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The Artful Craft of Improving Virtual Summer Camps in the Midst of COVID-19 (Work in Progress)

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The Artful Craft of Improving Virtual Summer Camps in the Midst of COVID-19 (Work in Progress)

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Abstract

The Artful Craft of Science (TACoS) is a week-long summer camp that the University of Wyoming has provided annually for up to 80 upcoming 5th and 6th graders since 2015. The program includes a variety of activities in science, technology, engineering, and mathematics (STEM), including a five-day introductory computer science (CS) class. In 2020 and 2021, TACoS ran virtually due to COVID-19, revealing a unique opportunity to compare two instances of the CS section of the program. This study focuses on answering two questions: 1) How does video quality impact student participation and engagement; and 2) How does the length of time that content is accessible affect how students engage with course material? Both virtual years (Summers 2020 and 2021), the CS program included five 20–30-minute videos, a corresponding website for students to follow, and physical components that were mailed to each student prior to the course. After the first year (Summer 2020), improvements were made to the CS course presentation including attention to video quality, fresh course content for repeat-attendees, and further streamlined lesson plans. In the second virtual year (Summer 2021), students were given access to course material for a longer amount of time, as content remained available for a month instead of only during the camp week. Over both virtual years, viewership data was collected from each video including the number of views per activity, the average view duration, the audience retention rate across each video, the average views per viewer, and the lifetime watch time for each video. A total of 37 (46%) parent evaluation reviews (including perspectives of their students) of the TACoS program were collected, providing insight on the overall impressions of the camp, the CS program specifically, the students' favorite project/course within TACoS, the course completion rate, the ranked comparison of parents' time spent helping their child with each TACoS program, and general parent feedback. Findings show that there was improvement in the video content which could have invited more participation in the project/course and higher student engagement with the project/course material in the second virtual year.

1 Introduction

STEM fields prove to be crucial in the continued development of our communities. As our dependency on STEM solutions grows, educators have responded in turn through offering increased access to STEM materials for community populations. While many K-12 students are offered courses in STEM early and regularly, students in rural areas often lack access to such opportunities. To combat this disparity, educators have offered outreach camps that focus on STEM fields while providing tangible practice in these areas.

1.1 Context

The TACoS has provided numerous outreach and professional development activities in the pursuit of engaging students and teachers in rural areas in STEM (Science, Technology, Engineering, and Mathematics) fields. Among these outreach opportunities, the University of Wyoming has offered an annual week-long summer camp to 5th and 6th graders for the last six consecutive years. This summer camp offers many STEM and art related segments for students to complete, providing opportunities in these areas that students in rural schools may not have to chance to experience otherwise. Each year TACoS offers students four unique experiences to engage in Chemistry, Photogram creation, Computer Science, and Geology. This work focuses on one experience, an introduction to computer science engagement that is offered which facilitates the interaction between students and experienced collegiate faculty (as well as college student volunteers) through a five-day course covering basic computer science concepts. This course explores programming and builds problem solving skills with the aid of Micro:Bits, $20 micro-computers that are programmed through block programming (drag-and-drop programming). This course generally covers an introduction to the Micro:Bit, basic programming concepts such as inputs and outputs, variables and basic data types, booleans and program execution / control flow, gamified learning applications, and applications in other areas such as music and entertainment.

While these interactions were traditionally ran on the University campus, after the fourth year of in-person instruction, the courses were moved to a virtual platform due to the challenges posed by COVID-19. This introduced a new opportunity to facilitate student-teacher interactions through an online platform. The TACoS camp has been offered online for the last two summers (2020 and 2021) and enrollment is open for next summer as well (2022). While the first virtual summer (2020) had to be transitioned to an online platform quickly, there was an opportunity to make improvements before the second virtual summer (2021)[1]. These improvements included adjustments that would have been addressed in any typical year such as refreshing course content and streamlining lesson plans, but also included adjustments that were resultant of the new virtual platform such as attention to video quality and the duration for which virtual materials were available. Efforts were made to make videos more captivating and easy to follow: animations and visual aids were added, varying scenes (slides, presenter, and screen record) were employed to break up lectures and activities and avoid monotony, pause points for breaks were included, background music was added, and a clear road map was presented for each activity.

[1] Videos for all TACoS VII can be viewed here: `https://wycsx.org/tacos7`

1.2 Research Questions

Given the rapid shift to a virtual platform in 2020 and the ability to improve the camp in 2021, adapting to COVID-19 enabled an evaluation of the 2020 and 2021 summer camps and a comparison between the effectiveness of each approach. Specifically, two main questions were investigated:

1. How does video quality impact student participation and engagement?
2. How does the length of time that content is accessible affect how students engage with course material?

Investigating these questions proved vital in understanding the trade-off between high quality content and the extra time and money it takes to create higher quality videos. It further helped establish best practices for online content such as where the content should be accessed from, for how long, and the overall delivery of the materials.

2 Related Works

2.1 Summer Camps

Summer Camps have become popular and efficient methods in education research. For example, Aritajati et al. [1] investigated students' attitudes towards computing careers and their computational self-efficacy by using summer camps. Braswell et al. [2] proposed to create a virtual summer camp that provides informal computer science learning opportunities that were intentionally designed to increase the confidence of Black and Latina girls in computing and to promote positive perceptions of computer science education and career opportunities. In [3], Burrows et al. found that informal engineering based on projects can serve as opportunities for participants to connect with integrated STEM. At the same time, their study showed that it is necessary to support traditional school STEM learning and traditional K-12 classroom instruction by encouraging community engagement in integrated STEM. Gibson et al. [4] examined the long-term impact of the Summer Science Exploration Program (SSEP). Their conclusion is that SSEP students maintained a more positive attitude towards science and a higher interest in science careers than students who applied to the program but were not selected. To address most education camps and programs that were not available for students owing to the pandemic, Klotzkin et al. [5] proposed to develop a week-long Arduino workshop to give middle school students an opportunity to actively engage in fun and educational STEM activities. Their results showed that this workshop is an efficient way to learn knowledge of electronic hardware and Arduino programming for students. In [6], the authors investigated the association between middle-school students' reported participation in science summer programs and their reported expectation of a career in science and engineering. Results indicated that students who once participated in science summer camps were more likely to later report a career interest in the science and engineering fields compared to students who did not. In [7], the authors also showed that STEM Camp is efficient to improve students' interests in STEM content and STEM career. They created Blue STEM Camp to provide enriching opportunities in locations with practicing

STEM professionals in an effort to provide future career opportunities and role models for middle-level students. Wolf et al. [8, 9] also argued that outreach camp is good for K-12 students and teachers to learn programming, especially for the people who are not familiar with techniques. They empirically showed that integrated outreach can increase students' engagement in Computer Science and Cybersecurity. In [10], the authors explained the organization and execution of a summer engineering outreach camp designed to attract and motivate high school students as well as increase their awareness of various engineering fields. The survey results indicated the success of the camp and the effectiveness of the hands-on, competitive engineering design experiences to attract students to engineering professions. In [11], the authors described a few of the summer camp options and discussed the challenges, opportunities and lessons learned from their experiences.

Therefore, Summer Camps are proved to be extremely useful for education studies.

