducting; and Reporting.

The planning stage is the initial stage of the SLR process. Firstly, the reason why an SLR is being performed should be made clear, which can be gathered by reflecting on the objectives of the systematic review or on the conclusions that could be inferred from it. Secondly, a research protocol should be developed to minimize researcher bias and to ensure that the systematic review is performed strictly. Lastly, the research questions should be laid out, making sure they are pertinent to the research being conducted [22].

The conducting stage follows the previous step and focuses on carrying out the established research protocol. This stage will allow for gathering a select group of search results, from which the required data must be selected and extracted [22].

The last stage is the reporting phase, during which the extracted data should be structured and summarized according to a predefined template to answer the previously established research questions [22].

3.3   Case Study Research

Following the previous SLR process, a case study research was also performed in a Portuguese higher education curricular unit, in a Master's course of Computer Science and Engineering. This report will cover a particular type of case study research called participant-observer research. In a participant-observer case study, the researcher, instead of being detached from the organization being studied, can become fully immersed in its setting, recording his/her experiences and reflecting upon them [23].

It is worth mentioning that participant-observer research can induce researcher bias by not having the researcher detached from the research subject. This bias can arise from the researcher's influence over the participants or from the researcher's beliefs [23]. In order to keep such bias in check, the data collected from the participants were gathered from multiple sources, and with the researcher distanced from the participants while doing so. The data collection was accomplished by employing remote questionnaires, which the participants could answer in their privacy and free time, and by gathering records from the tool the participants used throughout the research.

This collection of data from several different sources, besides attenuating the bias associated with the research itself, also constitutes a form of data triangulation, particularly data source triangulation [24].

Data source triangulation adds further validity to the research findings, as conclusions will be reached not by a single data source but by combining multiple data sources, which provide a more comprehensive array of results [23]. The differing data sources also provided distinct points of view of the same setting, as where the questionnaires could focus more on the participant's perspective, the data acquired from the tool they used detailed how it was used and how frequently.

4   Preliminary Research

A preliminary research was carried out during the first term of the year 2021/2022, in Instituto Superior Técnico, on the subjects of Foundations of Information Systems (FSI) and Communication Skills in Computer Science and Engineering I (CCEIC-I).

This analysis was performed in three phases of questionnaires, one at the beginning of the course, one at its halfway point, and a last one after its conclusion. The first two phases were only performed in the FSI course, while the last phase was performed in both courses, so as to compare results. The questionnaires were comprised of multiple choice and open questions, with some sections following the Service Quality (SERVQUAL) model [25]. The questionnaires were done online through Google Forms. All questionnaires and processing of collected answers were done

with the consent of the inquired students, according to General Data Protection Regulation (GDPR) guidelines.

The video interaction tool in both courses was FeedbackFruits which was incorporated into the Moodle Platform of Instituto Superior Técnico's "Departamento de Engenharia Informática" (Department of Informatics Engineering). However, both courses approached video interaction in different ways. In the FSI course video interaction did not have an impact on the final grade and was only used to post doubts for clarification, whereas in the CCEIC-I course, the video interaction tasks were graded and had an impact on the student's final grade. Moreover, in the FSI course, FeedbackFruits was only used as a video annotation tool, whereas in the CCEIC-I course more features were used, such as multiple-choice questions, open-answer questions, and teacher annotations.

The first questionnaire received 11 answers, the second received 9 answers, and the last one received 14 answers (6 answers from FSI students, and 8 answers from CCEIC-I students).

4.1 Initial Enquiry

In the first questionnaire, students were asked about their study habits (regarding the usage of videos in their studies and whether they usually study in groups), previous experiences with flipped learning, previous experiences with interactive videos, and overall expectations.

