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Flipped Learning with Interactive Videos

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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.

Resumo

O uso de vídeos interativos na aprendizagem invertida, uma metodologia de aprendizagem ativa, provaram ser uma ferramenta valiosa para aumentar o engajamento de alunos(as) e a comunicação entre alunos(as) e professores(as). Uma revisão sistemática de literatura foi realizada para pesquisar os tipos de interação por vídeo atualmente empregados na aprendizagem invertida e seu impacto. Os resultados revelaram que as ferramentas de interação por vídeo mais empregadas foram anotações de instrutores(as) e alunos(as), e questionários nos vídeos. Os benefícios mais relatados foram um aumento da participação e melhoria da avaliação de alunos(as), e os seus desafios mais significativos foram o aumento do tempo e esforço despendidos por professores(as) e alunos(as). Uma pesquisa de estudo de caso com observador participante foi subsequentemente conduzida para analisar o impacto de vídeos na aprendizagem invertida num curso universitário. Esta análise foi realizada numa unidade curricular do Instituto Superior Técnico que implementou materiais interativos nas atividades de preparação e aplicação em casa. Alunos(as) foram questionados(as) sobre as suas experiências e opiniões sobre a implementação desses materiais, e os seus dados de interação também foram consultados e analisados. O feedback foi em geral muito positivo, sendo reconhecido o papel dos materiais interativos em estimular o seu pensamento e atenção, além de proporcionar oportunidades para discutir os tópicos com colegas. Apesar disso, alguns alunos(as) optaram por não interagir com esses materiais, e a elevada quantidade de anotações por vídeo também foi um problema relatado.

Palavras Chave

Aprendizagem invertida; Vídeos interativos; Aprendizagem Ativa; Investigação de caso de estudo; Observador participante.

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Acronyms

SLR Systematic Literature Review

FSI Foundations of Information Systems

CCEIC-I Communication Skills in Computer Science and Engineering I

SERVQUAL Service Quality

GDPR General Data Protection Regulation

CCEIC-II Communication Skills in Computer Science and Engineering II

LMS Learning Management System

1

Introduction

Contents

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 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.

The following thesis outline will detail how the report is organized and which chapter pertains to which research stage.

1.2 Thesis Outline

Chapter 1 introduces the topic covered in the report, presents the report's objectives, and outlines how it is structured. Chapter 2 provides a theoretical background into the main concepts covered in the report, active learning and flipped learning, which require an introduction before any findings are discussed. Chapter 3 presents the research methodologies used throughout the research and provides an overview of how they were conducted. Chapter 4 details how a preliminary analysis into two curricular units was executed, its results, and its findings. Chapter 5 covers each stage of an SLR conducted on the topic of this report, presenting its motivation, how it was conducted, its results, and a discussion of its findings. Chapter 6 describes a case study research conducted on a real-world higher education example, starting with its motivation, research questions, and a description of its participants and setting. The chapter then goes on to describe the software tool used during the research, the data collection techniques used, and the results associated with each of them. It finalizes by discussing its grouped results and answering the research questions. Lastly, Chapter 7 concludes the report by presenting its most relevant findings, the limitations of the research, and future work that can be done to further it.

2

Theoretical Background

Contents

This section presents an overview of the main concepts covered in this research, namely active learning and flipped learning, and how they correlate. Lastly, it will finish with some insights into using videos in a flipped learning model.

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]. Robert Talbert defines this learning model

as [1]:

> *"Flipped Learning is a pedagogical approach in which the first contact with new concepts moves from the group learning space to the individual learning space in the form of structured activities, and the resulting group space is transformed into a dynamic interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter."*

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].

2.2.1 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

Contents

This section will introduce and describe the research methodologies covered in this report, namely SLR and Case Study Research. As a preamble, it will also describe a preliminary research conducted prior to the SLR and case study.

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.

Chapter 4 will go into further detail regarding the research setting and participants, as well as the data and conclusions that could be drawn from it.

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 efficacy of the SLR process is as high as the quality of the search strategy used during the procedure. This search strategy must allow for gathering a rich and varied collection of search results while remaining unbiased.

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
- 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].

Chapter 5 will cover all phases of the SLR, as well as present its results and findings.

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.

The data sources were initially analyzed separately and only later correlated with each other to answer the outlined research questions.

The case study's execution, research questions, results, and findings are described in greater detail in Chapter 6.

4

Preliminary Research

Contents

This chapter will describe the execution of a preliminary research on the topic of interactive videos within a flipped learning context.

This 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. To this end, a consent form was presented to each student before answering each of the questionnaires.

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. A more detailed description of the implementation and functionalities of FeedbackFruits can be found in Chapter 6.

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[1], 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.

[1] First questionnaire in PDF format available **here**

Regarding video interaction, only 5 students had used it in previous courses, and all of them found it to be a positive experience as well, commenting that video interaction incentivised more communication between colleagues and teachers, and made teachers seem more approachable. The other students that had not used video interaction tools were generally hopeful about its impact on the course, giving the following statements:

> *"Seems to be a good way to post questions easily and immediately while watching the videos."*
>
> *"Makes it possible to faster clarify any issue. Unlike some times in the past where I left it to be clarified during the class only to later forget about it."*
>
> *"It's very good because of how instantaneous and direct the medium is, versus using a separate medium like WhatsApp or email, for example."*

One student left a less optimistic statement, remarking that the platform might not receive much use from the students and that could generate some confusion:

> *"I don´t think the interaction part will be useful since most students don´t feel comfortable using a platform of that style. In my opinion, it will make the access to the material more confusing."*

4.2 Intermediate Enquiry

In the second questionnaire[2], 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:

> *"Didn't have the need to use it yet."*
>
> *"I didn't feel like I had the need to start any threads or make any questions there."*
>
> *"This course's content it's pretty easy to understand. And I usually also read the book which fills any gap in understanding what's in the videos. Then the real-world examples given by the professors in class also complement the understanding of the topics."*

[2]Second questionnaire in PDF format available **here**

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[3] [4], 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:

> *"I believe that, by making these interactions part of the final grade, it will inevitably lead us to better pay attention to the concepts that are being taught throughout the semester's term, making it an effective way of promoting autonomous and continuous study."*

> *"They made you pay attention as you needed to apply the material straight away, the discussion threads were fun to interact with others!"*

4.4 Discussion

From this preliminary analysis it was gathered that in a case where video interaction is graded or impactful on the final grade, it will see much more use and interaction by the students.

[3] FSI questionnaire in PDF format available **here**
[4] CCEIC-I questionnaire in PDF format available **here**

Moreover, flipped learning, videos, and video interaction seem to be generally well received by the students, whereas video interaction tools seem to have helped with boosting their attention and practicing what they have learned.

Lastly, the insights acquired from this preliminary research also motivated the systematic literature review performed on the same topic.

5

Systematic Literature Review

Contents

This section describes the various stages of the aforementioned SLR, how it was executed, what were its results, and its findings are consequently discussed.

5.1 Planning the Review

This section focuses on the planning stage of the SLR. It outlines the need for the systematic review to be carried out, the research questions, and finally, the process used to perform the research itself.

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*))*

This search string includes terms such as “flipped” or “inverted” because, as previously mentioned, both are used to refer to flipped learning. The same logic was employed to include terms such as “classroom” or “learning” or “model”, as either of these can be used to refer to the flipped learning model.

The terms “video” and “media” were included side by side as much of the software for video interaction can be applied to other media, such as images or PDFs [26]. Several synonyms or actions connected with video interaction were used, such as “communication”, “contributions”, and “questions”, among others.

All terms used in the search string used the wildcard operator to include many variations of each term (such as “flipped” or “flipping”, in the case of the term “flipp”). Because some of the terms of these expressions can often not show up side by side (like in the expression “flipping the classroom”), the “near” proximity operator was used with a maximum distance of five terms, which was able to find terms that were at most five words apart, regardless of their order. This proximity operator was used for all expressions within the search string.

Furthermore, the expression “blended learning” (and its variants) was also included, using the same proximity and wildcard operator. 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]. Moreover, both models usually implement preclass tasks, often using video lectures and video interactivity tools [1, 6].

This search string was used to query the EBSCO Online Digital Library using its “Advanced Search”. The AB abstract field was selected for this query while also using the search option that allowed to find all search terms of the search string to get more accurate matches. The search was also expanded to allow searching within the full text of the articles and to be applied to equivalent subjects. The search was also 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.

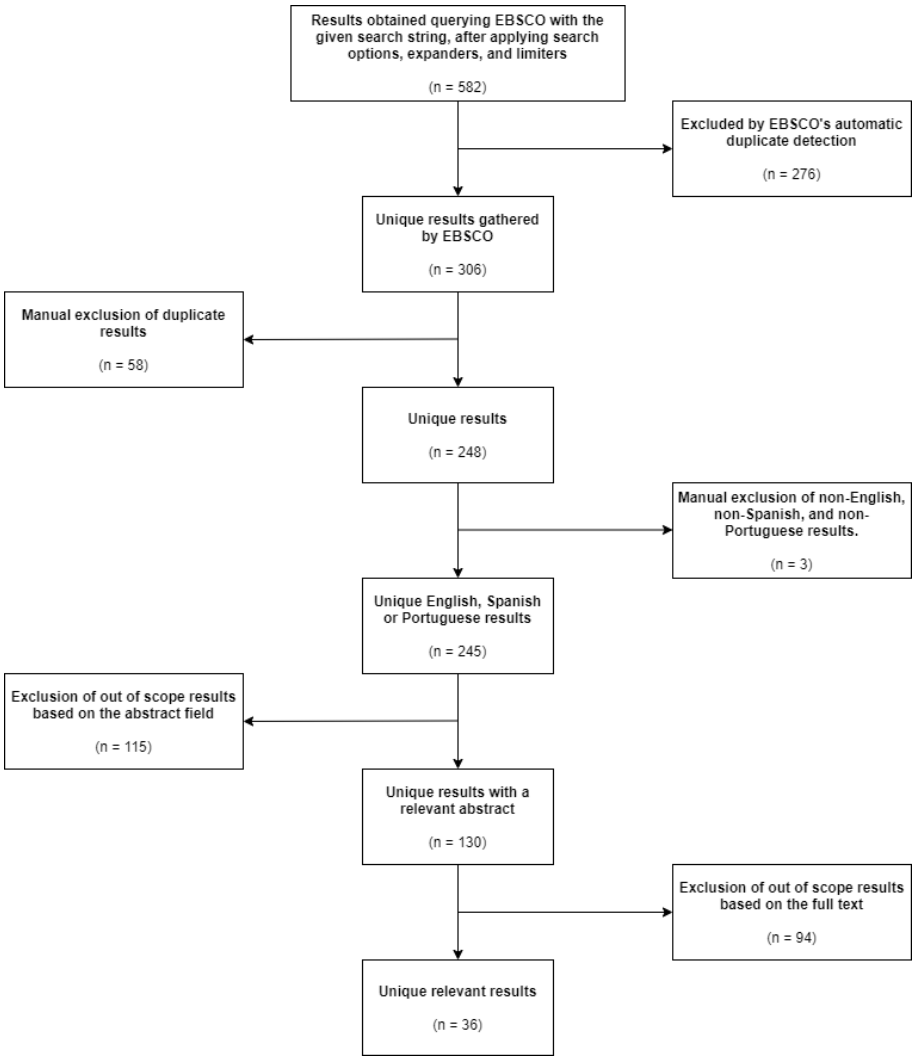

Figure 5.1: Result Selection Process

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. The conduction of this process is summarized in Figure 5.1.

The final results pool was comprised exclusively of articles, and their publication dates were distributed as shown in Figure 5.2.

