PATTERNS OF INTERACTION WITH VIDEOS AND COLLABORATIVE ASSIGNMENTS IN AN ASYNCHRONOUS ONLINE STATISTICS COURSE

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This paper investigates a fully and asynchronous online introductory statistics course with a collaboration component (Collaborative Keys). We evaluate how students use collaborative assignments and videos, whether they are used as intended, and how they relate to student performance. The results suggest that the use of course resources is related to student achievement, with higher performing students focusing on video resources created by the instructor and showing more consistency in their use of resources throughout the term. Based on these findings, improvements were made to the collaborative assignments to provide better engagement and interactions between the students and to make students more accountable for watching the videos.

INTRODUCTION

One of the biggest challenges in teaching an online asynchronous class is to re-create the positive interactions that usually happen in a well-designed face-to-face environment. Providing opportunities for students to interact with each other and work collaboratively in an online class can help create a sense of community, which is very important and facilitates the learning process (Everson & Garfield, 2008; Mills & Raju, 2011). In addition, students can also construct knowledge together as they interact with other students (and with the professor). Recommendations in the field of statistics education suggest the use of real-time online discussions for better student-to-student and student-to-professor interactions (Summers et al., 2005). However, many online courses are delivered asynchronously, making the interactions more challenging to arrange.

Statistics education research on online teaching has been focused on student performance and attitudes towards statistics across different modes of instruction such as online, face-to-face, and hybrid (e.g., Hahs-Vaughn et al., 2017; Scherrer, 2011). Only a few studies provide focus on students' interactions with course materials and with each other: Shotwell and Apigian (2015) investigate the use of course resources and time spent on the learning tool in an online introductory business statistics course; and Rayens and Ellis (2018) provide an example of a more innovative structure for online courses. There is a lack of studies that leverage log report data from Learning Management Systems (LMSs) to better understand students' behavior in an online statistics course. Data collected in the LMS log report include the resources students accessed, the time spent with the resources or spent on various tasks, and the sequencing by which they ordered their engagement with the resources.

This study uses log data to investigate student engagement with an asynchronous fully online introductory statistics course with a collaboration component called Collaborative Keys (described in greater detail below). Evaluation of how students use these and other resources, if they are being used as intended, and how the use is related to performance is explored in this study. The full research study is reported in Sabbag and Frame (2021). In this paper, we focus only on how students transition from video and textbook resources to some course activities (Collaborative Keys and Quizzes) and evaluate how these transitions differ by student performance over the course of an entire term. We also reflect on the course structure and consider changes to the use of videos and collaborative aspects of the course.

COURSE INFORMATION & LEARNING DESIGN

This study is focused on an online asynchronous statistic course taught at a mid-sized public university in western United States during Fall 2018. The course is a randomization-based introductory course for undergraduate social science students, which includes topics such as study design, significance tests and confidence intervals for one- and two-samples, analysis of variance, and simple linear regression. This was a 10-week course with 27 students (7% freshman, 67% sophomore, 4% junior, and 22% senior), and it was required for many of the students. The course was broken down by weeks, where most of the weeks follow the same structure:

- Phase 1 (Sunday–Monday): Students were expected to read and/or watch videos from assigned sections of the textbook resources and complete an online reading quiz (Readiness Quiz).

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- Phase 2 (Tuesday–Thursday): Students were expected to complete and upload their answers to two activities and create a collaborative answer key (Collaborative Key) for each activity (as a whole-class). Students were also expected to watch videos developed by the instructor (Video Wrap-ups).
- Phase 3 (Thursday–Saturday): Students were expected to complete an online quiz (End of Unit Quiz) covering the recent statistical concepts learned.

The textbook used in the course was *Introduction to Statistical Investigations* (Tintle et al., 2015), and students had access to the e-book and videos for each section of the textbook. These textbook resources were created by the textbook authors and were integrated into the course LMS page.

Most weeks, students completed two activities that covered the concepts from the textbook's readings/videos. After working through the activities, the students were expected to work as a class to create answer keys for each activity: the Collaborative Keys (see more information in the next section).

The instructor developed and recorded Video Wrap-ups that focused on important statistical information and difficulties students usually have while completing the activities. These videos lasted about 10 minutes, and the number of videos per activity varied from one to four. All Video Wrap-ups were hosted on YouTube and students accessed them by clicking on a URL link available in the LMS. The Video Wrap-ups were only available during Phases 2 and 3 after the professor's first feedback on the Collaborative Keys. These videos were intended to be a resource for students after their first contribution to the Collaborative Keys.