Most students answered that they often used videos in their studies and often studied alone. When inquired about previous experiences with flipped learning, 10 students answered that they had previously used flipped learning in other courses, and 8 of those students found it to be a positive experience. Regarding video interaction, only 5 students had used it in previous courses, and all of them students found it to be a positive experience as well. The other students that had not used video interaction tools were generally hopeful about its impact on the course. One student made a less optimistic statement, remarking that the platform might not receive much use from the students and that could generate some confusion.

4.2 Intermediate Enquiry

In the second questionnaire, students were asked questions about several aspects of the video lectures watched thus far, and about their usage of video interaction in those videos.

Regarding the video lectures, of the 9 students that answered the questionnaire, 7 found them to be easy to follow, 6 found that they had a good pace, and 7 found that they had a suitable length. However, the students rated the video lectures lower regarding their engagement. On the matter of video interaction, all students answered that they had not written any video annotations yet, mostly stating they had not needed to use the video interaction tool yet. As a suggestion to increase student engagement, one student suggested the addition of multiple-choice questions at the end of the videos to consolidate the contents in them.

4.3 Final Enquiry

In the third and last questionnaire, students were once again asked about several aspects of the video lectures they had watched throughout the course, and about how they made use of the video interaction tools at their disposal. The questions pertaining to the video lectures covered the same topics as the second questionnaire, and the students of both courses gave similar answers as the ones of the previous questionnaire.

Regarding video interaction, all FSI students answered they had not made use of the video interaction tool throughout the course, as they did not feel the need to do so. One student suggested the creation of discussion threads by the teacher to motivate discussion in the video. Regarding video interaction on the CCEIC-I course, all students answered they had made use of the video interaction tools, most manifesting it was a straightforward process, that it furthered the contents of the video, and provided a more human experience.

However, of the 8 CCEIC-I students who answered they had made use of the video interaction tools, only half of those students found it an enjoyable experience. Only 4 students agreed with the statement "It was more enjoyable to watch an interactive video than a video with no interactivity", while 3 were indifferent and one student disagreed. Students also remarked that interactive videos helped them pay more attention to the videos and allowed them to put their knowledge into practice.

5 Systematic Literature Review

5.1 Planning the Review

5.1.1 Identifying the Need for a Review. This review was performed to aggregate the many techniques and implementations of interactive videos in a pedagogical context, particularly while employing learning models like flipped learning, to outline the benefits and challenges of using videos in this context.

5.1.2 Research Questions. The following research questions were developed to get a greater insight into this topic:

- **RQ 1:** What are the techniques usually employed in the implementation of interactive videos with a flipped learning model?

- **RQ 2:** What are the benefits of implementing flipped learning with interactive videos?

- **RQ 3:** What are the challenges of implementing flipped learning with interactive videos?

- **RQ 4:** What are the enablers of employing interactive videos with flipped learning?

- **RQ 5:** What are the inhibitors of employing interactive videos with flipped learning?

5.1.3 Research Protocol. The research performed in this literature review used the following search string:

((flipp* N5 class*) OR (flipp* N5 learn*) OR (flipp* N5 model*) OR (invert* N5 class*) OR (invert* N5 learn*) OR (invert* N5 model*) OR (blend* N5 class*) OR (blend* N5 learn*) OR (blend* N5 model*))

AND

((video* OR media) N5 (annotat* OR interact* OR thread* OR comment* OR feedback* OR contribut* OR question* OR forum* OR communicat*))

The expression "blended learning" (and its variants) was also included in the search string. The reasoning behind this decision was that blended learning used many of the same video interaction mechanisms found in a flipped learning context, as these two models also share some characteristics. A blended classroom combines both online and traditional classroom teaching [6]. While flipped learning does not have to be necessarily implemented in a blended classroom, a significant amount of flipped learning implementations occurs in this context [1].

This search string was used to query the EBSCO Online Digital Library. The search was limited to academic journal articles with English abstracts. After running the query, the research process would go through a duplicate removal stage and another stage to remove any remaining results not written in English, Portuguese, or Spanish and with no translation available. Consequently, the abstract of every result would be analyzed to ascertain if it could be relevant to the research or if it was out of scope and therefore excluded. The exclusion criteria in this stage was the mention of video interaction in a pedagogical context. The same process would then be applied to the full text of the remaining results, leaving us with the final result pool.