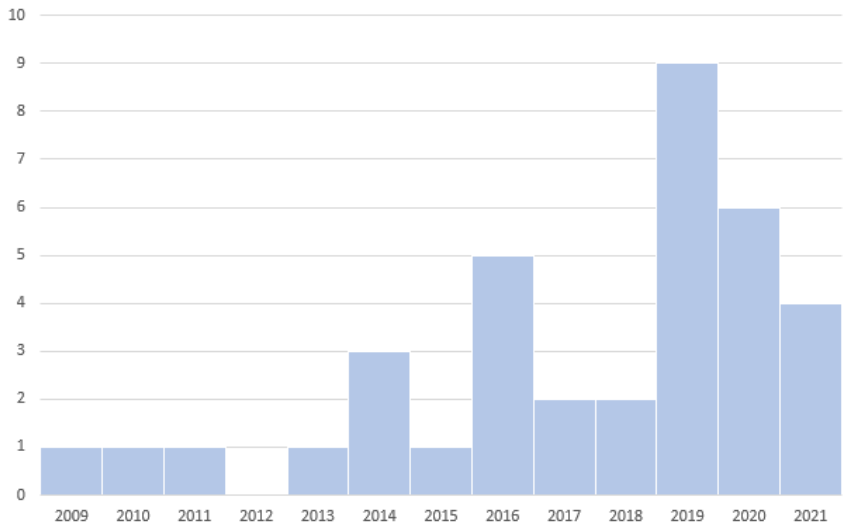

Figure 5.2: Academic Journals by Year

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.

Appendix A displays all articles obtained from the research while also categorizing them regarding their year, area of education, and research methodology.

5.3.1 Types of Video Interactions

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 section
- Like and dislike feedback
- Live chats

The articles on each of these types of interactions can be found in Table 5.1.

Table 5.1: Video Interaction Techniques

Interaction Techniques	#Articles	Articles
Instructor Annotations	14	[8]; [27]; [28]; [29]; [30]; [9]; [31]; [6]; [18]; [21]; [15]; [32]; [33]; [34]
In-video Quizzes	14	[35]; [27]; [36]; [5]; [37]; [38]; [9]; [19]; [15]; [39]; [4]; [7]; [40]; [41]
Student Annotations	10	[8]; [28]; [30]; [9]; [31]; [6]; [42]; [26]; [33]; [43]
Comment Section	2	[44]; [7]
Likes and Dislikes	2	[44]; [45]
Live Chat	1	[46]

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 [28].

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 [35], as it could provide immediate feedback to the students responding [40], 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 [31]. 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 [45]. 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 [46].

5.3.2 Benefits of Video Interactions

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

These benefits, and the articles pertaining to each of them, can be found in Table 5.2.

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 [42].

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].

Table 5.2: Benefits of Video Interactions

Benefits	#Articles	Articles
Increased student participation and interaction	12	[42]; [47]; [15]; [30]; [9]; [35]; [5]; [6]; [31]; [19]; [8]; [48]
Data to assess the student's performance	11	[42]; [45]; [40]; [34]; [9]; [35]; [37]; [41]; [29]; [8]; [44]
More engaging video learning	8	[7]; [46]; [9]; [35]; [37]; [4]; [36]; [6]
Better retention of information	5	[49]; [15]; [36]; [39]; [17]
Improved self-regulation	5	[32]; [47]; [20]; [31]; [38]
Increased concentration while watching the videos	5	[40]; [36]; [39]; [6]; [20]
Better performance and grades	4	[7]; [39]; [41]; [17]
Increased motivation to watch the provided videos	4	[40]; [9]; [17]; [18]
Increased critical thinking skills	4	[15]; [40]; [9]; [26]
Deepen the contents of the videos	3	[27]; [21]; [4]
Additional avenues to provide feedback	1	[45]
Less reliant on external interaction platforms	1	[30]

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 Interactions

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

These challenges, and the articles that pertain to each of them, can be found in Table 5.3.

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) [39], and the fact that less intuitive video interaction technologies or platforms might generate some confusion in the students (instead of clarifying certain topics) [4].

Table 5.3: Challenges of Video Interactions

Challenges	#Articles	Articles
Increased time and effort spent for professors	4	[47]; [27]; [6]; [28]
Increased time and effort spent for students	2	[6]; [28]
No penalties for wrong answers in video interactions may lead to students answering repeatedly until they get the right answer	2	[35]; [39]
Non-intuitive video interaction technologies may generate further confusion in the students	2	[4]; [26]
Technical difficulties accessing or using interactive videos	1	[30]
Cannot gather if tasks are done individually or using external help	1	[39]
Some students might not understand its purpose or benefits	1	[28]
Interactions less perceptible as their volume increases	1	[26]
Important information may be missed when interacting	1	[43]
No anonymity in interactions may lead to less engagement	1	[42]
Non-challenging interactions might not engage the students	1	[35]

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) [30], 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 [39].

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 [28].

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 [26]. Lastly, as the students pay attention to video annotations, they might focus less on the video itself, risking important information going unnoticed [43].

Finally, if there is no anonymity in video interactions, some students might become discouraged from engaging with them [42], and less challenging tasks in video interaction might also not motivate students enough to interact with them [35].

5.3.4 Enablers of Video Interactions

From researching the aforementioned final results, several enablers of video interaction techniques could also be identified.

These enablers, and the articles that pertain to each of them, can be found in Table 5.4.

Table 5.4: Enablers of Video Interactions

Enablers	#Articles	Articles
COVID-19 pandemic has catalyzed the usage of more varied innovative technologies	3	[32]; [33]; [26]
Video interaction technologies have become more and more popular	1	[30]

The only reported enablers for the usage of video interaction techniques were the wide variety and popularity of video interaction technologies in education [30], 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 [33]. These enablers were only reported in 4 of the 36 total articles.

5.3.5 Inhibitors of Video Interactions

From researching the aforementioned final results, several inhibitors of video interaction techniques could also be identified.

These inhibitors, and the articles that pertain to each of them, can be found in Table 5.5.

Table 5.5: Inhibitors of Video Interactions

Inhibitors	#Articles	Articles
Students and professors must be instructed in how to use interactive video platforms	1	[15]
Cost of the interactive video tools	1	[9]

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.

5.4 Discussion

The previously reported results found that the most used and mentioned types of video interaction were embedded annotations (either made by students or instructors), and embedded quizzes that the students could answer as they watched the videos. However, some articles did not report any specific type of video interaction, and others only mentioned them briefly, being more focused on covering video interaction or communication in a flipped learning environment as a concept.

The most notable benefits were boosting the interaction and participation of the students, providing analytics to instructors to monitor their learning, making watching the videos a more active task, and improving the retention of the information in the videos. Most articles touched on at least some positives of these interactions, so a significant amount of information could be gathered on this topic. Despite this fact, as most articles were more focused on presenting the benefits of these methods other than their downsides, some publication bias can also be present.

The most notable challenges were increased time and effort spent by students and professors. A significant number of challenges of this learning model could be found, albeit less than when compared to the information gathered regarding its benefits. Nevertheless, some pertinent pitfalls and issues of this learning model could be identified, which could be very relevant to consider when implementing video interaction in flipped learning. Some notable ones were non-intuitive video interaction tools (which could lower the student's understanding of the topic), as well as systems with no penalties for wrong answers (which reward trial and error instead of thought and reflection).

The enablers of video interaction were where less information could be gathered. One article considered the biggest enabler to be the wide variety of video interaction technologies available, while some written in the last two years considered the COVID-19 pandemic the driving force for adopting these technologies.

Lastly, some inhibitors could also be identified, which we considered could impede the implementation of these technologies in a flipped learning context. These were the cost of the video interaction technologies and instructing professors and students on how to use these tools.

6

Case Study

Contents

This chapter will cover the case study research performed following the aforementioned SLR. It will start by outlining the research questions this case study aims to answer, followed by a description of its participants and setting. It will also describe the data collection techniques used during this case study and its results. The chapter will conclude by discussing the data gathered during the case study and answering the research questions.

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 Communication Skills in Computer Science and Engineering II (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 but will be described in greater detail in this section for clarity.

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, and it took place during the seven weeks of classes of the course.

6.3.1 Preparation Modules

Starting with the preparation modules, these consisted of video and document interaction tasks provided to the students. These 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.

The students were also not obligated to complete all of the preparation modules. Nevertheless, these preparation modules were graded and contributed to the final grade, even if a passing grade could be obtained without completing all of them.

The video and document interaction tasks associated with the preparation materials provided each week consisted of YouTube videos made by third parties, scientific articles, and text documents related to the topics being covered. These were made available to the student online through the course's Moodle page, further described in the following section.

The grade of each preparation module would be given for watching/viewing the interactive materials, answering questions incorporated in those materials, creating a stipulated number of annotations, or replying to a stipulated number of annotations created by other students. Each preparation material was worth a certain percentage of the preparation module's grade in which it was included, which varied throughout the modules. Additionally, each interaction task of a preparation module also had its own weight toward the grade of that material, which also varied across interactive materials. These interactive tasks and materials will be further elaborated upon in the following section.

The course had eight preparation modules, with the first seven associated with each of the seven

weeks of classes, and an eight bonus module done after the last week.

6.3.2 Application Modules

On the other hand, the 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. 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.

The weekly home application materials could also be performed at any time after being published. The only restriction was a deadline placed at the end of the course.

The home application materials consisted of interactive videos created by the teacher, with the same types of interaction tasks as the ones found in the preparation modules. These application modules could be performed at home without completing their respective preparation module. However, students were highly incentivized to complete each week's preparation module before attempting the application module.

The course had seven application modules, one per each of the seven weeks of classes.

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) [50].

FeedbackFruits provides many tools to interact with study materials, such as videos, audio, and documents. These interaction methods can be either of the following:

- Teacher and student annotations
- Open and multiple-choice questions
- Discussion threads
- Voting system using ”likes”

Besides these features, other tools for peer reviews, self-assessment, and assignment reviews are also provided in FeedbackFruits. However, this section will focus exclusively on the interactive tools for study materials.

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 [51]. Moodle is one of such platforms and has seen widespread adoption in European and American faculties [52]. On the course's Moodle page, assignments and interactive study materials were published throughout the course, and students could submit deliverables whenever required.

A short showcase of the interaction tool's interface and functionalities will now be presented, accompanied by images to further illustrate its operation. This showcase will cover the interaction tools available to the students enrolled in the course.

6.4.1 Interaction Tool Showcase

Once the students log into Moodle using their account and click on their respective course, they will be redirected to the course's page. The course's materials can be presented and grouped on this page, alongside postings of assignments and other activities. In this course, the materials were grouped by week, as shown in Figure 6.1.

Figure 6.1: Student's course view

Once a material is selected from the course page, the student is redirected to its dashboard, as shown in Figure 6.2.

