ISSN: 1309 – 6575
Eğitimde ve Psikolojide Ölçme ve Değerlendirme Dergisi
Journal of Measurement and Evaluation in Education and Psychology
Research Article; 2023; 14(Special Issue); 332-344

Design and Development of an Interactive Video Player for Supporting Formative Assessment in Online Learning

Alper BAYAZIT* Gökhan AKÇAPINAR**

Abstract

In this study, the aim was to design a video player with embedded quizzes to enhance students' interactions with video learning materials and enable them to derive maximum benefit from these materials. The developed tool is integrated into the Moodle learning management system and presents questions from a question bank to students at predetermined time intervals set by the instructor. Additionally, it records interactions between the student and embedded quizzes, such as the number of attempts and the number of correct or incorrect answers. Furthermore, students' video interactions, encompassing actions like play, pause, and seek, are also stored in the database. The tool allows instructors to export 15 features related to students' videos and embedded quiz interactions. Consequently, students can assess their comprehension of the content they are viewing and receive immediate feedback, while instructors can access summary reports for all students. This enables them to find out how many students have watched the videos and their responses to the questions before or after the class. This paper explains the development process of the tool and presents findings from a pilot study utilizing the tool. The results of the pilot study revealed that students' video-watching behaviors in interactive videos differed from those in non-interactive videos. An interactive video player that allows embedding quiz questions to support formative assessment in online learning environments, can be advantageous for researchers, instructors, and learners.

Keywords: video analytics, in-video quizzes, interactive videos, video-based learning, online learning

Introduction

Due to the prevalence of mobile devices, the increasing number of Internet users, and the frequent utilization of online learning, video technology in education has advanced faster than ever (Sablić et al., 2020). According to Lacey and Wall (2020), utilizing video-based learning materials can improve student satisfaction (Üstün, 2023), student learning (Yoon et al., 2021), provide helpful feedback (Dohms et al., 2020), and increase student engagement (Mohammadhassan & Mitrovic, 2022). Additionally, using these materials can prepare students for real-world examinations (Lacey & Wall, 2020; Weeks & Horan, 2013), reduce test anxiety (Tripodi, 2018), enhance performance (Weeks & Horan, 2013), and lead to successful learning outcomes (Zaneldin et al., 2019). The importance of video materials is increasing for both students and teachers in flipped classrooms (Bakla & Mehdiyev, 2022; Rose et al., 2016; Xiu et al., 2018), hybrid, or distance learning environments (Barut Tugtekin & Dursun, 2022).

Crook et al. (2012) reported that students who only engage with video materials often need help receiving feedback. Furthermore, Montayre and Sparks (2018) have also found that they complain about the lack of interaction. Therefore, the students must understand if they have achieved the course objectives and need tools to test their knowledge. Furthermore, instructors need to know their students' level of interaction and progress to plan learning activities effectively. In-video quizzes offer an engaging and interactive way to learn new information (Cummins et al., 2016). Integrating formative assessment components into video materials can help learners improve their learning scores (Rice et al., 2019). In a way that is challenging in a traditional classroom environment, receiving immediate and individual feedback (Mirriahi et al., 2021) can make hybrid or online learning more effective.

* Asst. Prof. Dr., Ankara University, Faculty of Medicine, Ankara-Turkiye, e-mail: abayazit@ankara.edu.tr, ORCID ID: 0000-0003-4369-587X
** Assoc. Prof. Dr., Hacettepe University, Faculty of Education, Ankara- Turkiye, e-mail: gokhana@hacettepe.edu.tr, ORCID ID: 0000-0002-0742-1612

To cite this article:
Bayazıt, A., & Akçapınar, G. (2023). Design and Development of an Interactive Video Player for Supporting Formative Assessment in Online Learning, *14*(Special Issue), 332-344. https://doi.org/10.21031/epod.1286077

Received: 20.04.2023
Accepted: 10.09.2023

The instructors can use interactive in-quiz videos and integrate video interaction data to track students' progress in video-based learning. Researchers use video analytics to measure students' viewing behaviors, including the frequency of seeking, playing, and pausing (Yürüm et al., 2022). This data is analyzed to understand their viewing strategies (Akçapınar & Bayazıt, 2018; Yoon et al., 2021) and engagement with the course materials (Ifenthaler et al., 2023; Mohammadhassan & Mitrovic, 2022). Students may alter their approach to watching educational videos depending on their goals. As a result, their viewing strategies may vary (Yoon et al., 2021). Video analytics metrics, such as play, pause, seek, etc., can visually represent quantitative interaction data for a specific video timeline. Visual cues can help instructors improve their video material by identifying areas where students must review missed knowledge or replay a section for clarity (Kim et al., 2014). Furthermore, utilizing video analytics metrics can help develop a predictive model that identifies students at risk of underperforming (Mubarak et al., 2020).