5.2   Conducting the Review

This section pertains to how the search results were gathered using the previously described search process and a characterization of the gathered results during this stage.

Following the research process previously outlined, the first step in conducting this SLR was applying the search options, expanders, and limiters and running the search query through the EBSCO database, which provided 582 articles.

Of these articles, EBSCO excluded 276 by automatically detecting duplicate results amongst them, leaving a total of 306 articles that were deemed to be unique results. Not all these results were, however, unique. Therefore, some manual duplicate detection was also performed, excluding another 58 results. Some articles returned by the query were also not written in English, Spanish, or Portuguese, which prompted a manual exclusion of 3 results. This process left 245 unique articles, which could now be subjected to additional filtering.

The final stages involved filtering the out-of-scope results, starting by focusing on the abstract field and then on the full text of the articles. To determine the relevancy of an article based on its abstract, its title, abstract text, and keywords were analyzed. When analyzing the full text of these results, special attention was paid to their introduction to determine its relevance initially. The abstract and full text were checked for any references regarding video or media interactivity in a pedagogical context, focusing on flipped or blended learning.

After carrying out these filtering stages, 36 results were considered relevant to the research.

5.3   Reporting the Review

This section will focus on the final results pool obtained from the research and the information that could be extracted from them.

5.3.1 Types of Video Interaction. While reading the articles from these results, six types of video interaction could be identified: Instructor annotations; Quizzes embedded in the videos; Student annotations; Comment sections; Like and dislike feedback; and Live chats.

The most reported types of video interaction were instructor annotations and in-video quizzes, each mentioned in 14 articles.

Instructor annotations are usually notes or texts which can be embedded in the videos by the instructors themselves, which can be used to highlight certain sections of the videos or provide additional information on certain topics [8]. These were usually coupled with other interaction techniques, like in-video quizzes and, most notably, student annotations. In systems that also enabled the creation of student annotations, or that permitted students or instructors to reply to each other's annotations in a sort of discussion thread, it also allowed for back-and-forth interactions between students and instructors [26].

As the name suggests, in-video quizzes consist of questions embedded in the videos themselves. These embedded questions could come in several formats, such as multiple-choice questions, matching questions, or open-ended questions [5]. The most popular format for the embedded questions, however, was multiple-choice [27], as it could provide immediate feedback to the students responding [28], and information about students' performance to instructors [9]. Several articles also reported the usage of embedded questions combined with instructor annotations to further clarify the topics covered in the video [15].

Student annotations were also used as an interaction technique in 10 articles. This interaction technique consists of comments embedded in the videos, usually associated with a specific timestamp, which students can create to discuss the topics covered in the videos [29]. These can also allow other students to reply to the annotations, enabling the creation of embedded threaded discussions [8]. As mentioned previously, this technique was usually combined with instructor annotations, also enabling the same interactions but between teacher and students [8].

The least reported interaction techniques were video comments, likes and dislikes, and live chats, with comments and likes and dislikes reported in 2 articles each and live chats reported only once. Comment sections and likes and dislikes were reported as similar to the ones employed in other media-sharing platforms. They were mainly used to provide additional feedback to the

instructors regarding the quality of the videos [30]. Comment sections differed from annotations by not being timestamped or embedded in the video itself. Live chats were mainly used as a medium for the students to ask questions to the instructors in live video sessions [31].

5.3.2 Benefits of Video Interaction. From researching the aforementioned final results, several benefits of video interaction techniques could also be identified.

The most reported benefits of video interactivity were increased student participation and interaction, provision of data and analytics for instructors to assess the students' performance, students having a more active role when watching the videos, better retention of information, improved self-regulation, and improved concentration during the videos.