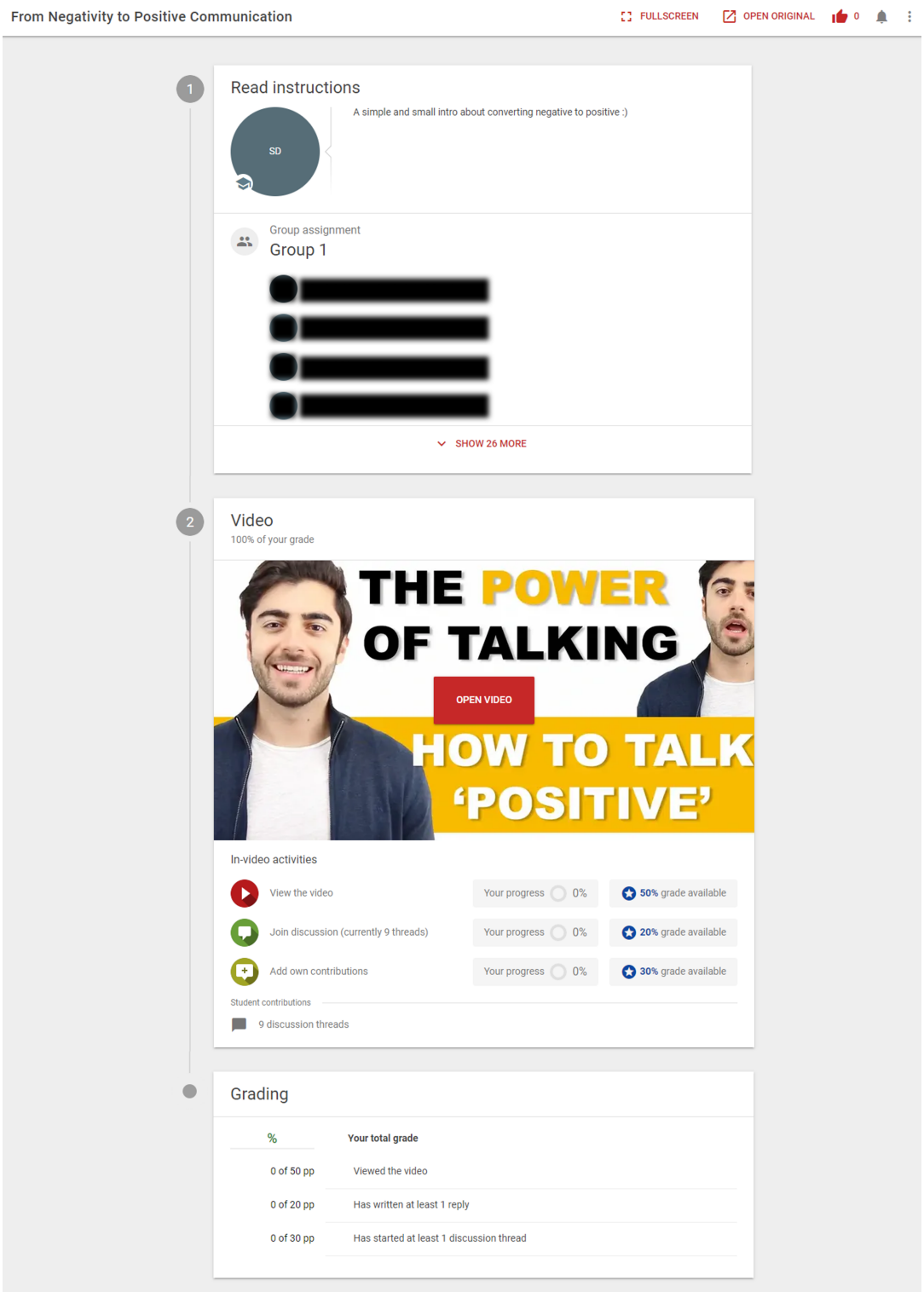

Figure 6.2: FeedbackFruits' student dashboard

Section one of the dashboard displays which group the student was inserted in and their colleagues. The second section displays the study material to which the activity pertains, as well as shows how many of the interaction tasks the student has completed and has yet to complete. This section also shows how many contributions the students have already left in the video discussion threads. The final section displays how much each interaction task weighs toward the material's grade and how much of that grade is already attributed to the student.

The groups shown in the activities' dashboards were created to reduce the volume of annotations in each video so that annotations could be more readable, visible, and spaced out. These groups consisted of a randomized group of students for each module.

After clicking on the study material displayed on the dashboard, the student can finally begin to watch and interact with it. An initial view of a freshly opened study material can be found on Figure 6.3. On the bottom, we can observe the video progress bar, which besides being used to forward and rewind the video, also displays the annotations already placed in the video as white dots. On the top right corner, the student's progress is again shown, as well as the percentage of grades already gained. It is also worth noting that the red plus sign above the progress bar, which, if clicked, allows the creation of a student annotation in the current timestamp of the video.

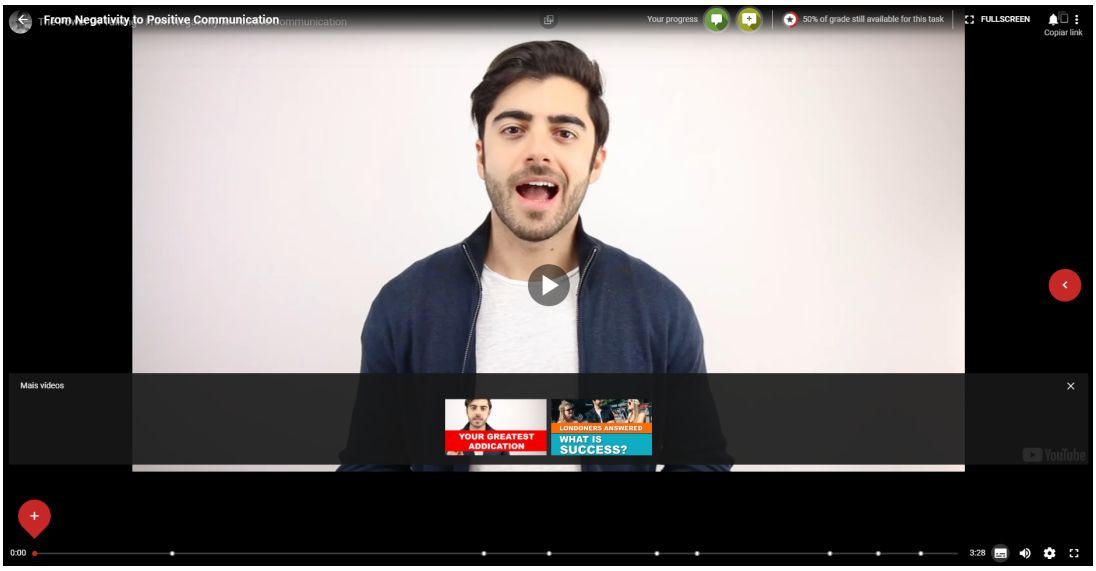

Figure 6.3: Initial view of an interactive video

If the student attempts to create an annotation, a panel on the right side of the video will be presented where the student can elaborate a contribution to the video, as displayed on Figure 6.4. The annotation can contain text; optionally, a file can be annexed alongside it. After creating an annotation, it will appear as another white dot in the video progress bar and can subsequently be rated and replied to by other students and instructors.

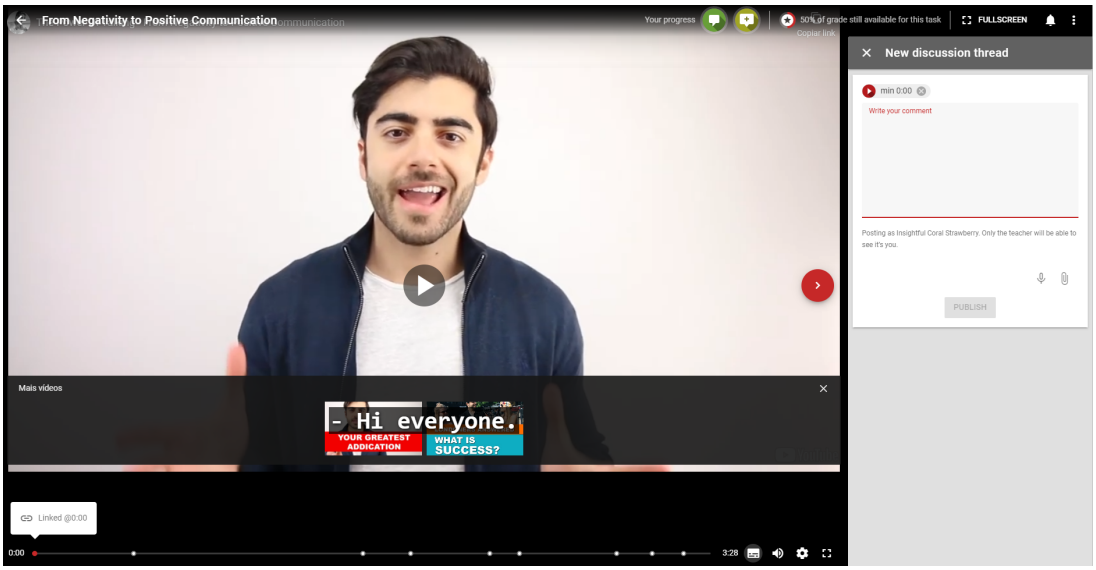

Figure 6.4: Creation of a student annotation

Once the video nears a timestamp where an annotation was created, a box will appear above the progress bar like in Figure 6.5. This box shows the text annotation, how many replies it has, and when it was created. The author of an annotation will be highlighted if the author is a teacher (in the case of teacher annotations).

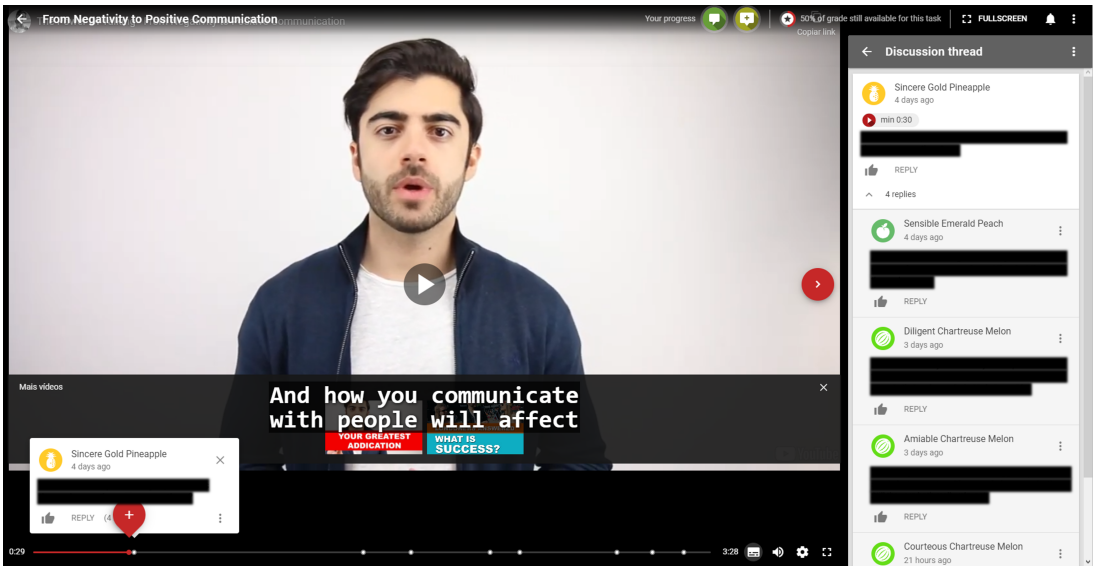

Figure 6.5: View of a student annotation and its discussion thread

Clicking the box with the annotation will open a panel on the right side of the screen with the discussion thread of that same annotation. It will show all the students and instructors that have replied and how many likes each reply has. The student can reply to the annotation and any of its replies by clicking

on the reply button, bringing out a text box similar to when creating an annotation.

In videos with multiple-choice or open questions, they will appear as padlock icons in the video's progress bar, as shown in Figure 6.6. When the video reaches a question card, depending on how the teacher sets it up, the student may or may not be required to answer the question to progress further into the video. In the curricular unit in question, however, all questions were marked as mandatory to progress.

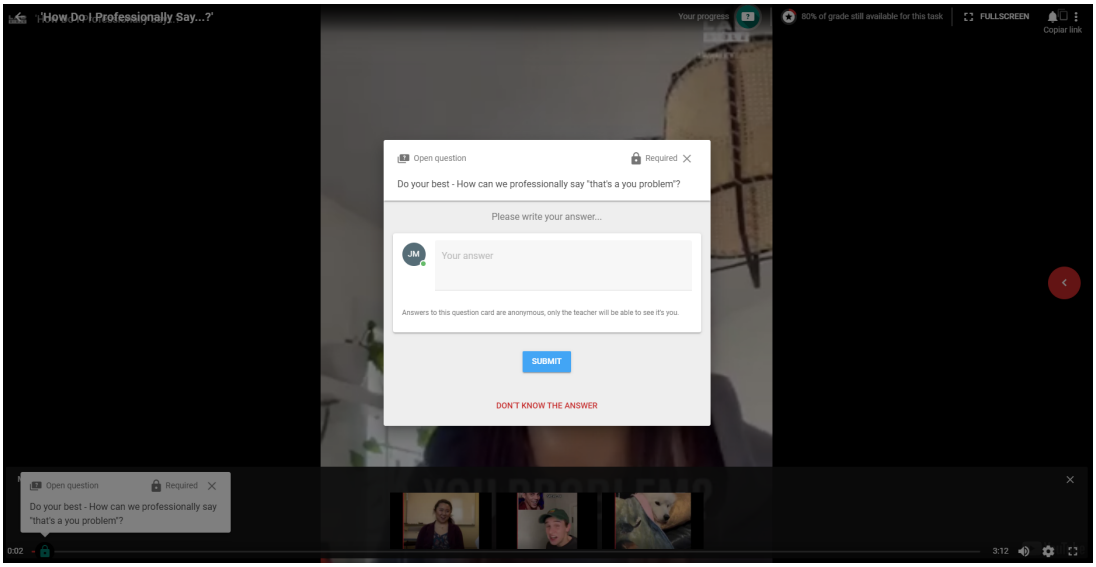

Figure 6.6: View of an open-ended question

In the case of multiple-choice questions, once the final answers are picked, the student will receive immediate feedback regarding which answers were the correct ones and which incorrect ones. In open-ended questions, the student will not get this instant feedback, as they require manual grading.