The End of Unit Quizzes were typical weekly homework. The first part of each quiz was comprised of a mix of multiple-choice and open-ended questions covering the content of the Video Wrap-ups. The second part of the quiz contained questions covering statistical concepts.

Collaborative Keys (CKs)

The challenge of encouraging students to interact with each other and with the instructor requires intentionality and careful thought for online courses. In a synchronous online course, real-time online discussions are possible and allow for interactions, however, encouraging interactions in an asynchronous online course is quite different. Discussions forums have been widely used in the field of statistics education (and other disciplines) as an alternative to real-time discussions in asynchronous courses (e.g., Everson & Garfield, 2008; Summers et al., 2005). Some of the challenges in using discussion forums is that the monitoring of each student's participation can be laborious. If many questions are provided in the forum, the resulting large number of students' posts can be hard to organize and grade. In addition, depending on the quality of the interface design, the discussion can become a very long, vertical, chaotic list of posts that can be hard to navigate and may hinder student interaction.

A different approach to discussion forums is discussed in this study: Collaborative Keys (CKs). CKs are simply Google Docs shared among several students that contain questions for which students make contributions to populate the document. Some researchers have used Google Docs to foster collaboration with middle school, undergraduate, and graduate students (e.g., Krishnan et al., 2018). However, we found no peer-reviewed publication on using Google Docs to support a collaborative assignment structure in a statistics course. Only two studies focus on collaborative online assignments in introductory statistics courses, but they did not use Google Docs. The first study, conducted by Mittelmeier et al. (2018), used an online platform called Udio and had students complete an assignment (explore real-world education statistics) in a computer lab during one class period. Zhang and Peck (2003) reported students collaborating on a problem-solving assignment (covering inference and regression) by using an "online forum."

In this study, the CKs have a cooperative learning structure that encourages students to work together to achieve the shared goal of having a rubric for the activities of the course. When completing this assignment, students can interact asynchronously with their classmates and with the instructor. Students are required to make two contributions to the CK. Each student's first contribution consists of a complete answer to one of the questions (all activities had at least one question per student). Their second contribution is to add an alternative correct answer to an already answered question, correct a wrong answer, or ask a question. Each week, students had two CKs to complete (one for each activity).

The CK was designed as an *assignment* during Phase 2. However, during Phase 3 and for the remainder of the course, the completed CK was intended to be a *resource* for students to use when they

complete the End of Unit Quiz and exams. Throughout the quarter, students had the option to access the CK through a URL link in the LMS.

DATA ANALYSIS AND RESULTS

This study aimed to understand if and how students were using the available resources in the course (Collaborative Keys and End of Unit Quizzes) and if their use of resources was aligned with the intended learning design of the course. To address this, we used log data from the LMS. The event log provided information about every click a student makes and their time and comprised a total of 8,251 records pertaining to the access of relevant course components. With this information, we were able to detect students' access to course resources and also estimate transition probabilities. These probabilities captured how students changed from one resource to another while they were learning. These probabilities only consider the immediate transition from a resource to other resources rather than multistep paths. These focus on only the relevant resources students might be transitioning from and to in a given period of time when the students should be accessing the materials and completing assignments/assessments. We computed the transition probabilities at the student level first. Then we combined the student-level transition probabilities as a weighted average to determine the transition probabilities for each grade category. These data were then merged with grade information. Because we did not have many students in the course, we ended up grouping students into three grade categories: (a) A or B, (b) C, and (c) D or F.

Before students provided their first contribution to the CK, the only resources available were the textbook's reading chapters and the textbook's videos. The top part of Figure 1 shows how these resources were used by students *before* they accessed the CKs, presumably to work on the CKs. We can see that A or B students have a higher probability of transitioning from the videos to the CK than from the readings. The opposite is true of the C students who seem to prefer readings. The results are a bit mixed for D or F students, who do not seem to have a preference for one resource over the other. For the bottom part of Figure 1, we can see what resources the students use *after* they access the CK, when they might be looking for help. All students transition more to the instructor-developed Video Wrap-ups than the textbook's videos, but they do also transition to the textbook's readings with a smaller probability. The transition probabilities do evolve differently throughout the term by grade.