Of the 36 articles, 12 articles reported increased participation and interaction. The introduction of interactive tasks in the videos encouraged students to participate more in the course and engage in discussions with colleagues and instructors [32].

Another 11 articles reported the provision of data to the instructors. Answering questions in the videos and annotating them gave the instructors valuable data to assess how well the students grasped the contents of the videos and to monitor their learning process further [8].

Seven articles also reported a more active learning role. Video interaction techniques were also often reported to have switched the learning role of the students from a passive to a more active role, in which the student could put into practice the knowledge from the videos as it was introduced [6]. Lastly, better retention of information, improved self-regulation, and increased concentration were each reported in 5 articles.

The least reported benefits of video interaction were better performance and grades, increased motivation to watch videos, increased critical thinking skills, deepening the contents of the videos by providing additional information, provision of additional ways to give feedback, and being less reliant on external interaction platforms like forums or discussion boards.

5.3.3 Challenges of Video Interaction. From researching the aforementioned final results, several challenges of video interaction could also be identified.

The most reported challenge of video interactions was an increased time and effort spent by professors to learn, set up, and monitor the video interaction activities [6], being reported in three articles. Besides this challenge, two articles also reported an increased time and effort spent by students to learn and use the interaction mechanisms, which increased the time spent when watching the videos [6].

Additionally, another two challenges were also reported in two articles each, such as students answering video questions repeatedly until they got the correct answer (in cases where no penalties for failing an answer were put in place) [33], and the fact that less intuitive video interaction technologies or platforms might generate some confusion in the students (instead of clarifying certain topics) [4].

Least reported were other challenges, such as possible technical difficulties when accessing or using interaction mechanisms (such as connecting to the platform used for these purposes or when creating an account, among others) [34], and not being able to verify if the tasks in the videos were performed by the students themselves or with help from a third party [33]. Moreover, some students might pose some resistance to these interactions if their purpose or benefits are not made clear, which might reduce their motivation to engage with the videos [26].

Furthermore, in the case of video annotations, the more the video is annotated, and annotations start to overlap, the reading and searching for annotations can become increasingly difficult, as the information can become too dense to be perceptible [35]. Lastly, as the students pay attention to video annotations, they might focus less on the video itself, risking important information going unnoticed [36].

Finally, if there is no anonymity in video interactions, some students might become discouraged from engaging with them [32], and less challenging tasks in video interaction might also not motivate students enough to interact with them [27].

5.3.4 Enablers of Video Interaction. From researching the aforementioned final results, several enablers of video interaction techniques could also be identified. The only reported enablers for the usage of video interaction techniques were the wide variety and popularity of video interaction technologies in education [34], and the COVID-19 pandemic, which has motivated the usage of new distance learning technologies such as the usage of video streaming and the associated interaction mechanisms [37]. These enablers were only reported in 4 of the 36 total articles.

5.3.5 Inhibitors of Video Interaction. From researching the aforementioned final results, several inhibitors of video interaction techniques could also be identified. The only mentioned inhibitors were the need to teach students and instructors to use these technologies [15] and the costs of the licenses of interaction tools [9], each being mentioned in one article each. The time and money investments required to set up video interaction tools might, in some cases, impede their usage if such investments cannot be performed.

6 Case Study

The case study research was performed to assess the impact of video interaction tools on a course following a flipped learning model, namely how it will impact student engagement, collaboration amongst themselves, and communication with other students and teachers. This research aimed to gather conclusions by performing a real-world analysis by enquiring the students that interacted with these tools and analyzing how they approached them.

6.1 Research Questions

The research questions for this case study research will be inspired by the previous SLR, but instead applied to this context:

- **RQ 1:** What are the benefits of incorporating interactive videos in flipped learning?

- **RQ 2:** What are the challenges of incorporating interactive videos in flipped learning?

- **RQ 3:** How can video interaction impact student engagement with the videos?

