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Unleashing Video Benefits: Student Perceptions in a Flipped Programming Course

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Abstract

More STEM courses are transitioning from traditional to flipped classroom models due to their emphasis on student-centered learning. In this approach, students are expected to prepare certain course materials before each lecture. While this model has several advantages for student learning outcomes, various factors can influence its effectiveness. Key factors include what materials students study before class, how they are presented, and their quality. Students may lose interest in the preparation component if the materials are not engaging, clear, or relevant, leading to dropouts or lower academic outcomes.

Among various methods for conveying this material, recorded videos by instructors are often a preferred resource for students. However, not all videos can be designed similarly; some are intended for topic descriptions, while others instruct techniques using practical examples. Given the crucial role these videos play in student learning and outcomes, it is important to understand students' perceptions of the benefits of video materials in a flipped classroom setting.

In this paper, we present a case study of a flipped programming course where students were introduced to two types of videos: 1) concept videos in which the instructor explains programming concepts and 2) coding videos that feature the instructor demonstrating these concepts through live coding examples. Given the importance of student feedback on the materials, this paper aims to address the following research question: What are students' perspectives on the two types of videos used in the programming course?

We collected data from 43 undergraduate students for 7 weeks to address the research questions. Participants completed a short perception survey of 7 questions: 5 Likert scale items and 2 open-ended questions. The Likert scale items assessed student feedback on the videos' clarity, relevance, usefulness, engagement, and learning effectiveness. The open-ended questions captured students' perspectives on what they liked or disliked about the videos. Each student voluntarily answered the perception survey weekly after watching the two videos.

Using a multi-method approach, we analyzed the data with the Wilcoxon signed-rank test for related samples for the Likert scale questions. At the same time, the open-ended responses were examined for themes related to students' likes and dislikes. The results offer valuable insights for programming courses, highlighting key factors that instructors should consider when designing future materials. Moreover, the results highlighted the videos that the instructor may revisit to improve the course’s continuums.

Introduction

STEM courses benefit from learning material in and out of the classroom and flipped classroom models directly integrate that into classes. One of the biggest strengths of flipped classroom models is allowing students to learn at a pace more suited to them [1]. Video recordings by the course instructor allow students to access learning material according to their planned schedule

[2]. Also, rewatching material through video lectures can provide flexibility and less fear associated with one-time lectures [3]. With these flexibilities, students may learn more efficiently without their performance being hindered by insufficient time to understand a lecture's material [4]. Although many available online resources like YouTube and podcasts are found effective for students' learning, material from the instructor is mostly deemed helpful in students' learning experience [5]. One noted issue with other available resources is the varying structure of these videos, as they are not designed for single-course purposes. For example, some of these videos could be intended for topic descriptions, while others focus on teaching technical skills through practical examples [5], disrupting the learning pace. Besides student benefits of flexibility and readily available materials, flipped classroom models allow instructors to review students' readiness before re-adjusting the lecture material. Instructors can execute the quizzes, identify the knowledge gaps left in videos, and use class time to focus on parts students generally struggle to understand [6].

With these benefits of providing students with an easier learning experience at their own pace by allowing them to pause and review what they understood [1], performance could be negatively impacted if not designed properly [2]. For example, negative performance occurs if the material is not engaging [7], [8] or the instructor needs to engage more with students outside the video lectures [9]. The lecture material and the skills learned through it must also be appropriate in a flipped classroom model, as students may learn less efficiently if the material were better taught in a traditional classroom model [10]. Courses, especially conceptual courses that promote technical skills, can take advantage of the flipped classroom model. However, these videos must be designed according to the course material and in a way that helps students learn before an in-class lecture. The benefits of the flipped class model are closely tied to how the videos are prepared and presented to students [6], [11]. Like user experience studies, examining students' perspectives on varying aspects of videos could effectively identify potential issues [12].

This study explores the effectiveness of such videos created for a flipped programming course from students' perspectives. Student feedback is vital for these types of lecture materials so they can clarify the lecture material and provide insights on how and what to improve in the provided lecture materials. In this study, the students were introduced to two types of videos before the class: 1) concept videos in which the instructor explains the course topic, and 2) coding videos that feature the instructor demonstrating the concepts through live coding examples. The study aims to answer the research question: What are students' perspectives on the two types of videos used in the programming course?

Literature Review

Prior literature highlights various ways video lectures have been used to promote students' learning. These studies highlighted how videos enhance learning by providing explicit, interactive, and engaging content [13] in flipped [14], [15], [16], and otherwise online learning environments [17], [18].