2.2 Online Learning Environment

Besides Summer Camps, online learning is receiving attention, especially during pandemic years. For instance, Bolliger et al. [12] investigated faculty perceptions of strategies that foster student engagement in the online learning environment and contrast them with perceptions of students. Dixson et al. [13] investigated what activities or interaction channels might be expected to lead to more highly engaged students. Their results indicate two things: First, there is no particular activity that will automatically help students to be more engaged in online classes. Second, in general, multiple communication channels may be related to higher engagement. Thus, it is necessary to incorporate meaningful and multiple ways of interacting with students and encourage students to interact with each other. In [14], the authors investigated the importance of engagement of students and teachers in blended learning with a focus on factors that affect this engagement. They found that students' time spent online is directly proportional to the instructor's online time, promptness of instructors' response to online activities queries of students increased student engagement. In [15], the authors studied the relationship between reflexivity and student engagement in online learning environments. One of the implications of this study is that learning environment frame specific tasks and social relations, and thus expect particular profiles of reflexivity. Looyestyn et al. [16] investigated an interesting research problem: Are gamification strategies effective in increasing engagement in online programs? The results suggested that gamification can increase engagement in online programs, and enhance related outcomes. In [17], the authors investigated how course design influences student engagement and motivation in an online course. They applied the Project-Based Learning method and analyzed student reflection data. The experiment results showed that the course/module structure, content scope, project design, assessment design, instructional resources and tools are critical factors that are important to motivate students to learn online. In [18], the authors investigated correlates of both online classroom community and student engagement in online learning, as well as compared community and engagement across disciplines in higher education. Considering classroom community with instructors, classroom community with classmates, and engagement in learning, they found discipline differences when examining the three factors across the colleges.

2.3 Engagement and Interest Measurement

Engagement and Interest measurement are important to education research because it is essential to quantify the performance of students. Most researchers conducted their study from quantitative or qualitative perspectives. For example, Gixson et al. [19] proposed a new student engagement measurement in the online course, which is named Online Student Engagement Scale (OSE). This measurement correlates student self-reports of engagement with tracking data of student behaviors from an online course management system. In [20], the authors conducted a qualitative study that explored online student engagement experiences in a higher education institution. Their study showed that whether an online engagement is successful or not depends on a number of psychosocial factors such as peer community, confidence, or life load. However, this investigation is based on a very small sample size, i.e., they only collected data from 24 online students over one academic year. Kim et al. [21] proposed a new online CS education platform to understand how students learn programming, coined Elice. They demonstrated the practicality of Elice through case studies. However, Weinberg et al. [22] adopted a mixed-methods design to evaluate the effects of four experiential learning programs on the interest and motivation of middle school students toward mathematics and science. Their findings include two main points: (1) Students' interest in mathematics increased after completing the program; (2) A decrease in the importance of mathematics on students' sense of self and some gender differences were detected, with males showing more gains than females.

Different from the existing related research, our work focuses on investigating the impact of online video quality on student participation and engagement, which has not been studied before.

3 Methodology and Methods

Viewership data for each video (quantitative) and parent evaluation reviews (qualitative) were utilized in assessing the two summer camps. Recall that the two main questions were investigated:

1. How does video quality impact student participation and engagement?

2. How does the length of time that content is accessible affect how students engage with course material?

3.1 Quantitative Metrics and their Limitations

First, the quantitative data was evaluated through the reported YouTube statistics including:

- **Number of Views per Lesson**: Total number of times each video was played per day while the video was available.

- **Average View Duration**: The total time each video was played divided by the total number of video plays, including replays

- **Audience Retention**: The percentage of the audience retained throughout the duration of the video.
- **Average Views per Viewer**: The average number of times each video was played per person per day while the video was available.
- **Lifetime Watch Time**: The total number of hours users spent watching each video

Then, additional factors were considered such as the length of each video, the time spent creating and editing the videos, the number of collaborators, the cost of the materials, and the length of time the content was available. These metrics were used together to compose cohesive evidence supporting the student participation and engagement in the lessons. This quantitative data also provided preliminary evidence for how the length of time that the content was accessible affected how students engaged with the course material, thus establishing evidence to answer each research question.

Number of Views and Average View Duration: The use of many different metrics was vital in discovering the answers to the two central research questions. The number of views, used in conjunction with the number of participants, gave an idea of how many students participated in each lesson. While this provided a basis for further assessments and informed other metrics, this data alone was not sufficient to answer either research question because the unique number of students who watched the videos could not be determined (since a student re-watching a video would be represented the same way as two unique students watching a video). This could only be inferred through using additional metrics to give a more cohesive picture of the student engagement. Similarly, the average view duration, used in conjunction with the length of each video, provided a basic idea of whether or not the students were retained through the entire video, but this metric alone could not confirm the average amount of time each student spent on each video. For example, a student that clicked on the wrong link and accidentally started the wrong video would most likely realize their mistake before watching the entire video; while they weren't disinterested in the video, the average view duration metric would be negatively impacted as soon as they clicked back to find the correct video.

Audience Retention: The audience retention data showed the percentage of the audience that was watching the video for each second of the video. For example, a video may show that nearly 100% of viewers were still watching the video at the ten second mark, but that by the three minute mark, only 20% of viewers were still watching. This would indicate that viewers were less engaged with the material and clicked away after losing interest. The audience retention data could also show spikes at certain times, indicating that students frequently had to replay certain sections of the lesson to better understand, or could show dips at certain times, indicating that students were under-stimulated and fast-forwarded to a more interesting section of the lesson. In other words, at any given time in the video, three different patterns were considered. First, a constant percentage suggests that the lesson was progressing appropriately. Second, a spike suggests that the material introduced at that time was confusing to the students, causing them to interrupt the lesson to backtrack. And third, a dip suggests the material introduced at that time was too basic or repetitive, causing the students to lose interest. This means that in general, the developers were aiming for smoother audience retention plots and videos that were not smooth should be addressed and better delivery should be achieved.

Average Views per Viewer and Watch Time: The average views per viewer showed the average number of times the students watched each video. This was collected on a daily basis as well as compiled for each video. Results were split up between the number of times the students watched each video during the week-long camp as well as the number of times per day the students watched each video after the camps ended (while the materials were still available). This gave insight on how providing the materials for a longer amount of time effected student engagement over time. Additionally, the total watch time was recorded for each video. This was used to compare the lessons and help determine which were most engaging; however, it was not immediately clear whether videos with longer watch times were more engaging. It could be that students needed to re-watch parts of the videos to understand the material or that the videos could be playing in the background while they completed the programming challenges. In other words, it is not clear how the students were engaging with the material. This data was therefore used in conjunction with the retention data as well as the qualitative data to make conclusions about student engagement.

Additional Developer Factors Lastly, additional quantitative metrics were gathered that were focused on the development of the materials rather than the YouTube viewership data. These metrics included the time spent creating the materials, editing the videos, the number of collaborators each year, and the cost of materials spent each year. These additional factors aided in a cost-benefit analysis that helps dictate the increased cost associated with the change in student engagement as well as add scope to the findings.

3.2 Quantitative Assessment of Student Engagement

In short, due to the limitations of individual statistics, many different quantitative metrics were used together to assemble insights into the student participation and engagement. Specifically, student engagement was determined using two combinations of metrics. First, the number of views were considered in unison with the average view duration. The lessons that had a higher number of views with a higher view duration were indicative of better quality material. Higher quality camps were reflected in lessons with more steady viewership (more consistent number of views) with a slightly higher number of views expected for the first lesson since the directions for how to flash the program onto the board were given in the first lesson.

Next, the audience retention rate was analyzed and helped give more insight into the effects the refreshed material and new videos had on student engagement. Recall that there are three patterns possible when plotting the retention of the video, spikes that indicated that part of the video was commonly replayed, dips that indicated that part of the video was commonly skipped, and smoothness that indicated that part of the video was commonly watched from start to finish. The videos were therefore considered to have better quality when their retention plots had smoother plots.

Then, the number of views per viewer and the average watch time were each evaluated by lesson. Because the 2021 camp materials were available for a substantially longer period of time, each lesson was considered by day, meaning that the data was gathered on the number of times the average student watched each lesson each day, with 2020 data spanning 14 days and 2021 data spanning 49 days. Similarly, the total amount of time each video was played for each day was also gathered across the same time spans. These were considered together to determine the time spent by the average user, including replays.

Lastly, the length of each video, the time spent creating and editing the videos, the number of collaborators, the cost of the materials, and the length of time the content was gathered together were all evaluated. This information helped quantify the amount of student engagement by providing baseline information and a frame of reference for the quantitative data.