- **RQ 4:** How can video interaction impact student communication amongst themselves and with the teachers?

6.2 Participants

The participants of this research will be the students who, at any point of the course's execution, either responded to questionnaires made available or formally facilitated their data through a data collection form.

All the answers given by these students who participated in this case study research were anonymized, and the data they facilitated. Neither the data nor the students' answers to the provided questionnaires were accessible to the course instructors. The data was viewed and analyzed strictly by the researcher.

Additionally, as a participant-observer case study research, the researcher himself was also a participant.

6.3 Setting

The case study research was performed during the third term of the year 2021/2022 in the curricular unit of CCEIC-II in Instituto Superior Técnico, which saw the enrollment of 449 students. This curricular unit operated similarly as CCEIC-I mentioned in Chapter 4.

The course used continuous evaluation, where the student would be evaluated throughout the execution of the course through several tasks and a final project. The continuous evaluation was conducted using video and document interaction tasks on provided course materials or in the classes themselves.

The continuous evaluation had two distinct components: the preparation modules and the application modules.

Starting with the preparation modules, these consisted of video and document interaction tasks provided to the students. Each of the eight modules would be opened to the students one at a time every week, covering the topics discussed in class the week after. Students were highly incentivized to complete the preparation module before coming to the respective class as they introduced the topics covered in class and encouraged reflection on them. However, completing a module before its corresponding class was not mandatory. Preparation modules could be performed after their corresponding week up to a deadline after the seven weeks of classes. These modules were graded, but a passing grade could be obtained in the course without completing all of them.

On the other hand, each of seven application modules could be performed in two different ways: in-class or at home. The application in-class consisted of activities performed in the classroom, presentially. Each activity of each application module performed in the class would net the students the points of the activity. However, the application at home consisted of several interactive materials or assignments that could be done online, either created by third parties or by teacher. The students, therefore, had the option each week of either attending the class and completing its activities in the classroom or completing that week's application modules' tasks on the course's page. The application modules, like the preparation modules, were also not mandatory. Each application module contributed to the course's final grade, so not completing an application module would mean the student would forgo a part of the final grade.

6.4 Video Interaction Tool

The video interaction tool used during this research was FeedbackFuits, an active learning tool suite built for incorporation in a Learning Management System (LMS) [38].

FeedbackFruits provides many tools to interact with study materials, such as videos, audio, and documents. These interaction methods can be teacher and student annotations, open and multiple-choice questions, discussion threads, and a voting system using "likes".

In this course, FeedbackFruits was once again incorporated into the Moodle platform, the LMS used by Instituto Superior Técnico's "Departamento de Engenharia Informática" (Department of Informatics Engineering).

An LMS is a platform that enables teaching and learning to be done remotely, providing teaching materials and activities, as well as communication avenues between students and teachers LMS. Moodle is one of such platforms and has seen widespread adoption in European and American faculties [39]. On the course's Moodle page, assignments and interactive study materials were published throughout the course, and students could submit deliverables whenever required.

6.5 Data Collection Techniques

Data was collected in the form of two questionnaires (done at the start and end of the execution of the curricular unit), from the use of the video interaction tool by the students, and by the observations of the participant research. Both questionnaires were performed using Google Forms and thus could be answered remotely at any time.

The questionnaires assessed students' expectations, perceptions, and opinions of the learning model. They contained multiple choice and open questions to collect more detailed statements and the student's opinions and impressions of the learning model employed.

A qualitative analysis was performed on the data from the questionnaires and video interaction tool. Furthermore, a

statistical analysis was also performed, displaying the frequency the students engaged with the interactive materials and their performance in such tasks.

It is worth reiterating that all students considered for this analysis consented for their data to be collected and analyzed. Any others were not considered for this analysis. All questionnaires and data collection forms were presented to the students, accompanied by a data consent form, per the regulations of GDPR. Since the exported data from FeedbackFruits carried with it the name of the students, all data was consequently anonymized.