FeedbackFruits also allows students to create their question cards to be answered by their peers. However, in the course being researched, this feature was disabled.

Interactions with documents were also used in this course and can be done by highlighting the text one wishes to annotate, as displayed on Figure 6.7. Creating and viewing other students' annotations functions in the same manner as previously described. Documents can also have open and multiple-choice questions, which, in this case, were also set as required to complete if the student wished to progress further into the document.

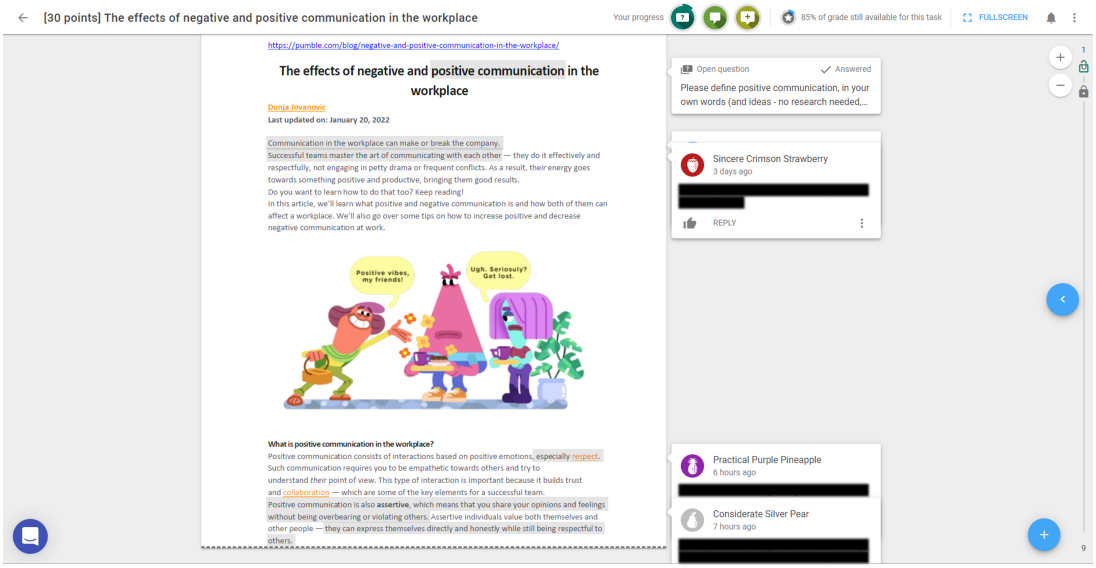

Figure 6.7: View of an interactive document

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.

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. Hence, insights into their benefits, challenges, student engagement, collaboration, and communication could be gathered.

Both questionnaires were performed using Google Forms and thus could be answered remotely at any time. This platform was chosen to give students the highest degree of freedom possible to answer the questionnaires at whatever time and place that was more accessible to them. All multiple choice questions were marked as mandatory, and all open questions were marked as non-mandatory. The open questions were marked non-mandatory to make the questionnaire more accessible to students with less time to answer. Lastly, all questionnaires contained a suggestions section, where the students could leave some additional comments that did not fit within the questions previously asked.

The multiple choice questions contemplated in both questionnaires followed the SERVQUAL model of questions (with only a few exceptions in questions that prompted a yes/no type of answer). Thus, these multiple-choice questions were presented as sentences where the student would have to rate them on a scale of 1 to 4 using a Likert scale. In these Likert scales, one would equate to "Strongly

Disagree", whereas four would equate to "Strongly Agree". As there was no neutral option offered, these questions were classified as forced Likert scale questions [53], as they forced students to take a stance on each sentence presented.

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.

6.6 Initial Questionnaire

The initial questionnaire[1] focused on three topics:

- Students' study habits
- Expectations regarding preparation tasks
- Expectations regarding interactive video materials

These topics were chosen to analyze how much students were already familiar with the flipped learning model, interactive teaching materials, and what learning materials they primarily used in their studies (videos, scientific articles, and text documents). The questionnaire also gathered insights into their past experiences with these tools and learning models and what expectations and reservations they might have had regarding their use in the course they were about to start.

6.6.1 Participants

The first questionnaire was made available to students at the start of the course and saw the participation of 26 students, out of 449 enrolled. Figure 6.8 shows the gender distribution of these students.

[1] Initial questionnaire in PDF format available **here**

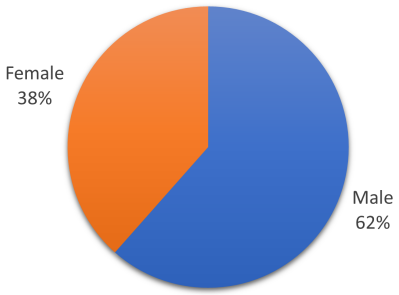

Figure 6.8: Gender distribution in the initial questionnaire

6.6.2 Part 1 - Students' Study Habits

The first part of the questionnaire touched upon the learning materials the students usually employed in their studies and how often they studied individually and with colleagues. The questions in this section aimed to assess the students' familiarity with the learning materials employed in the CCEIC-II course, as well as determine how commonly students partook in individual and group learning (since both are covered in FeedbackFruits).

Regarding the sentence "I tend to consult videos made by third parties to aid with my studies", 19 students answered as agreeing with the statement, with 9 of those students answering as strongly agreeing. Only 7 students disagreed or strongly disagreed with the sentence, implying that most of the 26 students that partook in the questionnaire were familiar with these learning materials and made ample use of them.

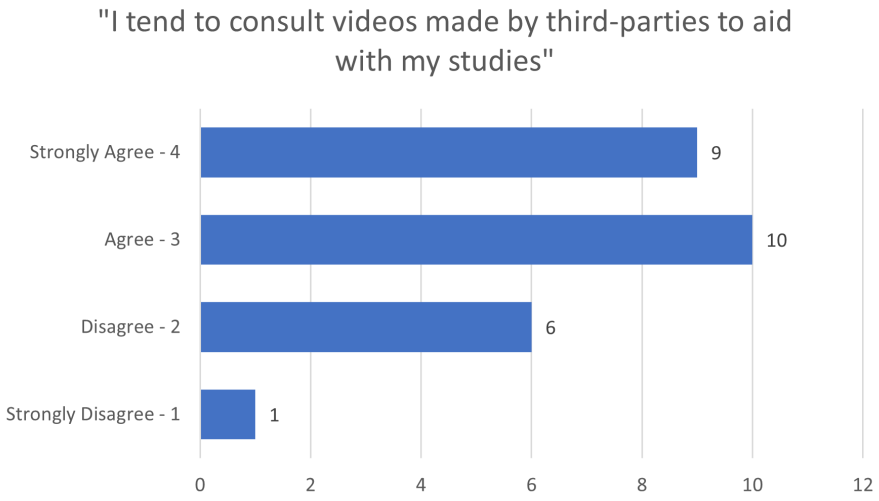

Figure 6.9: Consultation of third party videos

However, the results were very different in the use of scientific articles in the student's studies. The most common answer for the sentence "I tend to consult scientific articles to aid with my studies" was a strong disagree, with 8 students providing this rating. In total, 15 students disagreed or strongly disagreed with the sentence, and only 11 agreed or strongly agreed. This was a striking difference from the previous question, outlining that students preferred learning from videos instead of scientific articles.

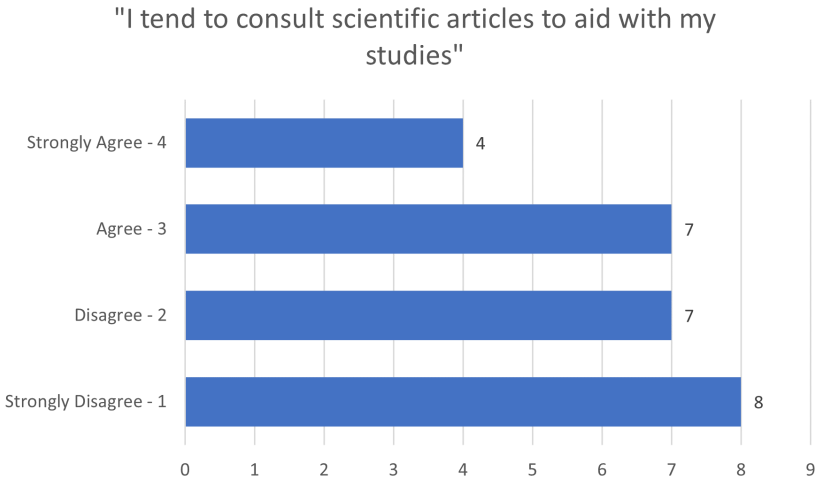

Figure 6.10: Consultation of scientific articles

Finally, the students were asked how often students they studied in groups and individually. Regarding individual study, 25 students answered positively to "I tend to study individually", with only 1 student disagreeing. On the other hand, 8 students responded favorably to "I tend to study in a group with other colleagues". One can conclude from these answers that, while the students did not see both study methods as mutually exclusive, individual study was the most commonly employed method.

6.6.3 Part 2 - Preparation Tasks

The second part of the questionnaire focused on the student's use of preparation tasks in previous courses (such as the preparation tasks used in a flipped learning context) and their expectations and reservations regarding their use.

This part of the questionnaire started with a yes/no question that prompted the students to answer if they had had any previous experience with preparation tasks. Of the 26 participating students, 21 answered they had already been through a course that used preparation tasks or materials, and only 5 replied they had not. With most students already familiar with this learning model, one could infer that most students would have already had their own opinions regarding this learning model and had a general idea of what to expect from the current implementation.

The 21 students that answered yes to this question would then be prompted to reply to questions

enquiring about past experiences with preparation tasks and materials. The remaining 5 students were enquired about their expectations regarding this learning approach yet unfamiliar to them.

6.6.3.A Past Experiences with Preparation Tasks

Starting with the 21 students who had already used preparation tasks in the past, Figure 6.11 shows the student's answers regarding how adequate the time spent on preparatory tasks was, and Figure 6.12 presents the students' opinions regarding their difficulty. The answers to these questions reflect that the majority of students considered that previous iterations of preparatory materials had been respectful of their time and had an accessible difficulty.

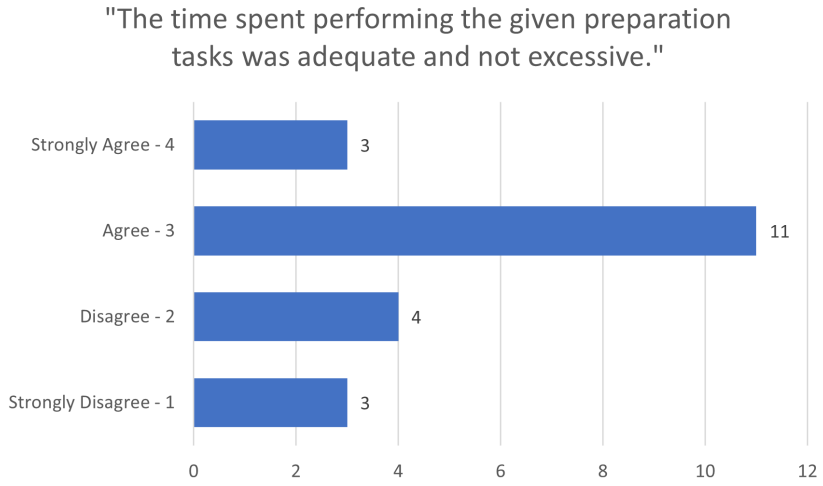

Figure 6.11: Time spent on previous preparation materials

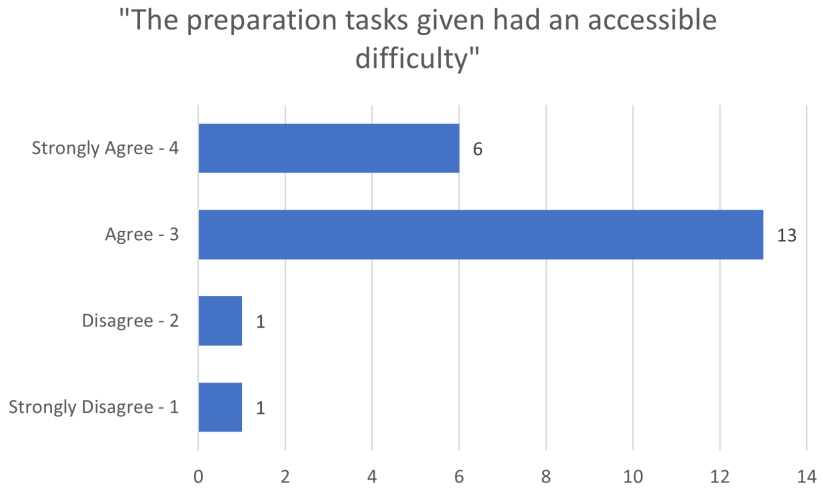

Figure 6.12: Difficulty of previous preparation materials

However, the answers were less favorable when students were asked about their motivation to perform these tasks. Of the 21 students who had engaged with preparatory tasks before, 16 disagreed or strongly disagreed that they had been consistently motivated to engage with them, leaving this question the most negatively rated by students in this section of the questionnaire.