In summary, educational videos are commonly used in education because they facilitate visual learning (Chen, 2020; Mohammadhassan & Mitrovic, 2022), improve comprehension (Coakley et al., 2020), and promote memory retention (Seo et al., 2021). Incorporating video-based learning into students' academic experiences can be beneficial, as they serve as multimedia learning tools (Park, 2022) and support asynchronous education (Choe et al., 2019). Students prefer video materials because they connect theoretical knowledge and practical application (Dohms et al., 2020; Evi-Colombo et al., 2022) while fostering essential skills like problem-solving and reflection (Liu et al., 2021), critical thinking, and reasoning (Chen, 2020; Gartmeier et al., 2019). By supporting various designs, they can be utilized to educate individuals in different fields. An example is the diverse learning objectives and content, including lecture lessons, hands-on programming tasks (Atapattu & Falkner, 2018), surgery training with a head camera and narration (Ahmet et al., 2018), and presentation recordings (Chorianopoulos, 2018). To support active learning, videos should be designed to be more effective and interactive. Adding questions to videos can help students evaluate their readiness, track their progress, and identify misconceptions. Furthermore, analyzing student interactions through video analytics can offer comprehensive insights into the efficacy of video designs and the learning methods utilized by students. Therefore, this study aims to design and develop an interactive video player for online courses. The rest of the paper explains the development process of the tool and presents findings from a pilot study utilizing the tool.

Literature Review

Formative Assessment and Learning Analytics

Formative assessment is an ongoing, dynamic, and informal evaluation process used in education to track and evaluate students' learning progress (Bell & Cowie, 2001). It provides feedback for students to understand their progress and improve, while also giving teachers insights into the teaching process (Nicol & Macfarlane-Dick, 2004). Therefore, summative assessments are called “assessments of learning” while formative assessments are called “assessments for learning” (Kulasegaram & Rangachari, 2018). Formative assessment can take several forms, including quizzes, discussions, surveys, peer assessments, or self-assessments.

Learning Analytics (LA) enhances learning by analyzing data during education and follows four stages (Clow, 2012). Learners improve their knowledge and skills by engaging in diverse applications across multiple environments. Various sources provide data, such as LMS, online platforms, assessments, digital resources, and student demographics. Machine learning algorithms and statistical methods analyze the data to identify patterns, trends, and relationships (Üstün et al., 2022). Personalized learning and identifying at-risk students are crucial to maintaining student success.

LA can enhance the potentialities of formative assessment, such as by creating materials with automatic formative assessment and creating collaborative activities for students (Barana et al., 2019). LA can enhance the eliciting of students' conceptions, and for investigating these strategies, formative assessment tasks can be used (Stanja et al., 2023). An early warning system can be designed for at-risk

students, or personalized assignments based on student errors can be given (Rodríguez-Martínez et al., 2023).

Video Analytics Tools

Video analytics give insight into the teaching and learning process (Giannakos et al., 2015). Student engagement, interest, and behavior data can be measured through metrics such as the number of video view, play and seek (Bakla & Mehdiyev, 2022; Brinton et al., 2016; Seo et al., 2021). Using video timeline data, students get personalized content recommendations based on their interactions and preferences (Belarbi et al., 2019). Video analytics also offers automated assessment and feedback (Chatti et al., 2016). By analyzing video interactions, instructors can provide individualized feedback to students based on their challenges, assess the effectiveness of their videos, or understand the learning gaps.