3.3 Qualitative Metrics and their Limitations

Reflections were gathered from each of the developers to better understand the process they took in updating the content and creating the course videos. These short reflections gave insight into where the developers focus was centered. Recall that in the first online year, only one developer was allotted for the computer science portion, as the need to switch from an online platform was not known at the time of the assignment. To boost the quality of the online version of the TACoS camp, three developers worked to improve the content from the previous year. Understanding the shift in motivation and the change in the process for creating the materials helped identify why certain changes were made to the videos (eg - keeping to a lesson schedule, including upbeat music in the introduction, etc.) and how those changes may be reflected in the quantitative data.

These reflections were limited based on the time that they were gathered. Because the reflections were gathered after the camp, responses could be biased based on what was observed during the camps rather than being based purely on the development process. Regardless of this limitation, this qualitative data helped inform the value of the expected increase in student engagement with the increased cost of materials and development time.

3.4 Qualitative Assessment of Student Engagement

Finally, surveys of student participants and their parents, developed primarily for instructor and team feedback and iteration, were also collected. These surveys covered the whole TACoS camp (Chemistry and Geology, Microbe Art, Science Art, and Computer Science) rather than solely the computer science portion. The same questions were asked after both years of camps. The questions for the students included:

1. [Upcoming] grade level: 5th grade, 6th grade

2. Overall, I liked TACoSSTEM Summer Camp this much (pick one): A lot, A little, I don't know

3. I liked the Computer Science micro:bit (ComputerSci) sessions this much: A lot, A little, I don't know, I didn't do it

4. What is the thing that you liked best about TACoS Summer Camp this year?

The questions for the parents/guardians included:

1. Which sessions did your student attempt but not finish?: Chemistry/Geology, Microbe Art, Science Art, Computer Science
2. Which sessions did your student finish completely and make a finished product?: Chemistry/Geology, Microbe Art, Science Art, Computer Science
3. I saw my student enjoying the TACoS VII activities at home: Yes - Almost all the time, Sometimes - About half of the time, No - None of the time
4. I helped my student with the following activities (in terms of time spent): Ranked Chemistry/Geology, Microbe Art, Science Art, Computer Science among Most time spent (1st), moderate time spent (2nd), Some time spent (3rd), Least time spent (4th)
5. Are you planning to work on the TACoS Curiosity Labs at Home in the future?
6. What suggestions do you have if TACoS Summer Camp is held online again in the future?
7. Anything else that you'd like for us to know?

4 Findings

4.1 Viewership Data

4.1.1 Views by Activity

First, consider the views by activity. These results are broken down by activity as well as by day. In the 2020 year, the highest number of views was for the first activity which was expected since that video contained the instructions for how to program the Micro:Bit board. The first activity peaked at 49 views in one day, the official first day of the camp, and then trailed off throughout the rest of the camp. The second and third activities peaked at 10 views throughout the camp and views decreased much faster for those activities than the first. The fourth activity had 12 views on the fourth official day of the camp and the fifth activity had four views on the fifth official day of the camp. These statistics together indicate that approximately five to ten students were able to keep pace with the materials throughout the week, with very few making it to the end of the material. The full results are given in Table 4.1.1.

The following year, because the camp materials were available for seven weeks, they provided a more casual pace for the students. This is reflected in the number of views for each video per day. The number of views for the 2021 camp did not peak like in the camp the previous year. Rather, they remained consistent with each activity receiving two to five views on weekdays, with sparing views on the weekends. These results are shown in Table 4.1.1. Here, the views for each activity are given for the first 14 days to compare with the

Table 1: Number of views for each activity broken down by days available for 2020

Day Available (Index)	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Date
0	3	0	0	0	0	2020-07-19
1	49	0	0	0	0	2020-07-20
2	8	9	0	0	0	2020-07-21
3	19	8	10	0	0	2020-07-22
4	17	10	7	12	0	2020-07-23
5	7	8	2	0	4	2020-07-24
6	10	1	0	3	0	2020-07-25
7	0	3	0	0	1	2020-07-26
8	8	1	0	0	0	2020-07-27
9	1	0	0	0	0	2020-07-28
10	2	1	1	0	2	2020-07-29
11	3	2	0	0	0	2020-07-30
12	0	0	2	3	2	2020-07-31
13	0	0	0	0	0	2020-08-01

previous year, then the sum of the views received in the remaining five weeks are given to show that the videos continued to garner views for the remainder of time the material was available (beyond the time that the first camp was offered). Each video had, on average, one view per day (including weekends) during those five weeks. The full results for the number of views is plotted in Figure 1.

4.1.2 Retention Rate

Next, consider the retention rate, which is considered as the percent of the total viewers that were watching the video at each percent of the video. For example, for the first activity in 2020, 72% of the people who started the video were still watching after 1% of the video had progressed while 26% where still watching until the end of the video. Note that it is possible for the retention rate to exceed 100% as viewers can watch the same section of a video multiple times. The full retention rate for each activity is plotted in Figure 2. From these plots, it can be determined which parts of the video were replayed versus skipped. For example, for the first activity in 2021, a large portion of the video (from the 60% mark to the 80% mark) was replayed frequently, as there is a spike in the retention plot. Upon review, this is the section of the video that described how to program the Micro:Bit board, so a spike in replays was to be expected. The second activities in each year were relatively smooth; however, in the 2021 camp, viewership dropped quickly at approximately 65% of the video. This portion of the video asked students to attempt a simple program on their Micro:Bits, indicating that students who completed the program likely did not watch the rest of the video or that students stopped watching the video after the programming assignment was given. The remaining activities had rather smooth retention rate curves, aside from activity five of the 2020 camp. In this activity, there were two spikes. The first, happening around 60% of the video, was when instructions were given to help the students connect

Table 2: Number of views for each activity broken down by days available for 2021

Day Available (Index)	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Date
0	1	0	0	1	0	2021-07-04
1	2	1	1	2	0	2021-07-05
2	5	4	4	2	3	2021-07-06
3	3	1	1	0	0	2021-07-07
4	1	2	1	0	0	2021-07-08
5	0	0	2	3	0	2021-07-09
6	1	0	0	0	1	2021-07-10
7	8	3	2	1	1	2021-07-11
8	5	4	2	1	0	2021-07-12
9	3	0	4	3	3	2021-07-13
10	0	0	1	2	2	2021-07-14
11	0	0	0	0	0	2021-07-15
12	1	0	0	0	0	2021-07-16
13	2	2	1	1	1	2021-07-17
14 - 48	45	30	33	31	28	2021-07-18 to 2021-08-21

a moisture sensor to their Micro:Bit for a plant-watering application. The second peak, happening around 70% of the video, was a portion of the video were instructions were given to have the students represent a wet and dry environment numerically in their program. This was the most complicated part of the most complex program, explaining the frequent replays at that time. Across all of the activities, the spikes in viewership can be attributed to students re-watching instructions and demonstrations, one potential benefit to providing the materials online.

Further, the retention rate for each activity was compared between the 2020 and 2021 camps. In these comparisons, two factors were considered. First, higher retention overall was considered to indicate a higher quality activity and second, a more consistent curve with fewer spikes and dips was considered to indicate a higher quality delivery. This is because a higher quality activity should retain the most attention while a smoother plot indicates that students were able to track the activity more organically from start to finish, rather than needing to replay parts while skipping other parts. Also, an average retention rate of 50% across the full video was targeted as ideal. The retention rates are plotted together by activity in Figure 3.