Literature suggests that effective educational videos can promote various benefits in students' learning in diverse educational settings, from K-12 classrooms to professional training environments [19], [20]. For example, they can help manage cognitive load, promote engagement, and integrate active learning to maximize student outcomes [21]. In K-12 education, videos are supplementary materials for science experiments to bridge abstract concepts with real-world applications [22]. Additionally, in corporate training, instructional videos are essential for onboarding, skill development, and compliance training [23]. Researchers have also discussed the supplemental nature of the course videos. For example, in a study, Handaya and colleagues discussed the effectiveness of videos with online classes [24]. The authors demonstrated that videos helped students perform better initially, but live instruction remained crucial for skill mastery. In another study, Fahrurozi and colleagues used video as a visual aid [25]. Results of the study showed that well-designed instructional videos not only improved student comprehension and engagement but also made them a valuable resource for complex topics like programming [25], [26].

Most literature on flipped courses discusses the importance of high-quality, well-integrated videos for fostering active learning and student success [27]. In flipped classrooms, videos are commonly used to introduce core concepts before class, allowing students to review material at their own pace and freeing up in-class time for interactive problem-solving and discussions [28]. For example, in a study, authors utilized flipped classrooms [29]. The qualitative content analysis revealed that flipped classrooms positively impacted students' motivation and interaction [29], [30]. However, challenges such as video quality and instructor readiness were also highlighted. To mitigate the challenge, the literature provides practical guidelines for educators on designing and utilizing videos effectively [31]. For example, the authors emphasized that well-structured videos enhance student engagement and learning outcomes. Patterns of video usage and their corresponding impact on students' engagement have also been studied [32]. Beatty and colleagues found that video usage patterns and students' engagement with videos varied widely. There was no strong correlation between video viewing and academic performance. However, it is reported that students' satisfaction with videos was linked to more frequent viewing.
Based on the existing literature on the importance of the quality of videos and students' perceptions of the same, this study focuses on exploring students' perspectives on different types of instructional videos in a flipped classroom.

Research Design and Methods

The study uses a multi-methods research design to answer the research question using quantitative and qualitative data and analysis. We chose the multi-method approach to explore students' perspectives on different types of videos during the course topics.

Site and Participants

The data were collected from 43 undergraduate engineering students enrolled in a C++ programming course at the University of Florida (a large R1, southeastern university) during Fall 2024. The students voluntarily participated in the study and were not awarded any credit or incentive to provide the data. The course introduces the students to various topics for structured and object-oriented concepts. The course focuses on students' problem-solving and computational thinking skills through engineering problems. To provide more hands-on experience to students during the class, the course is designed using a flipped class model, where each week, three phases are conducted: 1) Before the class, students prepare for the upcoming class by watching videos. 2) During the class, students practice the learned concepts through hands-on exercises, and 3) After the class, students focus on solving more challenging homework problems related to the topic. This study explores students' perspectives on the videos they watched before coming to the class. Students were introduced to two types of videos

1) Concept videos: In these videos, students were introduced to the week's topic in a lecture video. In the video, the instructor conceptually explained the programming topic by discussing the details of concepts for about 30 minutes, and
2) Coding videos: In these videos, students were exposed to the syntax and semantics of the programming topic. The instructor demonstrated the week's topic using simple examples and described the coding process using a live coding approach for about 20 minutes. The instructor also explained the basic functions students could use during class time while solving the in-class problems.

Data Collection and Measures

In this study, we explored students' perceptions of the two different kinds of videos they watched before coming to the class for hands-on experience with the programming topic. The data was collected for eight programming topics (7 weeks), where videos were available to students each week through the course management system. The eight topics are Arrays (A), Structures and Classes (SC), Constructors and other tools (C), Operator overloading (OO), Strings (S), Pointers (P), Inheritance (I), and Polymorphism and Virtual functions (PV). Students were asked to complete a small survey describing their perception of each video. Each participant had about a week to answer the survey questions after watching the videos (concept and coding videos) that were provided as the main study materials. Table 1 presents the survey items.