Regarding the remaining topics, students' opinions were largely positive once again. Most students agreed that the preparation tasks had helped to further the contents of the courses, with 8 students agreeing and 9 strongly agreeing with this statement. Additionally, even more students agreed that these tasks allowed for a more accessible way to interact with the study materials and course as a whole, with 18 students also agreeing or strongly agreeing. Lastly, 14 students agreed that the preparatory tasks helped improve communication with the teachers, and 15 considered it improved communication with other colleagues.

Students could also optionally leave some more detailed answers regarding previous preparation tasks. Table 6.1 shows what some of these students had considered being their most positive aspects, and the consensus was that they allowed them to go to class more prepared and thus understand its contents better. Some other students also remarked that the ability for these preparation tasks and materials to be rewatched was also helpful when they could not understand them at first glance. Additionally, their increased flexibility meant they could be performed at the students' own pace.

Table 6.1: Positive Aspects of Past Preparation Tasks

"Allowed for a better understanding of the class."
"Introducing the topic alleviated the mental effort in class."
"Knowing the theme of the class."
"I can rewatch them if I don't understand something."
"Forced us to study."
"Since I have to publish the answer, it makes me really think about it and carefully choose my words, which I love."
"Allows to have a small introduction to the topic and have context before class."
"The flexibility. You can do them whenever you want and take as much time as you need."

The students mainly outlined negative aspects were the added time demanded by the course and the length of the materials associated with the preparation tasks. Students also mentioned that they could become easily demotivated to perform such tasks and lacked human feedback when performing preparation tasks. One of the students said in-person classes were much more enticing than virtual tasks at home. Some of the most notable comments provided by the students are presented on Table 6.2.

Table 6.2: Negative Aspects of Past Preparation Tasks

"Takes much more time since you know have to prepare before, be in the class and study after it. Adds a bigger number of study hours."
"It can easily go sideways and demotivate the students."
"The fact that the half the students don't really read the documents at hand because they are too long."
"Hard to find motivation to do it before class."
"Lack of human feedback."
"There is a limit to the material you can put in videos without having too much info in a video or too many videos."
"I don't like very much when I have to answer questions that are too obvious, there has to be thinking."
"If it is too much work, it is impossible to follow during the classes."
"Too much time consuming if not done properly."
"In-person classes are usually more enticing than the virtual ones."

6.6.3.B Expectations and Reservations Regarding Preparation Tasks

To end this section on preparation tasks, we will now focus on the 5 students who had not previously experienced these tasks. The 5 students were asked what they were hopeful and concerned about regarding their use in the course. One student answered to be optimistic that the grades would make it easier to get a higher grade, while three other students remarked that it would make it possible to come to classes better prepared. Regarding their concerns, two students noted that the preparation tasks would imply increased time and work done for the course. In contrast, one student was concerned about whether the answers to these preparation tasks were anonymous or not.

6.6.4 Part 3 - Interactive Materials

The final section touched upon the students' previous experiences with interactive materials, such as interactive videos or interactive documents. Once again, this section started with a yes/no question asking the participants whether they had already used such materials, to which 18 students out of 26 replied "yes". These students were enquired in further detail about their previous experiences with these materials and their opinions on them. The remaining students who replied "no" were only enquired about their views on their future use in the CCEIC-II course.

6.6.4.A Past Experiences with Interactive Materials

Starting with information retention, 12 of the 18 students agreed that the interactive materials had helped them better retain the contents of the course, and 13 students concurred that such materials had helped them to understand its topics better.

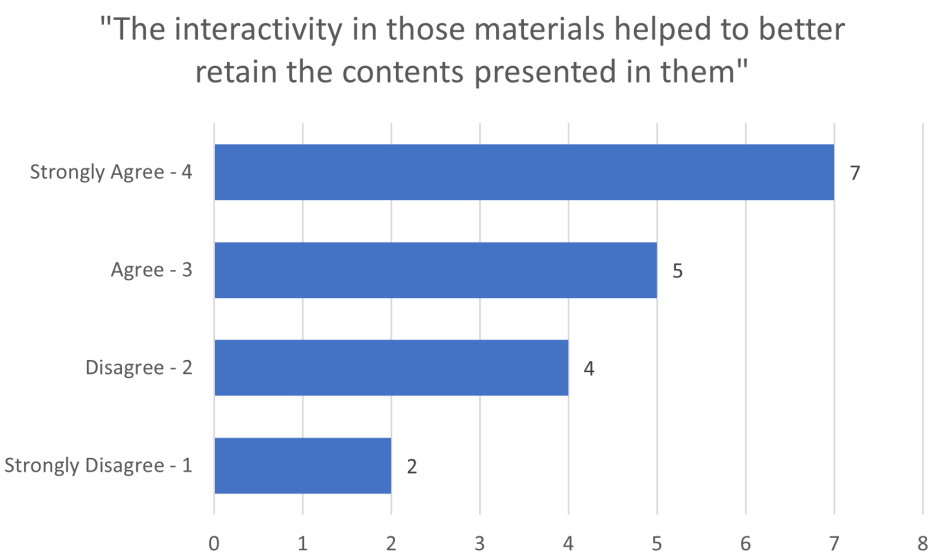

Figure 6.13: Information retention of past interactive materials

However, the answers were once again more negative when enquired about the motivation to interact with these materials, with only 8 students remarking they had felt consistently motivated to interact with them, with the majority disagreeing with this statement.

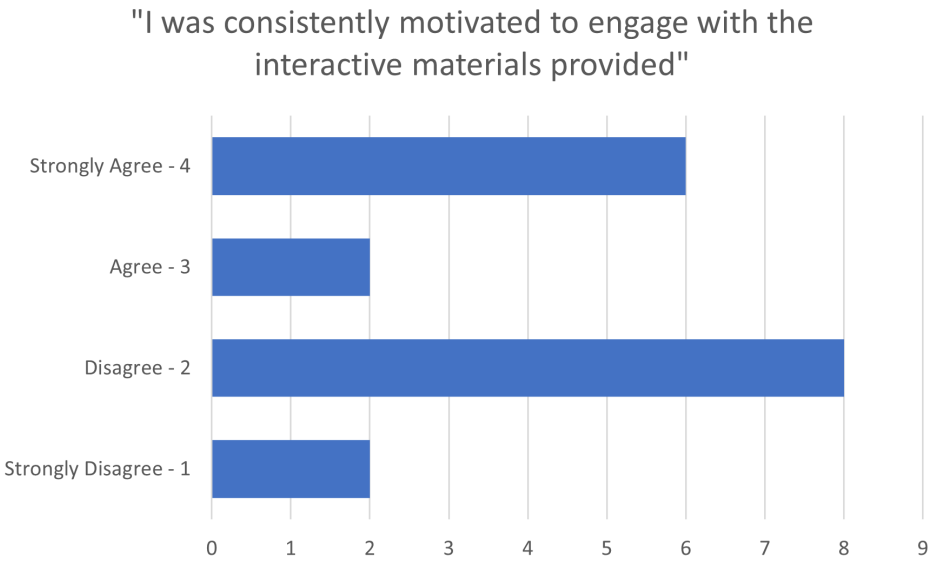

Figure 6.14: Motivation to interact with previous interactive materials

Most students also answered they found previous interaction platforms easy to navigate and accessible, with 13 students agreeing or strongly agreeing with this statement and only 5 disagreeing. On communication with teachers and students, 12 students agreed that communication between colleagues

had improved due to interactive materials, and another 12 students agreed that communication with the teachers had been improved as well.

The students were also asked in an optional question what previous interaction platform they had used, with 8 of the 18 students replying that they had previously used FeedbackFruits. Since some students enrolled in the course had once enrolled in CCEIC-I, which preluded CCEIC-II, this could explain why some already had some experience with the interaction platform.

Students were also asked to optionally give some more detailed remarks regarding their previous experiences with interactive materials, namely what they thought were their most positive and detrimental aspects. Starting with the positives, the students provided widely different answers but with a common theme of ”increased engagement”. One student found the accessibility of placing and answering questions to other colleagues to be desirable. Another student liked that such interactive materials allowed them to answer questions about the topic without having the pressure of being incorrect.

Table 6.3: Positive Aspects of Past Interaction Materials

“It allows to place questions and answer doubts from other people. I also believe that it makes the study easier.”
“More possibilities of interaction with the teacher.”
“It’s a more entertaining and motivating way to access material.”
“The answers are not right or wrong. They make you think about the topic, without the pressure of getting it completely right.”

On the other hand, the negative aspects pointed out by the students mainly revolved around interactive tasks incentivising discussion among colleagues. One student did not like to answer questions or create questions of their own, while another pointed out that coming up with questions to publish on the materials was difficult. One of the most interesting comments was that of a student who pointed out that the time students decide to begin the interactive tasks can be impactful. This student went on to mention that students who begin the activities earlier had a more challenging time completing the interaction tasks because there were yet few students to interact with.

Table 6.4: Negative Aspects of Past Interaction Materials

“When interaction involves participating in discussion threads between different colleagues, students who do the tasks early end up being ”at a disadvantage”, with the reduced number of discussion threads limiting interaction options.”
“Too many questions. Being forced to disagree with something or to put questions where there isn’t one.”
“Not very effective at testing the level of understanding”
“Sometimes is hard to come up with questions/comments for the videos and articles”

6.6.4.B Expectations and Reservations Regarding Interactive Materials

The final section of this questionnaire enquired the students who had not previously used interactive materials about what they were hoping for and their reservations about using such materials in the course. On the positive remarks, students were optimistic that the interactive materials would make learning more interesting, fun, and easier to digest. On the other hand, one student remarked that such interactions could also lead to further distractions from the teaching materials. Another student also commented that interactive materials could make it so that studying from these materials could be more difficult, despite not thinking that such would happen in this course.

6.7 Final Questionnaire

One final questionnaire[2] was also then performed at the end of the course which focused on the preparation and interactive tasks performed throughout the CCEIC-II course. The students were thus enquired on their experiences regarding:

- Preparation tasks
- Application tasks
- Interaction techniques used
- The interaction tool itself

This questionnaire aimed to provide an in-depth overview of the students' experiences with this flipped learning implementation with interactive videos and enquire the students about the interaction tool used. As this course also used interactive materials that were not strictly in video format, students were also requested to comment on them since they shared the same interaction techniques. However, as per the theme of this thesis, particular emphasis was placed on video interactions and video learning materials.

6.7.1 Participants

The last questionnaire was made available to students at the final weeks of the course and saw the participation of 55 students, out of 449 enrolled. Figure 6.15 shows the gender distribution of these students.

[2] Final questionnaire in PDF format available **here**

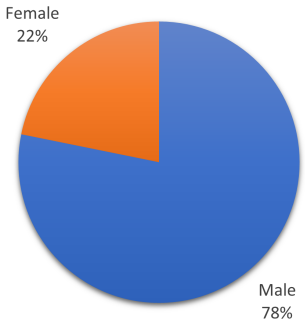

Figure 6.15: Gender distribution in the final questionnaire

6.7.2 Preparation Tasks

The participants were first asked if they had performed any preparation tasks published throughout the course. Only one student replied with ”no”, with 54 students having engaged with these tasks at least once.