Of the 449 enrolled students, the first questionnaire saw the participation of 26 students and the final questionnaire saw the participation of 55 students. The data collected from the interaction software encompassed 37 students.

6.6 Results

6.8.1 RQ1: What are the benefits of incorporating interactive videos in flipped learning? From the case study results, one could gather that many enquired students were willing to participate in the video interactive materials and found those interactive materials a valuable and enjoyable learning tool.

The enquired students noted that these materials were able to foster discussion and reflection on the topics they covered while also being relaxing to perform. As students could complete these activities at home without a strict deadline, these interactive activities could be performed at their own pace and whenever the student had available time. Furthermore, students also pointed out that the activities were mostly not too challenging while also managing to stimulate the students' critical thinking.

A majority of students also found the preparation and autonomous learning materials captivating, and that the interactive activities had them think in greater detail about their contents. It is also worth noting that the difficulty of learning how to use an interactive video tool (one of the inhibitors gathered during the SLR) did not have the negative impact one would initially expect. Most students instead found accessing and using the interactive tools an easy endeavor.

6.8.2 RQ2: What are the challenges of incorporating interactive videos in flipped learning? While student participation in the interactive videos was very high, several students did not fully complete the interactive tasks, while also preferring some interactive tasks over others.

The annotation tasks were the least favorite among students, with some students finding it very challenging to write a new annotation in the videos when they felt they had nothing to contribute to the discussions. This was exacerbated by the fact that when videos already had plenty of student annotations, it was increasingly harder to create a new one that would cover a different topic from the others.

Students also noted that the length of some videos was excessive and that some of these videos had too many question cards that would make them focus away from the contents of the video.

Additionally, outside factors like projects and work from other curricular units also impacted the time students could dedicate to the interactive videos.

Finally, the interaction tool could lock some students out of questions in case of an accidental click, and the mobile version of the interactive tool was found to be unwieldy by students.

6.8.3 RQ3: How can video interaction impact student engagement with the videos? Video interaction allowed a way to think deeply about the subjects covered in the videos by making students reflect using techniques such as embedded questions, creating annotations, and replying in discussion threads.

In the sample of students that was analyzed, most students at least started or viewed the interactive videos, with only a small amount not finishing some of the proposed interactive tasks. Between the embedded questions and creating or replying to annotations, the annotation-related activities were the least engaged by students, although by a small margin. This was corroborated by students largely preferring to perform multiple-choice and open questions in the videos over creating and replying to annotations.

All in all, students predominantly found the interactive video tasks to be approachable and valuable to their learning. Even without all interactive videos requiring completion to get a passing grade, each interactive video saw the majority of students interacting with it, albeit with a slight decrease in attendance throughout the course.

6.8.4 RQ4: How can video interaction impact student communication amongst themselves and with the teachers? Most students concurred that the interactive videos did in fact foster communication with students and teachers, a fact that is substantiated by the high student participation in the annotation related activities. However, some students sometimes felt like such participation was not natural due to it being a requirement to complete the interactive material in its entirety.

Nevertheless, one can conclude that the addition of a grade incentive greatly improved student participation in video discussions. When compared to the preliminary research, where one of the curricular units did have this component with a grade incentive, no students made use of the video discussions. Since in CCEIC-II the video discussions were a part of the final grade (even if not wholly mandatory), most students felt compelled to complete them. Additionally, the students that did not wish to perform such tasks could skip them and forgo a part of the grade (as was the case for some students), thus striking a balance between a grade incentive and accessibility.

7 Conclusion

The preliminary analysis performed on the topic of flipped learning and interactive videos concluded that grading and making video interactions impactful to the final grade helps to motivate students to use these systems. Additionally, this analysis also motivated the consequent SLR performed on this topic.

With the SLR, the most used techniques of video interaction in education were presented. Additionally, the most reported benefits, challenges, enablers, and inhibitors of these techniques were also compiled. With the wide array of benefits and different techniques available, it could be gathered that video interaction is very suitable for pre-class activities.