In the first activity, the 2020 and 2021 camps had very similar retention rates, with the instructions for programming the Micro:Bit giving the 2021 year a spike towards the end of the video. For the majority of the activities, the 2021 video had higher retention while the 2020 year had a smoother curve. Also consider that for the 2021 year, there were many more views that occurred steadily over the course of seven weeks rather than a peak of views on the first day of the camp. This could affect the retention rate if students approach the material differently at the beginning of the camp versus the end. Lastly, neither camp hit the target retention rate but the 2021 camp had a higher average retention across the whole video;

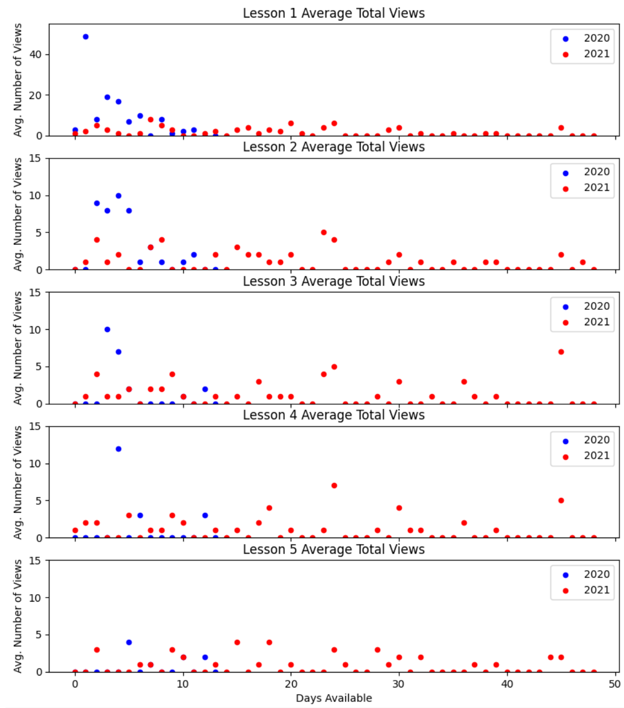

Figure 1: Views by Activity for 2020 versus 2021

the 2020 camp had an average retention of 36.83% while the 2021 camp had an average of 46.52%. In the second activity, the 2020 and 2021 camps had similar retention rates, both being markedly higher and smoother than the previous activity. The 2021 camp had a higher retention rate across the first 75% of the video, but then dropped to approximately the same retention rate as the 2020 video. At this point in the video (2021, activity 2), a walk through of the assignment was given for any students who were not able to complete the material on their own. The activity was completed by this point. The 2020 activity had a smoother curve overall, which is mostly due to the drop in retention at the 75% mark. The 2020 activity did not reach the target average retention rate (with 40.53% average retention across the whole video), but the 2021 activity was able to achieve this mark (with 53.64%).

In the third activity, the 2020 and 2021 activities had the most similar results across all of the activities. Both activities hovered around 50% retention throughout the whole video. Further, they both had rather steady retention, avoiding large spikes or dips. Both activities achieved the target average retention with the 2020 activity achieving 50.52% retention across the whole video and the 2021 activity achieving almost the exact same with 50.55% retention.

In the fourth activity, the 2020 activity had significantly higher retention than past activities, while the 2021 activity had slightly less retention. The 2020 camp had a higher retention than the 2021 camp across the entire videos. The 2020 video experienced many more spikes across the activity while the 2021 video had a much smoother curve. Recall that this indicates that the 2020 video had portions that were replayed many times while the 2021 video was more commonly watched from start to finish. The average retention rate across the full 2020 video was 82.94%, significantly higher than the target average retention

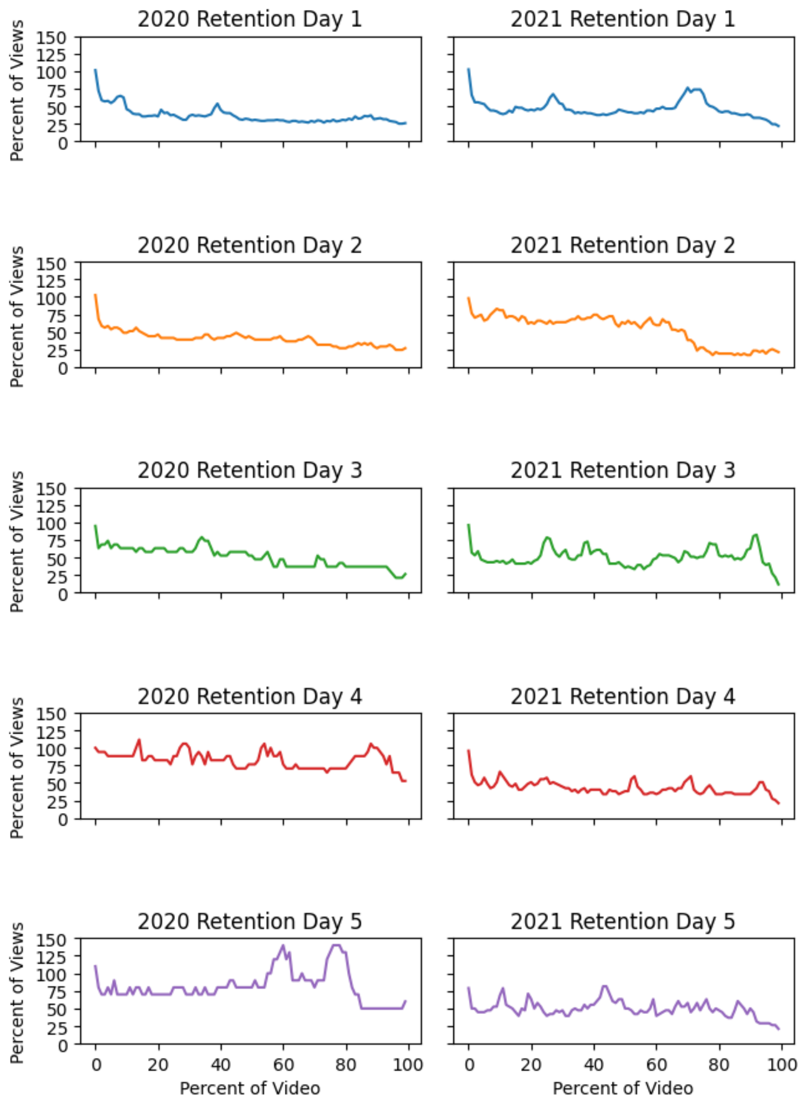

Figure 2: Retention Rate

rate, while the 2021 video had 43.04%, quite a bit lower than the target retention rate, but still higher than the first two activities from the 2020 year.

In the fifth and final activity, the 2020 activity sustained a similar retention as the previous activity while the fifth activity in the 2021 camp had a retention rate more consistent with all the activities from that camp. The 2020 camp had a higher retention than the 2021 camp across nearly the whole video. The 2020 video had two very large spikes, as mentioned above, due to the delivery of instructions. The 2021 retention rate was much smoother and consistent across the video. The 2020 video had an average retention of 81.8% while the 2021 video had 49.55%, both performing at or above the target average retention rate.

There are two further notes that should be made on the retention data. First, the 2020 year had fewer views reaching the fourth and fifth activities. Therefore, there may be a bias in the higher retention rate since students who were more likely to reach the fourth and fifth