These 54 students were then prompted to answer a series of questions about their opinions on the preparation tasks. This inquiry covered the preparatory tasks more broadly and then covered video and text materials independently. The questionnaire ended with a section comprising optional open-questions where the students could provide comments with more detail.

When enquired about these preparation tasks, the large majority of students strongly agreed that these tasks were able to motivate reflection and discussion on the topics covered, with 33 out of 54 students agreeing with this statement.

Additionally, 27 students strongly agreed that the preparation tasks fostered more frequent and better communication with the teachers, a statement agreed by 50% of the enquired students. Moreover, most students (23 students) also strongly agreed that communication with students was improved and made more frequent because of these tasks.

The participants were then asked how much each type of preparation material (videos or text documents) captivated them during their studies. While 31 students (57.4%) strongly agreed that video materials were captivating, text documents saw more mixed opinions. The most common rating for the sentence ”The textual preparation materials (scientific papers, and other texts) were captivating” was a 2 on a 4-point Likert scale, with 19 students (35.2%) providing this answer. However, more than half of the students (51.8%) still either agreed or strongly agreed that textual preparation materials were captivating as well.

Overall, when prompted to answer whether they would like to see such preparation tasks implemented in future courses, 37 students (68.5%) strongly agreed.

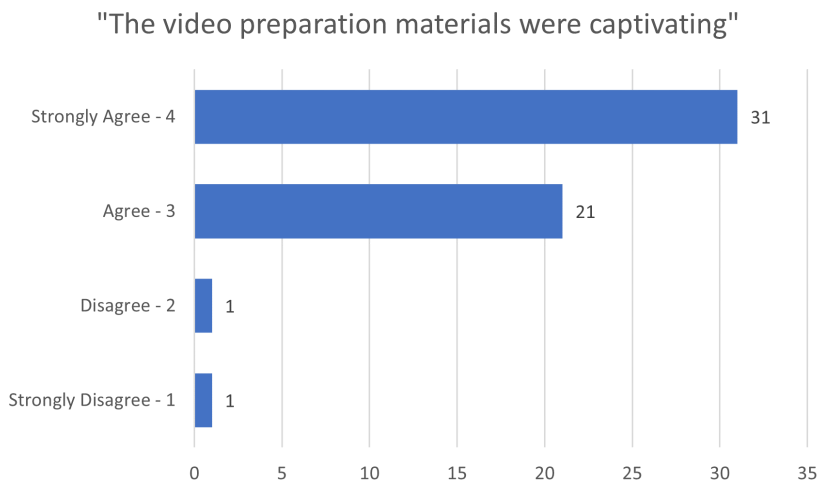

Figure 6.16: Video preparation materials rated on how much they captured student attention

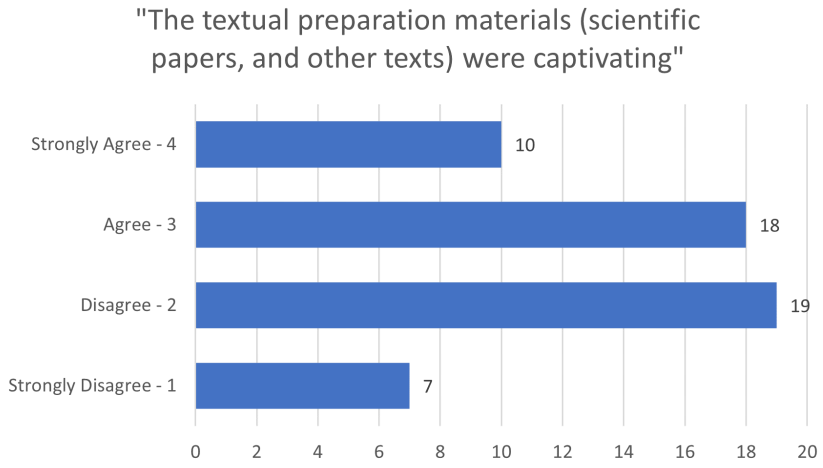

Figure 6.17: Textual preparation materials rated on how much they captured student attention

6.7.2.A Video Preparation Materials

Regarding the video preparation materials of the preparation tasks, 26 students (48.1%) strongly agreed that the annotations were sufficiently spaced out, and another 20 students (37%) also agreed. Only 8 students disagreed with the previous statement.

Additionally, 36 students (66,7%) either agreed or strongly agreed that the annotations did not reduce the visual clarity of the video. However, 15 students disagreed with this statement, and 3 strongly disagreed.

Furthermore, 18 students (33.3%) strongly agreed, and 21 additional students (38.9%) agreed that the video annotations did not distract from the contents of the videos themselves. Despite this, 10 students replied in disagreement, and 5 strongly disagreed.

Lastly, students were asked whether creating annotations disrupted the flow of the video, a question that received more mixed opinions. While 16 students (29.6%) strongly agreed and 17 students (31.5%) agreed, there was also a sizeable group of students disagreeing or strongly disagreeing (38.9%).

6.7.2.B Textual Preparation Materials

Even though it was not the main focus of this thesis, students were also questioned about the textual preparation materials (such as documents and scientific articles) included in the preparatory interactive tasks. The reasoning behind this decision related to how similar the interaction methods were to the ones used in the video tasks.

The students' perspectives on textual materials did not change much from the video materials. The majority of students (79.6%) agreed or strongly agreed that the annotations were well spaced out in the textual materials and that the annotations did not impact the readability of the documents.

Furthermore, 81.5% of students agreed or strongly agreed that the annotations did not distract from the texts they were reading, and 70.4% had the same opinion regarding the creation of annotations not disrupting the act of reading.

6.7.2.C Final Remarks

Lastly, the students were asked for some final remarks regarding the preparation tasks used throughout the course. Like the previous questionnaire, these open questions were optional and could be skipped. When asked what they thought was the best aspect of these preparation tasks, one of the most common answers was the videos themselves, with 10 students providing this answer.

Another positive of preparation tasks noted by the students was that they felt like the tasks made them think when watching or reading the materials, with 9 students highlighting this aspect.

Other positives remarks were the possibility of interacting with other students in these tasks, going to the classes with prior knowledge, the large deadline to perform these tasks, how intuitive the preparation tasks were, and the high degree of flexibility to perform them (by being able to them at any order). One student also commented that the preparation tasks were improved since the curricular unit CCEIC-I, demonstrating a preference for more learning materials with fewer interaction tasks in each one. Some notable student comments are highlighted in Table 6.5.

Table 6.5: Positive Aspects of the Preparation Tasks

"They give us a really good insight over the topic of the week. For me, it's more interesting to go to class and discuss the materials or practice what I already learned, over learning them for the first time."
"For the most part they are relatively relaxing to do, just watch a video, answer some questions and you're done."
"It promotes the motivation of learning and critical thinking, instead of just reading/watching."
"Autonomy and a safe space for asking questions."
"It allowed me to better understand what those concepts were and to fully grasp its knowledge."
"I think that they provided a really good way to interact with the material and forced us to think about what we were learning (at least that was the case for me)."
"I think annotations are a good way to incentivize participation both in videos and papers, and improved a lot in relation to CCEIC-I where sometimes we were asked an overwhelming amount of questions. I would rather have 2 papers with 3 annotation requirements each rather than one with 6."
"They were very interesting videos and articles. They talked about things we knew already but it is good to remind ourselves about it since these topics are very important for our lives!"
"They were a pretty novel form of "homework" and weren't too harsh to get through."
"Understanding the subjects at my own pace."

When asked about the negative aspects of the preparation tasks, the most common ones outlined by the students were the scientific articles included in some of the preparation tasks. The 11 students who provided these answers remarked that some articles were too long or too technical, exhausting the students before performing the interaction tasks. Moreover, 4 students also noted that the videos were, in their opinion, too long, and 5 students found the interaction tasks themselves too numerous and taking a long time to complete.

An additional 2 students also remarked that some outside factors detracted from the preparation tasks, such as having to rush through the preparation tasks due to pressure and work from other curricular units. Other students also commented that they found the interactions too forced since students felt compelled to interact with their colleagues and create annotations even when they thought they had little to add. Furthermore, one interesting remark was that 3 students felt replying late to an interactive task was also detrimental, as most students had already exhausted the majority of discussion points, and it was hard to find additional discussion topics. Finally, one student also found the annotation boxes to be distracting, choosing first to perform the interaction tasks and finally watching the video in its entirety. The most notable negative aspects outlined by the students are displayed on Table 6.6.

Table 6.6: Negative Aspects of the Preparation Tasks

"Some tasks really feel like a chore, especially those that require you to research in the middle of a video, or when it's "give 3 examples" (sometimes those are hard and take me 5+ minutes just for that part)."
"Sometimes we had to post a contribution on a 2min video. If you are not one of the first people to do so, you'll basically have to come up with something."
"Having to come up with discussion topics is not interesting at all, especially after 200 colleagues already exhausted every possibility in the video/doc."
"Most of the problems come from pressure from other UCs to have everything done, so sometimes I had to rush some tasks as to not let things accumulate."
"Sometimes, the scientific papers and articles, even if very interesting, were very long and dense, which made them hard to read all the way through and still have energy to answer to all of the questions."
"The annotations during the videos were distracting, usually I focused on answer them first and then watch the video normally."
"The necessity to add contributions. Sometimes the video was already cluttered with annotations and I had to skim the video some times to find something new to add."
""Add your own contributions" task does not make sense, since people have to post something even when they have nothing to add."
"Some tasks had an overwhelming number of question cards that detracted from the content."
"The length of some videos."

As a final open question, students were asked if they had any suggestions to improve these preparation tasks. Analog to what was mentioned in the question on the more detrimental aspects of these tasks, several students suggested less lengthy preparation materials, fewer interaction tasks per learning material, and to use more videos instead of articles.

Issues associated with starting tasks either earlier or later also came up again in the answers to this question. Two students who usually started the preparation tasks as soon as they were made available commented that they could not complete all the interaction tasks of a video or document because there were no students to interact with yet. One of these students suggested the creation of more teacher annotations so the students could reply to those even when there were no student annotations yet created.

Lastly, one student also found reading the video annotations distracting from the video itself and suggested that interactions were not mandatory to reduce the number of annotations in the videos.

6.7.3 Application Tasks

On the second part of the questionnaire, students were asked about the application tasks instead. Just like the previous part, it began by asking the students if they had engaged with the application tasks at any point; 49 out of 55 replied with "yes". These 49 students would then be enquired about their experience and opinions regarding these tasks.

The main difference between the videos used in the preparation tasks and application tasks was that the application tasks used videos created by the instructor from scratch. Since the nature of these videos differed from the ones used before, students were asked their opinions regarding them.

Starting with the pace of the instructor's videos, 35 students (71.4%) strongly agreed that the videos' pace was adequate, and an additional 9 students (18.4%) agreed. Moreover, when asked whether these videos had managed to captivate their attention, 27 students (55.1%) strongly agreed, and another 16 students (32.7%) agreed.

Furthermore, 35 students strongly agreed (71.4%) that the videos had good visual quality, and an additional 12 students (24.5%) agreed with this statement. Regarding their audio quality, 31 students (63.3%) strongly agreed that the videos' audio was clear and perceptible, with only 1 student disagreeing and another strongly disagreeing with this statement.

The majority of students (79.6%) strongly agreed that the videos successfully explained their subject matters, with only 4 students disagreeing.

When asked open questions about the positives of the application tasks, the feedback from students was very similar to the input provided for the preparation tasks. One other remark, however, was that students appreciated the flexibility the application tasks gave them to ”skip” a class and still be able to learn at home while also covering the same topics covered in class and performing the same tasks as well. However, one student still noted a clear preference for the in-class activities.

Table 6.7: Positive Aspects of the Application Tasks

“They were suitable for the content that was given on the theoretical classes and also were quick to make at home.”
“They make it possible for people who can’t go to class to still have the grade.”
“It is well correlated with the preparation material, and the guidance was very clear.”
“The fact that we could have instantaneous feedback and it was ok not to know an answer.”
“I could go at my pace and still learn.”
“Only did one but they were ok, still prefer the class ones.”