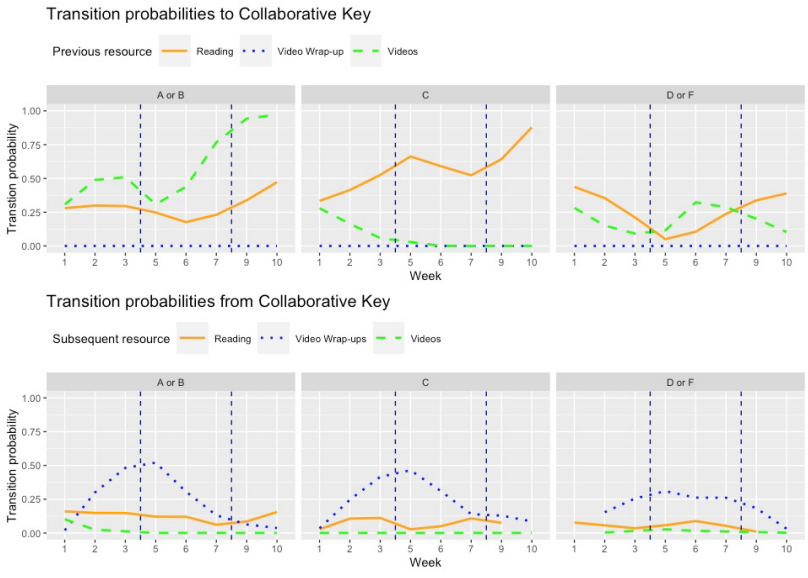

Figure 1. Transition probabilities *to* and *from* the CKs

Figure 2 shows the resources students are using *before* they access the End of Unit Quizzes, presumably to work on the quiz. The transition probabilities from textbook resources are considerably smaller than the transition probabilities from the Video Wrap-ups and from the CKs, which are typically the highest across all grade levels. The transition probabilities are somewhat more constant throughout the quarter for A or B students, whereas the other students show more week-to-week variation. Both C

and D or F students seem to transition less from the Video Wrap-ups after week 6. The transition from CKs to the End of Unit Quizzes seem to increase is the last three weeks of the quarter for all students.

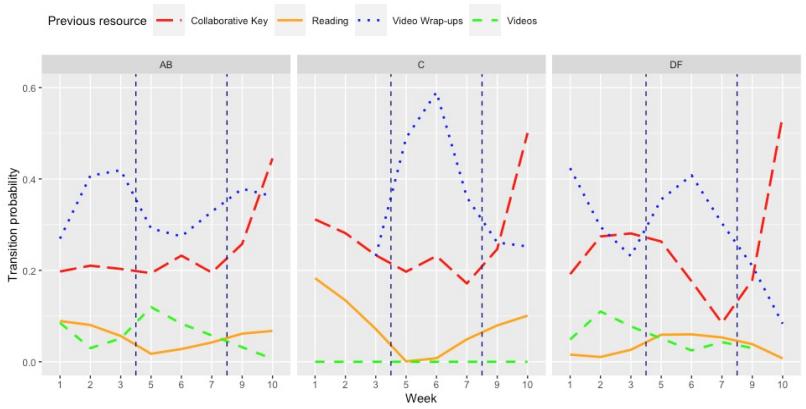

Figure 2. Transition probabilities to End of Unit Quiz for each week; dashed vertical lines indicate midterms. *Note: the vertical axis does not go to 1.*

The percentage of students accessing the CKs per week seems to be related to grade, as shown in Table 1. As a reminder, each week students had two CKs to complete. Most of the A or B students (70%) access both CKs throughout the quarter, but this is true for only about half of the C students. By the end of the term, there is a substantial percentage (37%) of C students that access neither CK. This evolution is even more pronounced for the D or F students. In the beginning of the term, fewer than half of the D or F students access both CKs, but after the midterm, most of these students (62%) access neither CK each week. Similar to the C students, many D or F students seem to give up on this resource by the end of term. The transition probabilities from the End of Unit Quiz for each week were omitted in this paper because no new resources were available after the quizzes, and these transitions did not vary much across grades and resources.

Table 1. Percentage of students per grade accessing both CKs, either CK, or neither CK each week, before and after the midterm

	Grades A or B		Grade C		Grades D or F	
	Before Mid	After Mid	Before Mid	After Mid	Before Mid	After Mid
Neither	20.00	10.00	25.93	37.04	41.67	62.50
Either	10.00	20.00	25.93	14.81	12.50	12.50
Both	70.00	70.00	48.15	48.15	45.83	25.00

DISCUSSION & CHANGES

The results of this study suggest a preference for A or B students to access textbook videos before accessing the CKs, whereas C students prefer to access the textbook's readings before accessing the CKs. D or F students do not seem to have a clear preference. Once the instructor's video wrap-ups are available, all students seem to transition more from this resource compared to the textbook resources. This is true not only for the transition from the CK but also for the transition to the End of Unit Quizzes.

Of course, it is encouraging for the instructor to know that students seem to prefer to access instructor-created videos than textbook resources; however, access to videos does not necessarily mean that students were actually watching them. Moreover, the access was not constant throughout the course for the majority of students (see Sabbag & Frame, 2021).