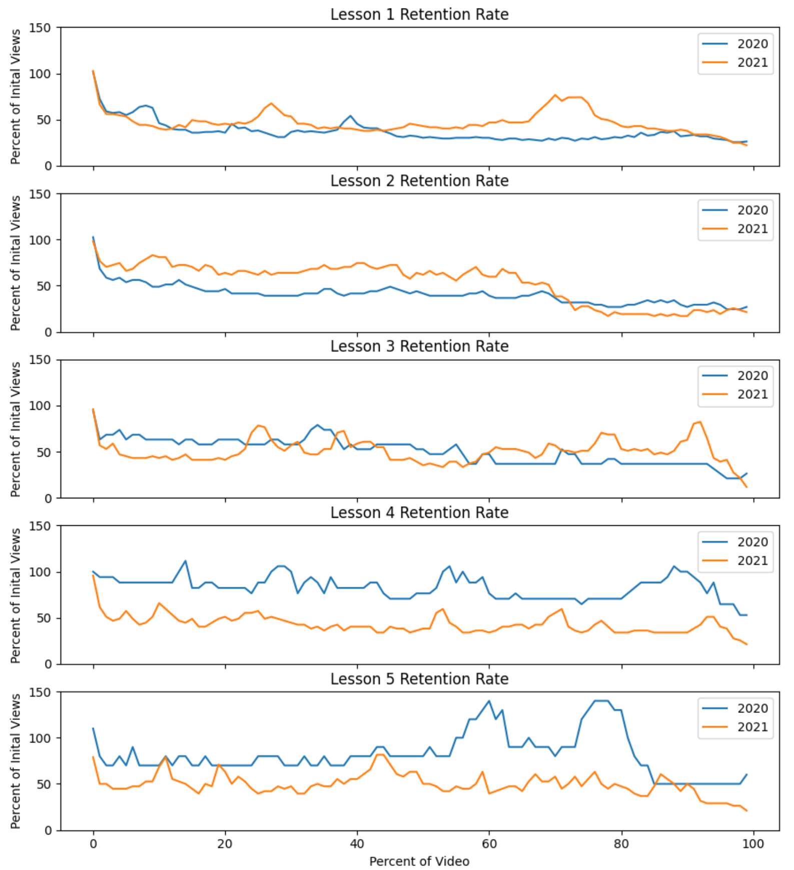

Figure 3: Retention by Activity, measured by percentage of total viewers watching at each timestamp throughout video, shown as the percentage of video playback. Peaks appear where viewers watched sections of video multiple times, and troughs are sections of video that viewers skipped.

activities may have been more likely to watch the entire video. Second, the 2021 video had significantly more consistent average retention rates across the five activities than the 2020 year, echoing the same consistency seen in the number of views between the two years.

These average retention rates are recapped in Table 4. Notice that the average and standard deviation are given for each year. While the average was higher for the 2020 year, the standard deviation was nearly six times larger, indicating that the 2021 activities had less variability in the amount of retention across the activity. This is likely indicative of fewer highly motivated students reaching the fourth and fifth activities in the 2020 camp versus many students at least attempting each activity in the 2021 camp.

4.1.3 Views per Viewer

Next consider the views per viewer, describing the number of times a video was viewed by the average unique student. For the first activity, the 2020 video had more views per student than in 2021 for the 14 days that it was available. The second activity had a similar number of average views per viewer during the span of time that both camps were available online.

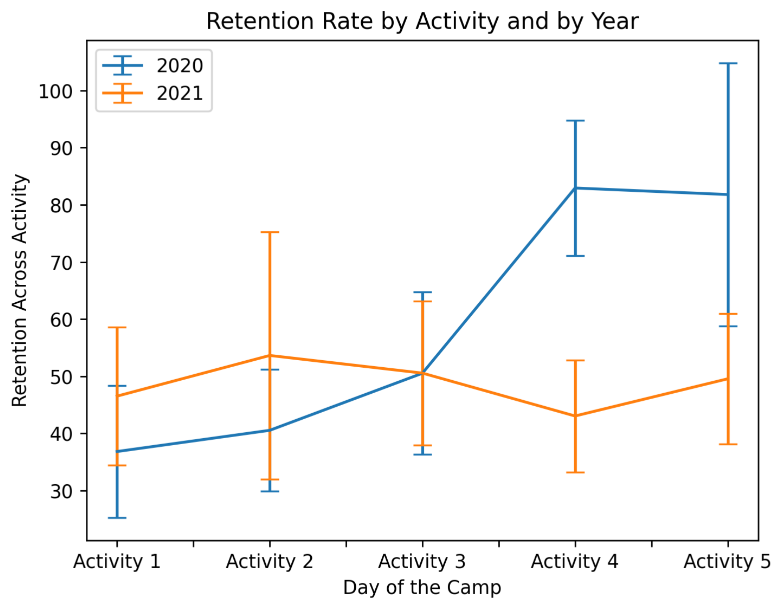

Figure 4: Average retention rate across each video for the five activities in each camp including a bar showing the standard deviation in retention rates across the full video. For example, Activity 5 in 2020 had a high retention rate, however the retention rate at any given part of the video varied greatly.

In activities 3-5, the 2021 videos generally had more views per viewer even in the early days of video access, suggesting more student engagement as the camp progressed.

It is important to note that the 2021 videos continued to have consistent views per student while the material was available, even though the material was available more than three times as long, indicating that providing the material for a longer amount of time was beneficial. These results are plotted in Figure 5.

Views per viewer is an important metric to consider when looking at total view counts on each video. YouTube's criteria for counting views include: 1) the viewer initiates playback; 2) the viewer watches at least 30 seconds of the video, which do not need to be consecutive. View counts are not limited by unique viewers, meaning that if a unique camp attendee watched a video multiple times, each time they met the two previously stated requirements, YouTube would count a view. For example, if one fifth grader watched the first 30 seconds of Activity 1 five times, then five views would be added to the total view count. Thus, using the average views per viewer and the total view count, it is possible to determine the number of unique views of each video.

The unique views, listed in Table 4, suggest that camp attendees remained much more engaged during 2021 than in 2020. The video with the highest number of unique views across both years was Activity 1 in 2020, with 63 unique views (13 more than Activity 1 in 2021). In 2020, unique views dropped precipitously for each video after Activity 1, decreasing by more than half three times: once between videos one and two, a second time between videos two and four, and again between videos four and five. Only 5 students persevered through the final activity that year.

Table 3: Average retention rates across the full activity for 2020 and 2021. the comparison of retention rates for each activity. The retention rates are normalized to the percentage of viewers watching at a particular moment that loaded the video at 0%. Note that a higher retention rate, therefore, does not imply a higher number of views, simply the percent of the audience that was retained at a given moment.

	Avg. Retention Rate	
	2020	2021
Activity 1	36.83%	46.52%
Activity 2	40.55%	52.64%
Activity 3	50.53%	50.55%
Activity 4	82.94%	43.04%
Activity 5	81.80%	49.55%
Average	58.53%	48.46%
Std. Dev.	19.98%	3.35%

Unique views in 2021 were much higher and much more consistent than in 2020. The lowest number of unique views in 2021 was 23 for Activity 4. Despite having the lowest unique viewers for 2021, this video still had a similar number of views as video two in 2020, and had more views than 2020's video three, four, and five. While unique views also dropped throughout the 2021 camp, a higher of number of camp attendees were maintained throughout all five activities; the 2021 camp finished with 25 unique views of the final video, five times more than in 2020.

4.1.4 Watch Time

Next consider the watch time, describing the total hours per day the videos were watched (across all viewers). The watch time of each video per day shows that camp attendees in 2020 watched each video according to the camp schedule while 2021 attendees watched the videos more regularly at their own pace. The 2020 activities each had a peak day for watch time, which generally corresponded with the camp schedule, but greatly decreased as the camp went on. On the first day of camp in 2020, camp attendees watched the first video for 4.8 hours. They watched the second video for 1.1 hours on day two of the camp (slightly less than the 1.3 hours they watched this video on day 3), the third video for 2.1 hours on day three, the fourth video for 1.1 hours on day four, and the fifth video for hours 0.5 hours on day five. Besides these peak days, watch time in 2020 was much lower, with less than one hour per day for all of the videos except video one, which seemed to continue to receive higher numbers until finally falling on day five of camp. In 2021, rather than having peak days, watch time was spread out while the videos were available, indicating a more relaxed pace for students. These results are plotted in Figure 6.