Finally, when asked about the more negative aspects of these tasks, the students' opinions were once again very similar to those provided on the preparation tasks, albeit with minor differences. Like in the preparation tasks, students again mentioned they found some videos to be too long and that the annotations appeared too frequently. One student also remarked that the activities were too repetitive, and another that they felt more of a chore compared to the preparation tasks.

Moreover, one student commented that questions or tasks that had students click off the video to perform additional research broke their train of thought and the flow of the video.

Furthermore, one student also remarked that questions with only one answer available served no purpose. While such questions were usually presented to highlight a teacher annotation or prompt student reflection, the student preferred to have more options to give their own input so as to give a more sincere answer.

Table 6.8: Negative Aspects of the Application Tasks

"Questions of the collages appearing all the time."
"Too repetitive tasks sometimes."
"Some of the preparations were actually more effective than application tasks that, most of the time, were more like a chore unlike the preparations."
"I really dislike questions that make me open another tap to research things and those that ask for X examples, those break the train of thought and the flow of the video is completely lost."
"Sometimes the videos were too long but I enjoyed them nonetheless."
"Some questions don't really make us reflect, also heavily dislike questions where the only answers are "Done", "Yes" and "Okay". Why are they being asked if you don't want an honest answer? They serve no purpose."

6.7.4 Interaction Techniques

In this section of the questionnaire, students were asked about the interaction techniques (open questions, multiple-choice questions, creating annotations, and replying to annotations) used in the preparation and application tasks.

When enquired about which interaction method was the most enjoyable to engage with, multiple-choice questions were the most popular answer, with 69.1% of students. This was followed by open questions (12.7%), with creating annotations (5.1%) and replying to other students' annotations (5.1%) being the less popular answers.

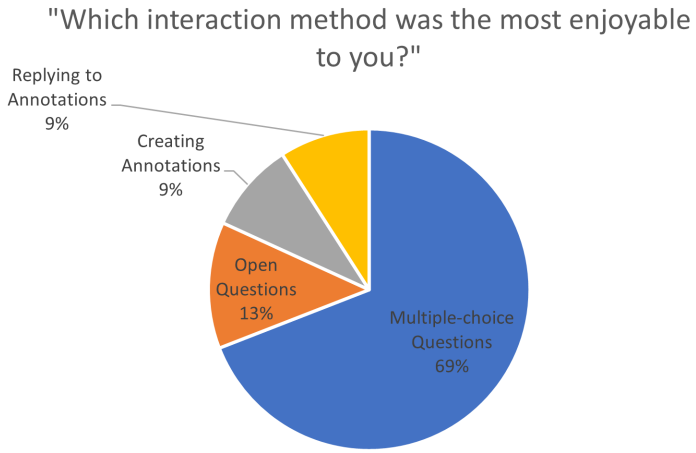

Figure 6.18: Interactions methods students liked engaging with the most

Afterward, students were then asked about which interaction technique, in their opinion, promoted a better learning experience. The two most popular answers were multiple-choice questions (34.5%) and open questions (32.7%), which also highlighted that while students preferred multiple-choice questions, they regarded open-choice questions as valuable to their learning process. The least popular answers were replying to student annotations (21.8%) and creating annotations (5.5%). Only 5.5% of students responded that they preferred to watch the videos or read the documents without interacting with them.

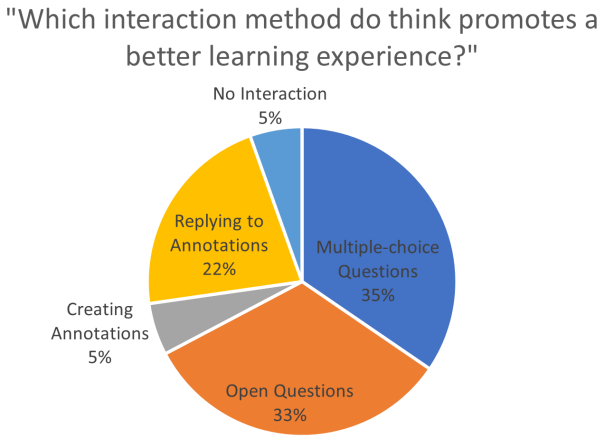

Figure 6.19: Interaction methods students found to promote a better learning experience

6.7.5 Interaction Tool

In the last section of the questionnaire, students were asked about the interaction platform itself. When asked whether accessing the platform was easy and without issues, most students (76.4%) strongly agreed, and an additional 18.2% agreed. Moreover, 76.4% of students strongly agreed that learning how to use this system was quick and easy, and another 18.2% agreed with this statement.

Students were also asked whether they had encountered any technical issues, to which 58.2% strongly agreed that the interactions could be performed without any problems. Only 4 students disagreed, and another 3 strongly disagreed with this statement.

As to which issues students mostly encountered, the most reported issue was the grades not updating in real-time, often requiring a refresh. Two other students reported question cards disappearing or annotations not being created. One other student also mentioned that it was possible to be locked out of questions by accidentally skipping them, which would also forgo the grade associated with that question. Additional issues reported were the slowness of the platform, annotation and question boxes overlapping each other, and the mobile version of the platform being hard to use.

However, most students (89.1%) strongly agreed that teachers provided timely and effective support regarding technical issues, and another 7.3% agreed with this statement.

6.8 Students' Interaction Data

Throughout the course, the FeedbackFruits interaction tool amassed data regarding the students' performance and frequency of use. The data collected during the course was then exported and analyzed and will be presented in this section. As previously stated, only students that had consented to their data being collected and analyzed were considered for this analysis, and all other students' data was not accounted for. Thus, 37 students were considered for this analysis, having been the ones to consent to this data collection and analysis out of the 449 enrolled students.

The data that was able to be exported by FeedbackFruits pertained to:

- How many students viewed each interactive material
- How many students left comments in the interactive materials
- How many students answered the questions incorporated in the materials
- The grades associated with each interactive material

All these types of data were analyzed by task and grouped by week, showing the weekly evolution of student engagement and performance throughout the course. A bonus week was also accounted for in the preparation tasks, as one was provided to the students after week 7.

6.8.1 Viewing the Materials

Starting with the viewership of the interactive materials, Figure 6.20 shows how it evolved throughout the weeks. Each week's bar corresponds to one of the interactive materials available for that specific week. Consequent graphs may have a different number of weekly interaction materials due to some not having commenting tasks or embedded questions.

As shown on Figure 6.20, week 1 started with perfect student attendance for the preparation tasks and slowly diminished throughout the course. However, the viewership of the interactive materials never fell below 31 students, the lowest point achieved during the sixth week.

Regarding the application tasks, student viewership was much lower because it was offered as an alternative to the in-class tasks. Students who had performed the tasks in the class were not required to complete them at home to get their corresponding grades, leading to a reduced viewership of these tasks.

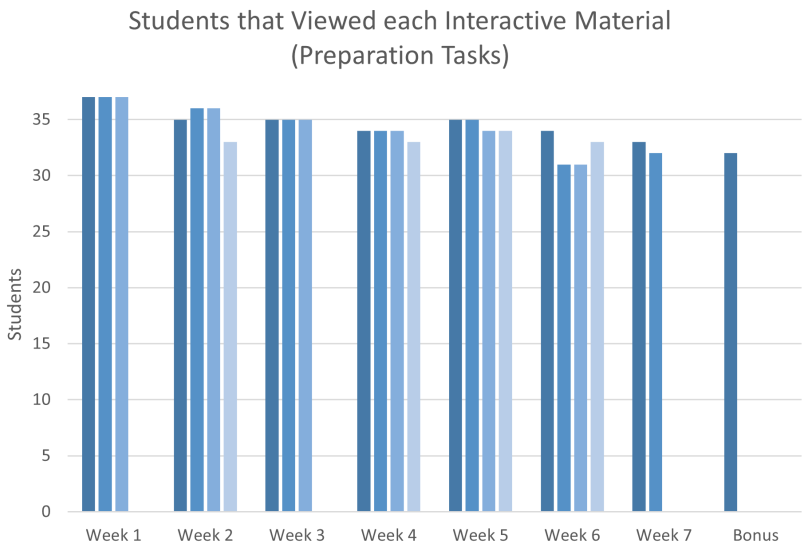

Figure 6.20: Students viewing the preparation tasks per week

Figure 6.21 shows how many students viewed the application materials per week. Like in the previous figure, each bar corresponds to an interactive material, whereas the first week was an exception due to having two interactive materials available. While student viewership started with 7 students on the first week, it diminished until week 3, when only 3 students interacted with the application tasks. However, student participation in these tasks slowly rose until the end of the course, ending with 12 students on week 7.

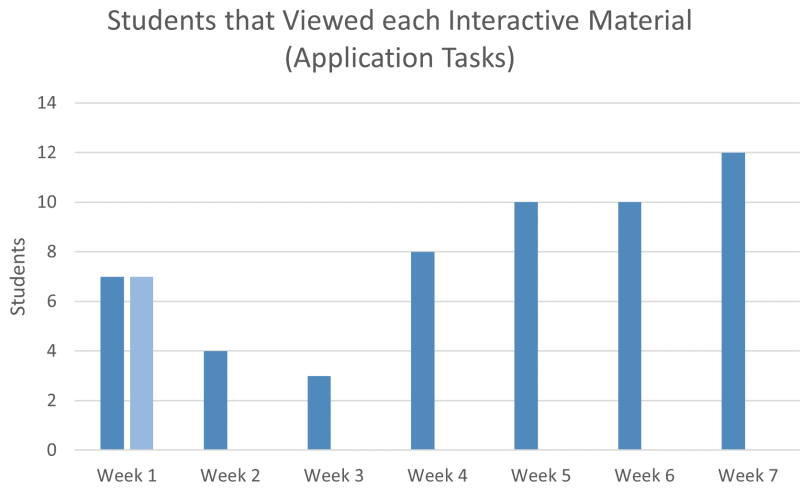

Figure 6.21: Students viewing the application tasks per week

6.8.2 Student Comments

When analyzing the frequency that students completed tasks associated with comments on videos, FeedbackFruits' exported data did not distinguish between the annotations created by students and replies to other annotations. Thus, both the creation of annotations and replies were analysed together in the same category.

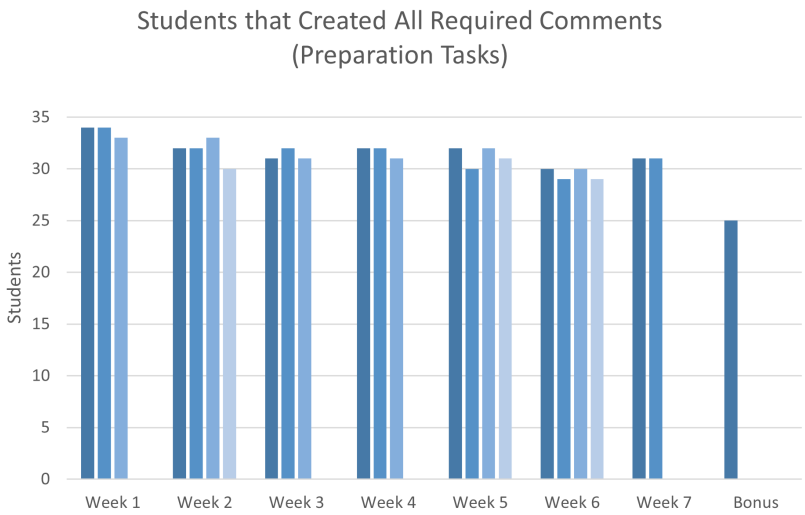

Figure 6.22: Students' comments on preparation tasks per week

Figure 6.22 shows how frequently students completed annotation and reply tasks for each preparation material. This frequency was consistently slightly lower than the student viewership of each interactive material, implying that there was always a small group of students who did not complete the creation of annotations or replies. This frequency slightly decreased through the weeks, reaching a low of 25 students in the bonus week.

Tasks pertaining to the creation of annotations and replies were only present in the materials of the first four weeks of the application tasks. However, the results were the same as in the preparation tasks. Student attendance was, on average, lower than the viewership per task. The only exception was the fourth week when all 8 students who viewed the application task also completed all its annotations and replies.

6.8.3 Embedded Questions

FeedbackFruits also stored data on how many of the embedded questions students answered per interaction task. Akin to the students' comments, FeedbackFruits' exported data did not distinguish between multiple-choice and open questions, thus, both were analyzed together. Figure 6.23 shows how many students completed all the embedded questions in each preparation material.