Table 1: Survey items for the study

Concept Video	Coding Video
Please rate the Module *[#]* lecture video on *topic]* - Clarity of material	Please rate the Module [#] live-coding video on *topic]*- Clarity of material
Please rate the Module *[#]* lecture video on *topic]* – Usefulness of material	Please rate the Module *[#]* live-coding video on *topic]* – Usefulness of material
Please rate the Module *[#]* lecture video on *topic]* - Relevance of material to course needs	Please rate the Module *[#]* live-coding video on *topic]* - Relevance of material to course needs
Please rate the Module *[#]* lecture video on *topic]* – Engagement with material	Please rate the Module *[#]* live-coding video on *topic]* – Engagement with material
Please rate the Module *[#]* lecture video on *topic]* – Learning from the material	Please rate the Module *[#]* live-coding video on *topic]* – Learning from the material
What do you like in the Module *[#]* lecture video on *topic]*	What do you like in the Module *[#]* live-coding video on *topic]*
What do you dislike in the Module *[#]* lecture video on *topic]*	What do you dislike in the Module *[#]* live-coding video on *topic]*

The survey comprised 7 questions, where the first 5 questions targeted students' perceptions of various aspects of video effectiveness and quality. These aspects include clarity of the material, usefulness of the material, relevance of the material to course needs, engagement with the material, and learning from the material. In these questions, students rated their perceptions using a 5-Likert scale where 1 indicated the lack of the aspects (poor rating), and 5 indicated the presence of the aspect (excellent rating). Also, the survey had two open-ended questions, where students described what they liked or disliked in the video. As participation in the study was voluntary, a different number of students responded to the survey each week.

Data Analysis

The Likert scale data were analyzed using the statistical software SPSS V 30.0. As the sample size varied between each week, and the data was not normal, non-parametric tests were performed. We conducted the Wilcoxon Signed Rank Test for two related samples for each topic to understand which kind of video students preferred each week. The related samples are responses to concept and coding videos for each topic.

Additionally, to examine students' perceptions of what they liked or disliked in the video, we conducted in vivo coding and summarized the findings through deductive themes of like and dislike. The key likes and dislikes were identified and presented.

Results

First, we analyzed the Likert scale data using the Wilcoxon signed-rank test for each topic (8 topics of the course). The results of the tests are presented in Table 2. The related sample was established based on students' perception of each aspect of the concept and coding video survey responses.

Table 2: Students' perceptions of concept and coding videos on five aspects

	A N= 35	**SC** N= 13	**C** N= 11	**OO** N= 14	**S** N= 12	**P** N= 14	**I** N= 11	**PV** N= 11
	Clarity of the material							
Mean ± SD (Concept)	4.200 ± .833	3.846 ± .376	4.091 ± .701	4.143 ± .663	4.333 ± .492	4.214 ± .975	4.364 ± .674	4.000 ± .775
Mean ± SD (Coding)	4.171 ± .857	4.154 ± .376	4.182 ± .603	4.000 ± .679	4.333 ± .651	4.214 ± .802	4.364 ± .505	4.091 ± .302
Z	-.243	**-2.000***	-.577	-1.000	.000	.000	.000	-.447
	Usefulness of the material							
Mean ± SD (Concept)	4.206 ± .845	4.154 ± .376	4.273 ± .647	4.357 ± .745	4.417 ± .669	4.429 ± .646	4.545 ± .522	4.182 ± .751
Mean ± SD (Coding)	4.353 ± .884	4.154 ± .376	4.364 ± .674	4.357 ± .633	4.5 ± .674	4.5 ± .519	4.364 ± .505	4.364 ± .505
Z	-1.387	.000	-1.000	.000	-.378	-.577	-1.414	-1.000
	Relevance of the material to the course needs							
Mean ± SD (Concept)	4.278 ± .849	4.308 ± .48	4.364 ± .505	4.286 ± .726	4.583 ± .515	4.5 ± .65	4.455 ± .522	4.364 ± .674
Mean ± SD (Coding)	4.472 ± .845	4.385 ± .506	4.455 ± .522	4.429 ± .646	4.5 ± .674	4.5 ± .519	4.182 ± .751	4.091 ± .831
Z	-1.941	-.577	-.577	-1.414	-.577	.000	-1.732	-1.134
	Engagement with the material							
Mean ± SD (Concept)	3.857 ± .944	4 ± .577	3.909 ± .944	4.214 ± .579	4.417 ± .515	4.214 ± .802	4.273 ± .647	4.091 ± .701
Mean ± SD (Coding)	4.2 ± .933	4.231 ± .599	4.182 ± .874	4.071 ± .73	4.417 ± .669	4.286 ± .825	4.273 ± .647	4 ± .894
Z	**-2.443***	-1.342	-1.134	-.816	.000	-.302	.000	-.577