Considering the total watch time for each video (Table 4), there was a clear decrease in watch time per activity in 2020, but not in 2021. Comparing the total watch time of each video is complicated by video length. In 2020, videos 4 and 5 were much shorter than the other videos that year, so it would be expected for the total watch time of those activities to be less. However, in 2020, the total watch time from Activity 1 to Activity 5 decreased by

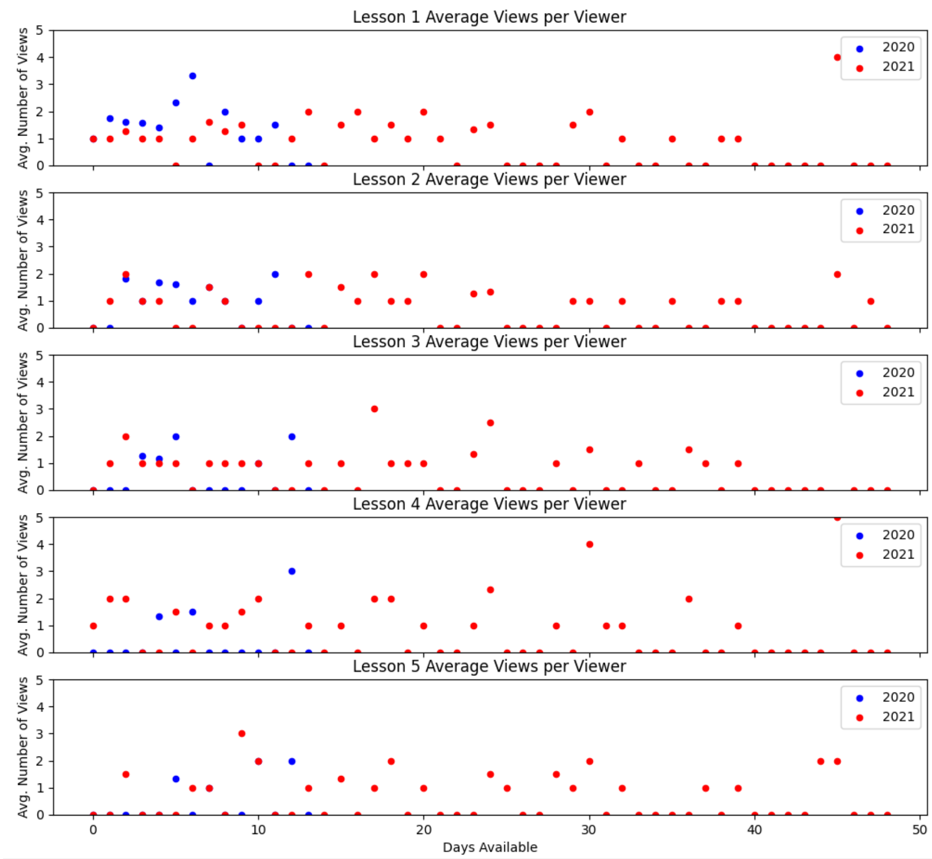

Figure 5: Average Views per Viewer by Activity

88.2%, while the final video was only 35.3% shorter than the first. Conversely, in 2021, while each video generally increased in length, the total watch time increased from activity 1 to activity 3, and then decreased from activity 3 to activity 5, ending close to where it started. In 2021, there was only a 5.2% decrease between total watch time from activity 1 to activity 5, while the final video was 51.1% longer than the first. This suggests that camp attendees were much more engaged with 2021 activity material, despite longer video lengths.

The same conclusion can be drawn from looking at the total watch time in comparison to the total length of video content in each year. In 2020, all of the activities totalled to 1:08:33, X% less than in 2021, which was a total of 1:43:14 long. Comparatively, the total amount of watch time in 2020 was 21.2896 hours, X% less than in 2021, which was 37.0837 hours.

4.1.5 Comprehensive Viewership Results Recap

Finally, the viewership data was analyzed holistically. Full analysis of the data requires considering the total views, retention rates, views per viewer, and watch time statistics together. A brief overview of the data is displayed in Table 4.

Some of the interactions between metrics were previously discussed. Recall that the total views divided by the views per viewer results in the total unique viewers. While a higher

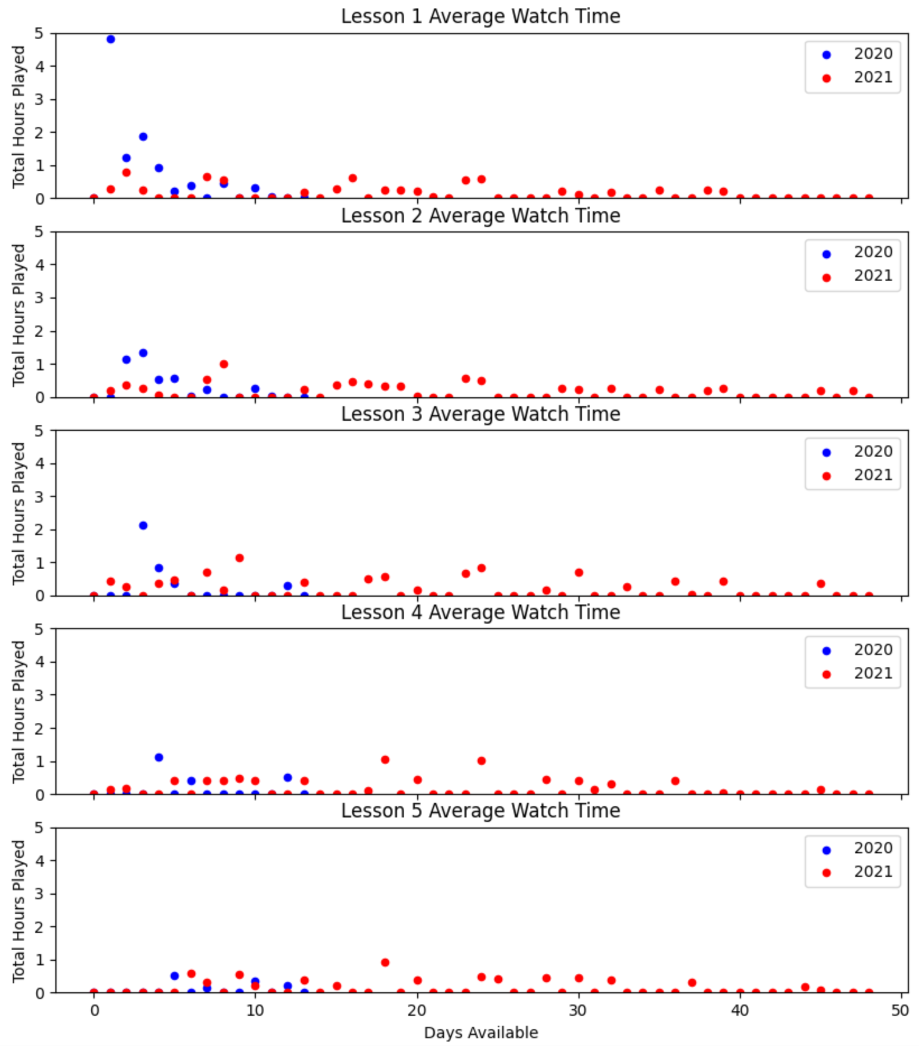

Figure 6: Watch Time By Activity

number of views and a higher number of views per viewer both suggest higher engagement in activities, higher views per viewer also mean that the total views are from fewer unique students. Further, higher retention rates with fewer unique views suggest high engagement, but only in a small number of camp attendees. Also, higher total watch time suggests more engagement, but is complicated by video length because longer videos naturally gather more watch time.

More conclusions can be drawn by looking at the data together. Consider the average video length, which increased by X% from the 2020 camp to the 2021 camp. The average view duration saw a significantly less increase while the number of views was better maintained, meaning that students may have been okay with the amount of content, but would prefer to see the videos in three or four shorter videos. This conclusion is further strengthened by considering average view duration and video length together. Despite video length, average view duration was almost always less than ten minutes, suggesting camp attendees may have about that much tolerance for video length, which should be considered in activity planning for future camps.