In the next iterations of this course, the instructor modified access to Video Wrap-ups in order to keep track of whether students were actually watching them. Instead of posting the videos in YouTube, the instructor used EdPuzzle. In EdPuzzle, it is possible to prevent students from skipping to the end of the video. In addition, if students minimize the browser, the video automatically stops

playing. Of course, we acknowledge that there are different ways that students can still "cheat the system." In addition, it is also possible to add questions to the videos in EdPuzzle. For subsequent iterations of the course, questions were added at the end of each video, and participation points were given to students for watching the videos. In addition, statistical questions based on the information addressed in these videos were added to the End of Unit Quiz and were graded based on correctness.

The results of this study also suggest that access to the CKs seems to be related to student performance. Access to both CKs each week was higher for A or B students than for other students, and CKs were a popular resource that students used before completing the End of Unit Quiz each week. Finally, overall access to CKs was less varied for A or B students throughout the quarter, but many C and D or F students seemed to give up on accessing this resource after the first midterm. Similarly, Sabbag and Frame (2021) also reported that the average number of clicks per student on the CKs typically decreased throughout the term but specifically after the first midterm.

It is important to note that even though we found evidence of a possible association between the use of resources and student performance, we do recognize that this relationship is not necessarily causal. In addition, access to the CKs does not necessarily mean that students are checking feedback or even contributing with answers and comments. Also, higher number of clicks is not necessarily better than lower number of clicks. We do not have the information about what students did after they clicked on the Collaborative Key. It might be that students clicked on the CK and provided great answers to the questions; they clicked and left; or anything else might have happened! It is also important to note that after the first midterm, some students engaged less with the CKs leading to many questions in the CK without answer keys. This was the first indication that the students were not always engaging with the CKs as intended.

Careful examination of the CKs showed very little interaction between students. These interactions mostly happened when a student provided a wrong answer, and another student corrected their answer. Instead of helping each other, students were mostly trying to get the correct answers independently. This makes sense because the goal of the CKs is to create the answer key to each activity. This is not the same as students collaborating and working with one another to create the answer keys. To fix this issue, in the next iterations of the course, we created a collaborative structure in the assignment to encourage students to work together.

The second phase collaborative keys (CK2s) were changed to be group assignments with two or three students in each group and fewer questions. Each student in the group was required to provide an initial answer to each question; then students would discuss their answers; and groups would create a final group answer. Very careful prompts were provided to students to make sure that the collaborative structure of the assignment was clear. Among other things, students were asked to read and compare answers, identify and correct mistakes, and reflect on what was different among the answers.

These changes were based on cooperative learning theory (e.g., Johnson & Johnson, 1999) and contained aspects of positive interdependence and individual accountability which, motivated collaboration among the students. We are happy to report that this new format of the CK2s led to more interaction between students; we have seen students helping each other to understand hard statistical concepts, students reflecting on their own understanding, and students referring back to other course resources to help each other overcome struggles with specific statistical concepts.

FUTURE RESEARCH

There are still many open questions regarding how statistics students interact with different types of course resources and tasks provided in online courses. Further studies could explore what types of tasks help facilitate more engagement with course materials, and what type of course materials and assignments best mimic the rich discussions that are characteristic of authentic learning. In particular, there are questions about whether data would support the claim that CK2s improve authentic interaction, and if so what about the CK2s might lead to improvements. Principles of good online tasks could be developed and incorporated into later editions of CK2s so as to further strengthen the discussion and interaction components of an online statistics course.

Moreover, the investigations of log data could be coupled with qualitative analyses of students' work and their interactions with each other. Qualitative study of students' responses on the CK2s may help uncover the deeper stories of what is happening behind the log data numbers. Such studies may

involve developing measures for various desired behaviors from students such as the quality of interaction between students or the nature of their social responses to each other.

The CK2s have been used in seven sections of this asynchronous online course taught between Fall 2020 and Winter 2021. Currently, research undergraduate students at the California Polytechnic State University are working to fix the format of these CK2s assignments submitted by students so that text analysis can be done successfully. We hope to get measures of average contribution per student measured by number of words, order and change in order of answers over time, and number of contributions per student, among other measures. In future studies, we will use qualitative analyses of these CK2 assignments to investigate how interactions between students are related to the format of the CK2, to student performance, and to attitudes towards statistics. By investigating students' written discussions, we aim to better understand the different aspects of written collaboration, how group interactions are established, and how they might change over time. Finally, we also hope to identify the types of questions that lead to more insightful discussion among students and how the CK2s might be improved to continue to encourage the rich discussion that promotes authentic student learning and engagement.

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