	Learning from the material							
Mean ± SD (Concept)	4.029 ± .891	3.846 ± .376	3.818 ± .874	4 ± .877	4.333 ± .651	4 ± .877	4.455 ± .522	4.182 ± .751
Mean ± SD (Coding)	4.229 ± .877	4.154 ± .689	4.091 ± .831	4.286 ± .611	4.417 ± .669	4 ± .784	4.273 ± .647	4.091 ± .701
Z	-1.941	-1.633	-1.342	-1.414	-.447	.000	-1.414	-.577

**p<.05, **p<.01*
Note: (A=Arrays, SC = Structures and Classes, C= Constructors and other tools, OO = Operator overloading, S= Strings, P=Pointers, I=Inheritance, and PV = Polymorphism and Virtual functions.

The results indicate a significant difference between the two pairs of concept and coding videos. The first significant relationship exists for structure and classes where with $Z(12) = -2.000$, $p = .046$, coding video provided more clarity of the material than concept video. Similarly, the second significant relationship exists for the Arrays topic where $Z(34) = -2.443$, $p = .015$ coding video provided more engagement than concept video. Other results are non-significant, indicating no difference between the other aspects for all other topics.

Another notable result was derived based on the descriptive statistics of all videos. The results indicate that both videos on inheritance and strings provided the most clarity with the material. For the usefulness of the material, the inheritance and pointers videos were the top choices for the concept videos. In contrast, the strings and pointers videos were the top choices for the coding videos. For the relevance of the material, the strings and pointer videos were the top choices for both concept and coding videos. For engagement with the material, the top choices for the concept videos were the string and inheritance videos, and the coding videos were the strings and pointers videos. For learning from the material, the inheritance and strings videos were the top choices for the concept videos. In contrast, the string and operator overloading videos were the top choices for the coding videos. Overall, the top concept videos in order of ranking were the inheritance, strings, and pointers videos. Similarly, the top coding videos emerged as the strings and pointers videos. In the same realm, the least preferred concept videos in order of ranking were the structures and classes and the arrays videos. In contrast, the least preferred coding videos in order of ranking were the polymorphism, virtual functions, and operator overloading videos.

On students' perceptions of each topic on both types of videos, students mentioned various factors they liked in each video. Students liked the concept videos' straightforward structure, examples, and easy-to-follow, in-depth explanation. In contrast, in the coding video, students appreciated the step-by-step explanation, simpler examples, pace of the instructor, breaking down information into smaller chunks, and already commented sections in the code. The exemplary quotes are presented in Table 3.

Table 3: Direct quotes to describe students liking and disliking of the videos

Perception	Concept Video	Coding Video
Like	*"I liked how the video was straightforward and well organized."*	*"liked her in-depth explanation of each line of code [instructor] wrote. [instructor] does this in all live coding*

	"[instructor] explained the topic in depth and i can understand a few ways to use classes and structures" *"I liked how it was laid out, easy to follow."* *"The textbook chapter was confusing at times, so the lecture was very crucial in my understanding. It provided good examples and helped clarify the topics discussed in the textbook."* *"I liked how concise the information and explanations were and I thought the slides were easy to understand."*	*examples, but she does an excellent job of explaining each step, one by one."* *"I like that the video is in depth, and shows the pseudocode behind how to do the coding, taking the programmer step by step in each function"* *"I like the step by step walkthrough of the live coding because it is at a good pace"* *"I liked how the content was divided, I also felt that starting with already commented code was nice. And we only needed to go over the new stuff."* *"[instructor] explained how things work and how to break down each part of the problem."*
Dislike	*"video is lengthy, can be boring at times."* *"I feel like the concepts are over explained that it makes it difficult to keep focus on the topic."* *"I didn't feel that the lecture video was very engaging, as a lot of the concepts were very theoretical and didn't have attached examples. I think showing example code could help students engage better with the material."*	"*I just think it could be better by providing more real code examples."*? *"The example was almost a little too basic. It's very helpful but it will still take trial and error to apply the information to more complex scenarios.*

Similarly, as clear from the exemplar quotes in Table 3, in the concept videos, students disliked the length of the videos, coverage of many concepts, over-explanation of concepts, and lack of engaging material. In the coding videos, students needed more detail and real-world examples.