Table 4: Summary of Video metadata and view statistics

Year	Video	Video Length	Total Views	Avg. Views per Viewer	Unique Views	Avg. View Duration	Avg. Retention	Watch Time (hr)
2020	Activity 1	14:37	127	2.0159	63	04:51	36.83%	10.2988
	Activity 2	15:10	43	1.7200	25	05:39	40.55%	4.0566
	Activity 3	20:05	22	1.2941	17	09:57	50.53%	3.6506
	Activity 4	09:14	18	1.5000	12	06:52	82.94%	2.0632
	Activity 5	09:27	9	1.8000	5	08:08	81.80%	1.2204
	Total	1:08:33	219	1.666	122	-	-	21.2896
	Average	13:43	43.8	1.6660	24.4	07:05	58.53%	4.2579
	Std. Dev.	04:03	43.1	0.2487	20.4	01:49	19.98%	3.1920
2021	Activity 1	11:59	77	1.5400	50	05:15	46.52%	6.7442
	Activity 2	19:32	47	1.3824	34	09:25	52.64%	7.3881
	Activity 3	24:02	52	1.5758	33	10:31	50.55%	9.1223
	Activity 4	24:13	47	2.1364	23	09:29	43.04%	7.4324
	Activity 5	23:28	39	1.5600	25	09:50	49.55%	6.3949
	Total	1:43:14	262	-	165	-	-	37.0837
	Average	20:39	52.4	1.6389	33	08:54	48.46%	7.4164
	Std. Dev	04:40	12.99	0.2582	9.5	01:49	3.35%	0.9388

4.2 Developer Processes and Reflections

There were two content creators for the TACoS summer camps. During the first virtual summer camp, only one developer was assigned since the camp had been offered many times before and at the time of assignment, the camps were expected to be held in person as usual. During the second virtual summer camp, three content creators were utilized to bolster the computer science course after the rapid platform shift the previous summer.

Developer 1: When I was presented with the opportunity to work on and develop TACoS all I could think was "wow, I wish I had this when I was their age." I feel extremely lucky I was introduced to the Computer Science field at a relatively young age by a relative and I was very excited to be able to give exposure to the field to young students. I think a major obstacle preventing people from going in to CS is just not knowing it exists or having knowledgeable people to ask about it. I tried to develop TACoS activities in a way that would show some of the exciting technology available to work and play with and provide that (potentially first) experience with programming and other computer science concepts. Making the shift to being completely online presented some unique struggles. We had to put ourselves in the shoes of someone who is being introduced to CS for the time and think through any hiccups they might encounter and address those proactively since we didn't have a synchronous way to answer questions as they did the activities.

Developer 2: Even though the timeline for TACoS in 2021 was much more forgiving than in 2020, we were still on a very tight schedule. Luckily, we had materials and course organization (a website paired with videos for each day) from the previous year to work with. We spent some time brainstorming as a group, deciding what hardware we might like to teach with, what the big final project would be, and the best way to cover the necessary materials. Then, we planned activities and activities for each of the five days accordingly and updated the website with new modules. We had enough people on the team to assign one day of activities to each person, so this phase was completed very quickly. As we completed the courses for each day, I recorded and edited each of the videos and sent them to our team for final reviews. I wanted them to be pleasant to watch, so I created animations, demonstrations, and step-by-step guides to make the videos visually pleasing and easy to follow. By far, the most time-consuming part of the process was making the videos, but I felt that the extra effort and long hours were necessary and well worth it to deliver the best possible product that we could.

Developer 3: Computer science is a limitless field and being able to provide the next generation with accessible computer science education is a dream. While creating the activities, I tried to keep the examples fun and applicable. I really enjoy writing programs, big or small, that have some visual component. For example, one program involved creating a light sensitive flashlight/night light that would get brighter as the environment got darker. I immediately felt like a kid at heart hiding the MicroBit under the desk or putting it next to a light to simulate different environments. At a younger age, education is about engagement and excitement, and I really tried to cater to those needs.

4.3 Parent Evaluations

In 2020 and 2021 parents and students were given a survey to complete together following the end of the week-long TACoS summer camp. This survey was a broad survey, covering all four TACoS sessions. In 2020, 24 parents submitted surveys, and 13 parents responded in 2021. Note that this is a low overall response rate, as the camp had between 40-80 students each year.

In 2020, out of 24 completed surveys, 7 parents/guardians reported that their student attempted the computer science sessions but were unable to complete the course. In addition to these seven students, one child indicated not having done the computer science portion of TACoS at all, but their parent did not indicate this in the "Which sessions did your student attempt but not finish" question (they marked "None of the Above," perhaps indicating that the student did not even begin the course). According to the data available, 66% of students completed the computer science sessions in 2020. In 2021, 6 of 13 surveys indicated students did not finish the computer science course, suggesting a 54% completion rate. However, it is important to posit why students may not have finished the computer science course. A few comments from parents provide some insight. Surveys from both 2020 and 2021 suggested that some students may simply not have time to complete the entire virtual TACoS camp in one week:

> "This was an amazing program with amazing materials and instructors. Thanks so much! She (E) struggled with the micro bit, but learned a lot and we plan on

doing the website tutorial for determining if a plant needs water. We just needed more time, but it is so cool! (E) and I are really impressed with the program and she'd love to do it again! Thanks again!" (2020)

"...He saved the Computer Science project for last and was unable to complete it, but that was because he waited too long and it was after the meeting times with the teachers were available." (2021)

One comment from the 2021 survey indicated that the computer science material proved to be some of the most difficult to transfer to an online platform due to the collaborative nature of the debugging process commonly facilitated during in-person programming sessions:

"The only reason he didn't finish the very last module of the computer science part was that he had an error in the one before, which made the game not work quite right and got frustrated. I didn't have time to examine it very closely and your folks were traveling so it got lost in the shuffle of our lives. Before that he was enjoying figuring it out and getting the microbit to do things.

If you [don't] want the "how much time spent" on each project ranked (and I'm not sure my rankings are accurate) I would have marked them all moderate. We spent about the same time on them all though I wasn't watching the clock. We did the ones I though would most interest him first, so that it would engage him and get him motivated to do all of them. They were all fun." (2021)

This comment also highlights the value of parent/guardian help, which may be integral to student engagement and success. It is difficult to draw specific conclusions based on parent involvement and time commitment because while many of the successful camp attendees appear to have had ample help from their guardians, parents of many of the students who did not complete the course also reported a high time commitment spent on activities. While parents can help their children succeed, they may also spend a significant amount of time struggling with their child if something in the activity is confusing or not working. Without specific feedback from parents, it is difficult to determine exactly what the case may be, but we can still draw insight from this metric.

Another important consideration is that a student's failure to complete the course does not necessarily indicate a lack of engagement; it could instead be indicative of a lack of time, a slow pace, etc. This is highlighted in another parent comment:

"The videos were great. Camp came together well. Hopefully, the videos will stay posted and we can finish the eventually finish the activities." (2020)

This comment in particular sheds light on a desire for continued access to camp materials, suggesting that leaving videos up for an extended period of time is beneficial.

5 Limitations and Implications

5.1 Discussion

Recall that viewership data for each video (quantitative) and parent evaluations as well as developer reviews (qualitative) were utilized in assessing the two summer camps. Two main questions were investigated and this section is dedicated to answering these questions via conclusions made from the quantitative and qualitative results.

5.1.1 Question 1: How does video quality impact student participation and engagement?

5.1.2 Question 2: How does the length of time that content is accessible affect how students engage with course material?

5.2 Limitations

The quantitative results were based on the viewership data gathered through YouTube's analytics. While it is expected that the viewership data is reflective of the students' engagement, this data cannot be guaranteed to be solely student data. It could be that parents also viewed the information and that while this likely still increased student participation, that would reflect in a different way than how students interacted with the material (i.e. - through parental guidance) rather than a conclusive correlation between video quality and student engagement. Likewise, it is possible that some views can be attributed to other TACoS teachers and organizers, or even our own team, ensuring proper uploads. These views would most likely be short and not representative of student engagement.

Further, analyzing retention rates is complicated by multiple factors. For example, the type of activity (the balance between time spent listening and time spent programming) influences the way a student will interact with the video. Because the individual viewership statistics interact with each other, care had to be taken in how the results were displayed and that they were considered separately as well as together.