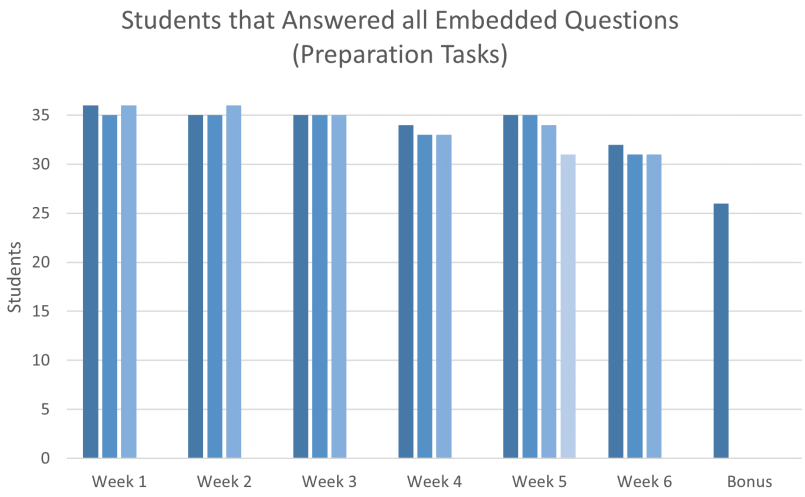

Figure 6.23: Student engagement with embedded questions on preparation tasks per week

Similarly to the students' comments, the frequency at which embedded questions were completed was slightly lower than the viewership of the interactive material. However, more students completed all presented embedded questions than the annotations and replies, showing a higher willingness to engage with the embedded questions.

On the application tasks, the same also applied. Student engagement was equal or higher than the annotation-related tasks, albeit slightly lower or equal to the number of students who viewed the interactive video.

6.8.4 Students' Performance

Lastly, an overview of the students' average grades on the preparation and application tasks will be presented on both Figure 6.24 and Figure 6.25. On both types of tasks, students achieved high performing grades, with the preparation tasks having a consistent student average performance of over 90%, with the only exception being the bonus week with an average grade of 84.3%. The application tasks on two interactive materials achieved an average grade of 100%, but also went as low as an average of 68.8% on week 2.

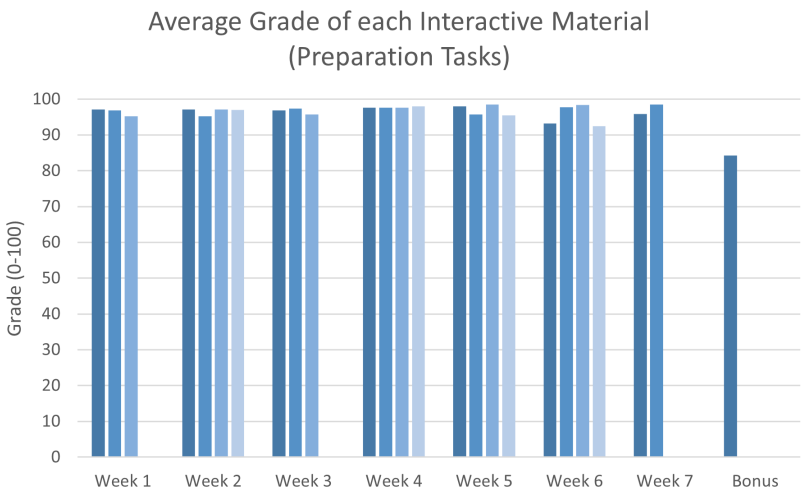

Figure 6.24: Average grades of preparation materials per week

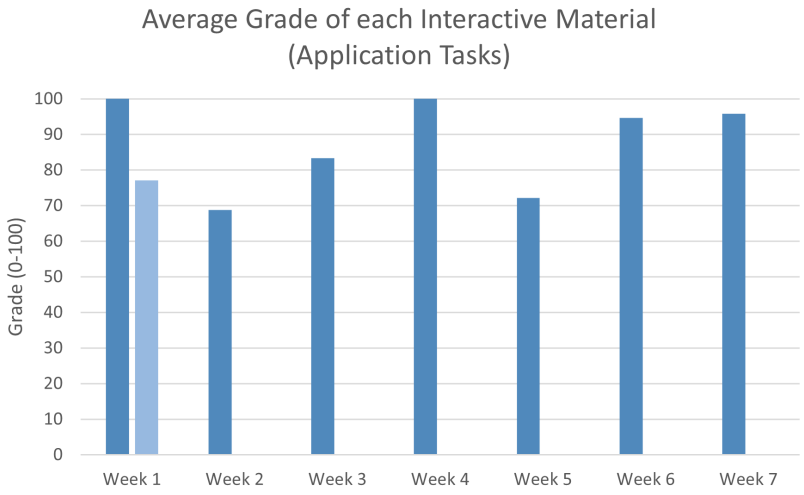

Figure 6.25: Average grades of home application materials per week

6.9 Insights from Participant Observation

Before answering the proposed research questions, a few insights from the participant observer will be presented. These were the researcher's perspectives while having been exposed to the same curricular unit, interactive materials, interactive techniques, and interaction platform.

Starting with the interaction platform, both Moodle and FeedbackFruits could be accessed and used without any issues. The interface was easy to navigate, and interacting with the materials was intuitive and, thus, easy to learn how to use. However, video and text materials with annotations very close

to one another would cause them to overlap, making them harder to read and select. Additionally, FeedbackFruit's mobile interface was not as comfortable and much slower, and creating annotations was made harder due to a tinier text box.

Regarding the interaction in the videos, watching them was a process in which one had to be much more attentive. In addition to the embedded questions placed throughout the videos, one also had to keep in mind to carefully listen to the contents of the video to contribute to group discussions and to create an annotation of one's own. All these interactions made each video more memorable and allowed its contents to be easily recalled when later discussed in class.

On the accessibility of these interactive videos, since there was no immediate deadline, the interactive tasks became very approachable and never done any pressure. Additionally, the difficulty of the interactive tasks was never great, as most challenged students to make them reflect upon the topics discussed in the videos where there was rarely a single correct answer. This also made the interactive tasks a much more positive environment, where students could present their own ideas and debate with one another, free from any concerns of correct or incorrect answers.

While on the topic of student discussions, from a personal perspective, it became the most exciting aspect of interactive tasks. Several annotation threads would eventually initiate discussion threads where many students would also reply and give their ideas and arguments. Such discussion threads would expand on the topics covered in the videos, connecting them with other real-world situations and even providing additional knowledge from talking to one another.

Additionally, the teacher's annotations throughout the videos also accomplished a similar effect by providing extra insights, further connecting the videos' contents to the contents of the course. Furthermore, it also made watching videos (made by third parties) a more personal and ḧuman" activity. It allowed a back-and-forth between the teacher and students, in preparation videos and in the classes and home tasks, where student comments from the preparation tasks would also be discussed.

However, the interactive videos and tasks were not void of issues. As previously outlined by the students in the second questionnaire, the time at which students initiated the interactive tasks was crucial in determining how their video annotation tasks would be approached.

Starting an interactive material early (from the day it was published to at most one day after) would mean few students had yet interacted with the materials, leaving very few student annotations created and thus few annotations that could be replied to. However, starting the tasks earlier meant the students had more freedom to start any annotation of any topic they found interesting throughout the video or document. Regrettably, the full benefits of the student discussions could only be attained a few days after the materials were published, when plenty of students had finally created new annotations and discussions.

In contrast, starting an interactive material later also proved to be a challenge of its own. While it

would imply that there were plenty of discussion threads to engage with, it would make it much harder to create a new one from scratch since a large number of the topics of the videos or documents would have already had an annotation associated with them. The students would, therefore, have to be more creative to add an interesting contribution. Despite students being divided into interaction groups to reduce the overwhelming number of annotations per material, this was still a significant issue.

Overall, as a participant observer, the interactive materials were very enjoyable to learn with and to return to every week. Since the preparation materials were always discussed in the class that followed, there was always an underlying motivation to perform them before class since they successfully introduced the topics before class while also providing opportunities for group discussion.

6.10 Discussion

This final section will provide answers to the research questions initially proposed at the beginning of the chapter based on the questionnaires, data, and insights previously presented.

6.10.1 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.

6.10.2 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.

6.10.3 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.

6.10.4 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

Contents

This section will outline the most relevant conclusions taken from the research, as well as present the limitations of the research. It will finalize by outlining future work to be done on the same topic.

7.1 Main Contributions

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.

7.2 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.

7.3 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 [54] (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.

7.4 Final Acknowledgements

A portion of the contents of this document was submitted for publication detailing a systematic literature review on the same topic of flipped learning with interactive videos, authored by João Fonseca, Miguel Mira da Silva, and Sofia Sá [55].

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A

Articles Obtained from Systematic Literature Review

Table A.1: Articles obtained from the research and respective categories

Articles	Country	Area of Education	Research Method
[42]	Spain	Higher education, telecommunications engineering	Quantitative and qualitative analysis of the usage of embedded student questions
[32]	Germany	Higher education	Quantitative analysis of students' self-evaluation of the learning process
[49]	China	Secondary education, Mathematics education	Quantitative and qualitative analysis of students' and teachers' preferences, and effects on recall and application

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Table A.1 – continued from previous page

Articles	Country	Area of Education	Research Method
[7]	China	Higher education	Quantitative analysis of students' performance and their acceptance and perception of the learning method
[33]	Germany	Higher education, medical education	N.A.
[47]	Oman	N.A.	N.A.
[45]	Malaysia	Higher education	Quantitative data analysis of students' survey answers
[15]	Ecuador	Higher education, Mathematics education	Qualitative analysis of students' satisfaction
[30]	France	Higher education	Design-based research
[27]	Germany	Higher education, medical education	Quantitative and qualitative analysis of videos and students' preferences
[40]	China	Higher education, English education	Quantitative and qualitative analysis of students' performance and preferences
[34]	Australia	Higher education	Quantitative analysis of user logs
[46]	Israel	Higher education	Quantitative analysis of students' enrollment and performance
[9]	Turkey	Language education	SLR of major interactivity tools
[21]	USA	Higher education	Quantitative and qualitative analysis of students' performance and preferences
[35]	United Kingdom	Higher education, computer science education	Quantitative analysis of in-video questionnaire data
[37]	Spain	Higher education, hydrology and irrigation education	Quantitative analysis of students' video participation
[4]	Canada	Higher education	Quantitative and qualitative analysis of students' performance and perception
[36]	United Kingdom	Higher education	Quantitative and qualitative analysis of students' in-video questionnaire responses and perceptions
[39]	Netherlands	Higher education, molecular biology education	Quantitative analysis of students' performance, and answers to surveys and questionnaires

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Table A.1 – continued from previous page

Articles	Country	Area of Education	Research Method
[5]	Spain	Higher education, computer science education	Quantitative and qualitative analysis of students' interactions and satisfaction
[6]	Australia	Higher education, legal education	Case study research of annotation and discussion methods
[41]	USA	Higher education, pediatric emergency medicine education	Quantitative analysis of students' participation and performance
[20]	Taiwan	Higher education	Qualitative and quantitative analysis of students' performance and comments
[28]	Australia	Higher education	Quantitative and qualitative analysis of students' preferences and comments
[17]	Taiwan	Elementary education, Mathematics education	Quantitative analysis of students' performance
[26]	Australia	Higher education	Quantitative and qualitative analysis of surveys and interviews
[43]	USA	Higher education	Quantitative and qualitative analysis of students' performance and self-assessment
[18]	Japan	Higher education	Quantitative analysis of students' questionnaire answers regarding the technology employed
[31]	South Africa	Higher education, teacher education	Qualitative analysis of teacher's preferences and perception
[19]	China	Higher education	Quantitative and qualitative analysis of students' satisfaction and performance
[29]	China	Physical education	Qualitative analysis of students' perception and preferences
[8]	Germany	Higher education	Qualitative analysis of users' perspectives and expectations
[48]	Switzerland	Higher education, engineering education	Quantitative analysis of video interaction patterns
[38]	USA	Higher education, biology education	Qualitative research into the implementation of interactive video vignettes
[44]	Saudi Arabia	Higher education, medical education	Quantitative analysis of viewership data