Discussion and Conclusion

This study discusses the importance of pre-class videos in a flipped class model for a programming course. Drawing from previous literature that suggests that video quality and student satisfaction are primary factors when considering the effectiveness of the conceptual flipped course [9], this study focuses on exploring students' perspectives after introducing them to two types of videos designed for a C++ programming course. The purpose of the concept videos was to provide a detailed introduction to the topic area. In contrast, the coding videos introduced students to the syntax of the topic and its basic operations using a live coding approach. The students' perspectives were explored on five quality aspects, i.e., clarity of the material, usefulness of the material, relevance of the material to course needs, engagement with the material, and learning from the material. Also, the study specifically focused on what elements of each type of video the students liked or disliked. The study took a multi-method approach to explore students' perspectives on each video and compared two types of videos.

The results of the study provide interesting insights. On the comparison approach between the two videos, the Wilcoxon signed ranks test results indicated that out of eight topic areas and five quality aspects, there were only two topic areas where students found the coding videos more effective than the concept videos. These topic areas are structures and classes, where the coding videos provided more clarity of the material, and arrays, where the coding video provided more engagement with the material than the concept video. For other topic areas and quality aspects, the coding and concept videos provided similar clarity, usefulness, relevance, engagement, and learning. These results provide interesting information as they may refer to uniformity in the video design. As the average result of each video is >=4 out of the 5-point Likert scale, most students appreciated the quality of the videos designed for the course. On a closer look at the topic areas of structures and classes, and arrays, for what students specifically liked or disliked, it was noted that students appreciated that in structures and classes, the coding video provided clarifying examples for the topic areas covered in the concept video. Similarly, for the arrays video, students found the step-by-step explanation of the arrays concept more engaging than in the concept video. These results align with existing literature, suggesting that videos are engaging when focused and go into smaller details for students' learning [30].

From the perspectives of individual videos, the results indicate that the concept videos of inheritance, strings, and pointers helped students understand the topic area's details. The strings and pointers coding videos are also perceived as excellent coding videos. On closer look, we found that students appreciated the explanation of different types of strings in the concept video and that the instructor explained the concept in detail. In the string coding video, students appreciated the visual element and coding during the video lecture and how it helped them see the string structure. Similarly, for the pointers concept video, the students appreciated the examples given in the concept video and found the coding video a continuation of the concept video. These results align with existing literature that suggest that students learn better when lectures help students’ scaffold [33] and build on previous knowledge to form new connections [34].

There are several implications of this study. For example, the study highlights that in flipped classes, video design elements in terms of what the topic area is, how detailed the provided information is, the pace of the instructor, and how it helps students to connect the current material with previous knowledge are important facets for students learning and satisfaction [33]. The study also highlights that students preferred more hands-on exercises and examples for clarity and engagement in conceptually hard courses such as programming. Also, similar to prior literature [33], this study highlights that student satisfaction is coupled with clarity and engagement with the material. AI-based Large Language Models such as ChatGPT can enhance students’ engagement with pre-class materials by providing interactive explanations, personalized feedback, and intelligent tutoring support tailored to individual learning needs [35].

The study's results must be viewed in the light of some limitations and future directions. First, the study was based on self-reported student perceptions of two types of videos. Future studies could consider other measures, such as time spent on each video and a performance measure after watching the video, providing more details on students' engagement and learning with the videos. Second, the study has a smaller sample size of 43 students, where participation differed for each topic area and created nonnormal data. Future studies can expand to a larger sample size for more conclusive results. Also, future studies can consider incentives to ensure that all participating students provide maximum data. Third, the quantitative section of the study focused on one kind of comparison between the concept and coding videos in five aspects only. The absence of a randomized control could affect the generalizability of the claims, which could be rectified in future studies. Also, future studies can consider more aspects relevant to the flipped class model. In this regard, multi-modal analysis [36], [37] can be used in future studies to better understand students' engagement by analyzing voice tone, facial expressions, clickstream behavior, and screen interaction data during video watching. Fourth, the data on students' qualitative perceptions were pre-organized into likes and dislikes, limiting the analysis to a deductive approach. Future studies can consider more open-ended and semi-structured approaches to collect the data. Also, future studies could rely on other process data and supplementary information, such as using classroom observations [38] as a secondary source of data, which may help to see researchers' perspectives on students' engagement and learning. Fifth, this study did not consider students' demographic information to understand the variations. Future studies could account for such variables.

The results of this study are novel and provide insight into how students perceived the use of two different kinds of videos to prepare them for the class. The results highlight important aspects that students value in programming courses, which could provide valuable information for future courses and revision of the understudy course.

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