The qualitative results were based on the reviews from the parents of the students attending. This sort of evaluation was limited because it polled the parents instead of the students themselves and because the evaluations were for the whole camp, rather than being a comprehensive review of the computer science portion of the camp. The parents were polled instead of the students because student evaluations can be easily swayed by auxiliary factors such as the computer science course being before lunch. Because the computer science portion was only one part of the camp, only a few of the questions could be focused on strictly the computer science videos.

5.3 Future Work

In future camps, videos should be broken up into smaller segments with more time spent programming than listening. Recall that the average view duration saw very little increase as the length of the videos increased, even when student retention and the number of views was maintained. This indicated that students were interested in the material, but staying actively engaged in the material for longer than nine minutes proved difficult. Further, parent and student reviews included comments requesting shorter videos.

Additionally, a more in-depth analysis of the data could be accomplished to give a better balance between quantitative and qualitative data. This could be achieved by asking for a short review at the end of each lesson. Lastly, as future camps begin to have less restrictions on in-person learning, these activities may be able to support hybrid activities with a mix of in-person and online content.

6 Conclusion

The University of Wyoming has offered a series of summer camps and professional developments that provide exposure of computer science topics to students and teachers in rural rocky mountain areas. TACoS, is a week-long summer camp that has offered annually for up to 80 upcoming 5th and 6th graders each year since 2015. While this analysis focused on the computer science class, the program includes a variety of science, technology, engineering, and mathematics (STEM) activities. In 2020 and 2021, TACoS ran virtually due to COVID-19, revealing a unique opportunity to compare two instances of the CS section of the program. Both of these camps included five 20–30-minute videos for the computer science course, a corresponding website for students to follow, and physical components that were mailed to each student prior to the course. After the first year, course developers attempted to improve the computer science activities through tactics including attention to video quality, fresh course content for repeat-attendees, and further streamlined lesson plans. In the second virtual year, students were given access to course material for a longer amount of time, as content remained available for a month instead of only during the camp week.

This study answered two questions:

1. How does video quality impact student participation and engagement?
2. How does the length of time that content is accessible affect how students engage with course material?

These questions were answered through a quantitative analysis based on YouTube viewership data and additional factors such as the length of each video, the time spent creating and editing the videos, the number of collaborators, the cost of the materials, and the length of time the content was available. The YouTube viewership data included the number of views per activity, the average view duration, the audience retention rate across each video, the average views per viewer, and the lifetime watch time for each video.

These questions were also answered through a qualitative analysis based on parent evaluations and developer reviews. A total of 37 (46%) parent evaluation reviews of the TACoS program were collected, including perspectives of their students. This gave insight on the overall impressions of the camp, the CS program specifically, the students' favorite project/course within TACoS, the course completion rate, the ranked comparison of parents' time spent helping their child with each TACoS program, and general parent feedback. Findings show that there was improvement in the video content which could have invited more participation in the project/course and higher student engagement with the project/course material in the second virtual year. Results also showed that providing the materials for a longer time helped student engage with the activities; however, student engagement dwindled by week six of the seven weeks the content was available for.

References

[1] C. Aritajati, M. B. Rosson, J. Pena, D. Cinque, and A. Segura, “A socio-cognitive analysis of summer camp outcomes and experiences,” in *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, 2015, pp. 581–586.

[2] K. M. Braswell, J. Johnson, B. Brown, and J. Payton, “Pivoting during a pandemic: Designing a virtual summer camp to increase confidence of black and latina girls,” in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 2021, pp. 686–691.

[3] A. Burrows, M. Lockwood, M. Borowczak, E. Janak, and B. Barber, “Integrated stem: Focus on informal education and community collaboration through engineering,” *Education Sciences*, vol. 8, no. 1, p. 4, 2018.

[4] H. L. Gibson and C. Chase, “Longitudinal impact of an inquiry-based science program on middle school students’ attitudes toward science,” *Science education*, vol. 86, no. 5, pp. 693–705, 2002.

[5] S. Klotzkin, H. S. Kimmel, and D. Klotzkin, “A hands-on online summer arduino workshop for middle school students,” in *Middle Atlantic ASEE Section Spring 2021 Conference*, 2021.

[6] X. Kong, K. P. Dabney, and R. H. Tai, “The association between science summer camps and career interest in science and engineering,” *International Journal of Science Education, Part B*, vol. 4, no. 1, pp. 54–65, 2014.

[7] M. J. Mohr-Schroeder, C. Jackson, M. Miller, B. Walcott, D. L. Little, L. Speler, W. Schooler, and D. C. Schroeder, “Developing middle school students’ interests in stem via summer learning experiences: S ee b lue stem c amp,” *School Science and Mathematics*, vol. 114, no. 6, pp. 291–301, 2014.

[8] S. Wolf, F. P. Moss, R. Manandhar, M. Cooley, R. Cooley, A. C. Burrows, and M. Borowczak, “Building collaboration and securing interest in computer science education through outreach opportunities,” in *2019 ASEE Annual Conference & Exposition*, 2019.

[9] S. Wolf, A. C. Burrows, M. Borowczak, M. Johnson, R. Cooley, and K. Mogenson, “Integrated outreach: Increasing engagement in computer science and cybersecurity,” *Education Sciences*, vol. 10, no. 12, p. 353, 2020.

[10] M. Yilmaz, J. Ren, S. Custer, and J. Coleman, “Hands-on summer camp to attract k–12 students to engineering fields,” *IEEE transactions on education*, vol. 53, no. 1, pp. 144–151, 2009.

[11] K. J. Krapcho and C. Furse, “Lessons learned developing an engaging engineering summer camp,” in *2014 ASEE Annual Conference & Exposition*, 2014, pp. 24–861.

[12] D. U. Bolliger and F. Martin, “Instructor and student perceptions of online student engagement strategies,” *Distance Education*, vol. 39, no. 4, pp. 568–583, 2018.

[13] M. D. Dixson, “Creating effective student engagement in online courses: What do students find engaging?.” *Journal of the Scholarship of Teaching and Learning*, vol. 10, no. 2, pp. 1–13, 2010.

[14] A. Dwivedi, P. Dwivedi, S. Bobek, and S. S. Zabukovšek, “Factors affecting students’ engagement with online content in blended learning,” *Kybernetes*, 2019.

[15] P. Kahn, L. Everington, K. Kelm, I. Reid, and F. Watkins, “Understanding student engagement in online learning environments: The role of reflexivity,” *Educational Technology Research and Development*, vol. 65, no. 1, pp. 203–218, 2017.

[16] J. Looyestyn, J. Kernot, K. Boshoff, J. Ryan, S. Edney, and C. Maher, “Does gamification increase engagement with online programs? a systematic review,” *PloS one*, vol. 12, no. 3, p. e0173403, 2017.

[17] K. Subramanian and K. Budhrani, “Influence of course design on student engagement and motivation in an online course,” in *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 2020, pp. 303–308.

[18] S. Young and M. A. Bruce, “Classroom community and student engagement in online courses,” *Journal of Online Learning and Teaching*, vol. 7, no. 2, pp. 219–230, 2011.

[19] M. D. Dixson, “Measuring student engagement in the online course: The online student engagement scale (ose).” *Online Learning*, vol. 19, no. 4, p. n4, 2015.

[20] O. Farrell and J. Brunton, “A balancing act: a window into online student engagement experiences,” *International Journal of Educational Technology in Higher Education*, vol. 17, no. 1, pp. 1–19, 2020.

[21] S. Kim, J. W. Kim, J. Park, and A. Oh, “Elice: an online cs education platform to understand how students learn programming,” in *Proceedings of the Third (2016) ACM Conference on Learning@ Scale*, 2016, pp. 225–228.

[22] A. E. Weinberg, C. G. Basile, and L. Albright, “The effect of an experiential learning program on middle school students’ motivation toward mathematics and science,” *RMLE Online*, vol. 35, no. 3, pp. 1–12, 2011.