However, employing video interaction may imply some additional challenges for students, mainly instructors, regarding the effort spent by the instructors in setting up the video interaction environment, as well as the increased watch time for students.

Several of the benefits reported in the SLR were once again found by performing a case study on a real-world higher education scenario. Students praised the studied implementation of flipped learning with interactive videos, noting it promoted reflection during the videos and made it a more stimulating activity, while also not being too daunting as introductory tasks.

In tandem with the noted benefits, students also reported additional aspects which acted to the detriment of the learning experience. Student discussions, while promoting collaboration among students and incentivizing an exchange of ideas, often took students' attention away from the videos due to a saturation of annotation cards. Nevertheless, the student opinion was mainly favorable towards interactive videos, with most showing a desire to see such techniques employed in future courses.

These investigations, therefore, allowed us to conclude that employing interactive video materials in a flipped learning context yielded a more engaging learning experience. While providing the students with the option to interact with one another during the videos may not correlate to wide usage of such interactive tools, grading such activities can significantly boost student participation in these activities. Moreover, suppose such activities are given more relaxed deadlines or made non-compulsory. In that case, students tend to appreciate this flexibility, implying a reduction in stress and a more positive sentiment toward the evaluation process.

As some final notes, some details in the implementation of this learning model can end up being detrimental to the learning process. Longer videos (and in larger quantities) can become more exhausting, as they are more time-consuming. Additionally, an overwhelming amount of interactive tasks or annotation cards in a single video can make all its information more difficult to apprehend and for the students to add their own unique comments and ideas. Thus, while interactive elements in videos are widely appreciated by the students and advantageous to the learning process, moderating the density of these interactions is required for them to be used to their fullest potential. Furthermore, the videos and software in which these interactive tasks support themselves are also pivotal choices, with shorter videos leading to more student engagement and intuitive interactive software leading to easier use of these tools.

7.1 Research Limitations

The conduction of the SLR had one notable limitation. Since the topic of video interaction in flipped learning is reasonably recent, there is still some limited coverage regarding its variations and impacts. Thus, the number of articles that comprised the SLR was limited by this factor. However, the recentness of the topic did not act entirely to the detriment of the research, as most articles covered in the SLR were from the last 10 years, covering some of the most up-to-date practices of video interaction with flipped learning. Furthermore, as the COVID-19 pandemic motivated the usage of more innovative distance learning technologies and models, its coverage may also increase in the future.

Additionally, the conduction of the questionnaires in the preliminary research and case study research, as well as the consent for the use of interaction records, was done with less student participation than anticipated. While the results obtained provided valuable data, with a plethora of conclusions that could be gathered, higher student participation could have provided further insights and perspectives from other students, giving a more reliable set of data.

It is our hope that, despite these limitations, this report could shine a light on the use of this learning model and succinctly describe its impact on students and the courses it is implemented in.

7.2 Future Work

Continuing from the previous section, it could be interesting in the future to perform another SLR on the topic of flipped learning with interactive videos. A new SLR counting with new articles with new interaction techniques, implementations in even more recent courses, and the ever-increasing number of articles on this topic could result in another very rich literature review of a still recent topic but an ever more prevalent learning model. Furthermore, comparing the current SLR with a new one could also highlight whatever developments occurred between the two literature reviews, how practices have changed, and what new analyses were performed.

Additionally, further research into new curricular units could provide vastly different data, covering how students from various learning areas could approach the same learning model and video interaction tools. Researching other curricular units could also give interesting insights into how well this learning model could fit different courses and could also permit covering different implementations of the same learning model.

Last but not least, researching different video interaction tools could also constitute very worthwhile future research. Performing analyses into other popular video interaction tools, such as H5P [40] (an also widely used open-source interactive learning tool), could give way for an overview of such platforms and research into their use in several other curricular units and their impact.

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