Previous studies investigated the students' video interactions to understand the students' learning strategies, learner profiles, engagement with the materials, active learning processes, and performance predictions. For example, Liao and Wu (2023) analyzed the video log data of 47 graduate students. Four learner profiles were examined based on their learning improvements: the Advanced, the Diligent, the Indifferent, and the Persistent. Students who were diligent and persistent took frequent self-paced breaks to take notes. Advanced students had a high seeking backward frequency, and indifferent students had the highest ratio for seeking backwards, indicating distraction problems. As a result, video-based interactions are a reliable measure of learning motivation. Similarly, Yoon et al. (2021) analyzed student profiles during video-based online learning. Four behavior patterns were found: browsing, socializing, seeking info, and environment setup. These led to two clusters. Active learners, the first cluster, are frequently engaged in social interaction, information seeking, and environment configuration. The second cluster, passive learners, mainly browsed. The study found that active learners achieved higher learning outcomes than passive learners. Zamzuri (2022) analyzed YouTube videos based on student interaction metrics in another study. On average, students only watched one-third of the total video duration. However, they paid more attention during the demonstration sessions, primarily when the whiteboard was used and visualizations were included in the materials. Video analytics can assist in identifying the segments of videos that students tend to watch more frequently. Consequently, this information can be used to make inferences about video design. Yürüm et al. (2022) conducted a quasi-experimental study to examine how interactive videos affect students' engagement and satisfaction. After controlling for motivation, they discovered students were significantly more satisfied with interactive videos. Additionally, students were less likely to revisit essential points and more likely to skip unimportant ones in interactive videos. Their findings suggest that interactive video lectures can convert videos into interactive ones. This research indicates that including formative assessment features in videos can enhance their effectiveness. Combining self-reports and video analytics metrics like play, pause, seek, and question interaction could provide a more comprehensive outcome. In a quasi-experimental study, Mohammadhassan and Mitrovic (2022) examined data from a platform incorporating note-taking, peer-reviewing, and personalized prompts. They compared levels of engagement, such as the number of videos watched and comments, as well as learning gains. The results indicated that visual LA in videos encouraged constructive behavior and enhanced learning outcomes. Various factors, such as time and purpose, can influence video viewing strategies. For example, Seo et al. (2021) showed that students tend to perform more searches within the video during exam weeks and when rewatching videos. After analyzing video analytics tools utilized in previous research, we summarized their advantages and disadvantages for students and instructors in Table 1.

Table 1.

Video platforms used in educational video analytics studies

Tool	Metrics	LMS/MOOC integration	Video Markers	Assessment Features	Tracking Scope
Vimeo	Views, finishes, time watch	Embed	Yes	multiple-choice	Video
Panopto	Play, pause, seek,	LTI	No	multiple-choice	User
Youtube	Views, duration	Embed	No	No	Video
SocialSkip	Play, pause, seek,	Not supported	No	multiple-choice, true/false	User

Vimeo provides paid options with advanced analytics and the ability to include quiz questions. The system cannot directly match with LMS users, only through embedding. This restriction makes it difficult to conduct further investigations. Panopto provides valuable insights into video engagement for businesses and can be integrated with Moodle using the LTI plugin. While it has limitations in matching student IDs and numbers, it does allow for quizzes. However, more information is needed on adding markers to question areas. When analyzing student interactions, YouTube videos only provide video-focused reports and visualizations. Adding quiz questions through Google Classroom can help, but there needs to be a marker in the sections linked to the questions. Integrating with an LMS is possible through embedding, but collecting and analyzing student-based data has challenges. SocialSkip is a helpful plug-in that enables the collection of student interaction data. SocialSkip offers free access to various question types but must be fully integrated with Moodle.

Various educational video analytics tools support collecting metrics such as play, pause, and seek. These tools are typically commercial, with different prices depending on the number of users and videos. Some tools need to be able to connect to Moodle and require separate memberships for data collection. Adding a formative assessment item to a different system while keeping it in a pool in the existing question bank is impractical. Integrating LMS interaction data and video analytics data in the future may be complex due to incomplete user account integration.

Method

This is a tool development study, so from this perspective, details of the tool development process are reported in the method section. The purpose of the developed tool is to provide students with formative assessment during their video-watching sessions so that students can assess their comprehension of the content they are viewing and receive immediate feedback, while instructors can access summary reports for all students.

Components of the Tool

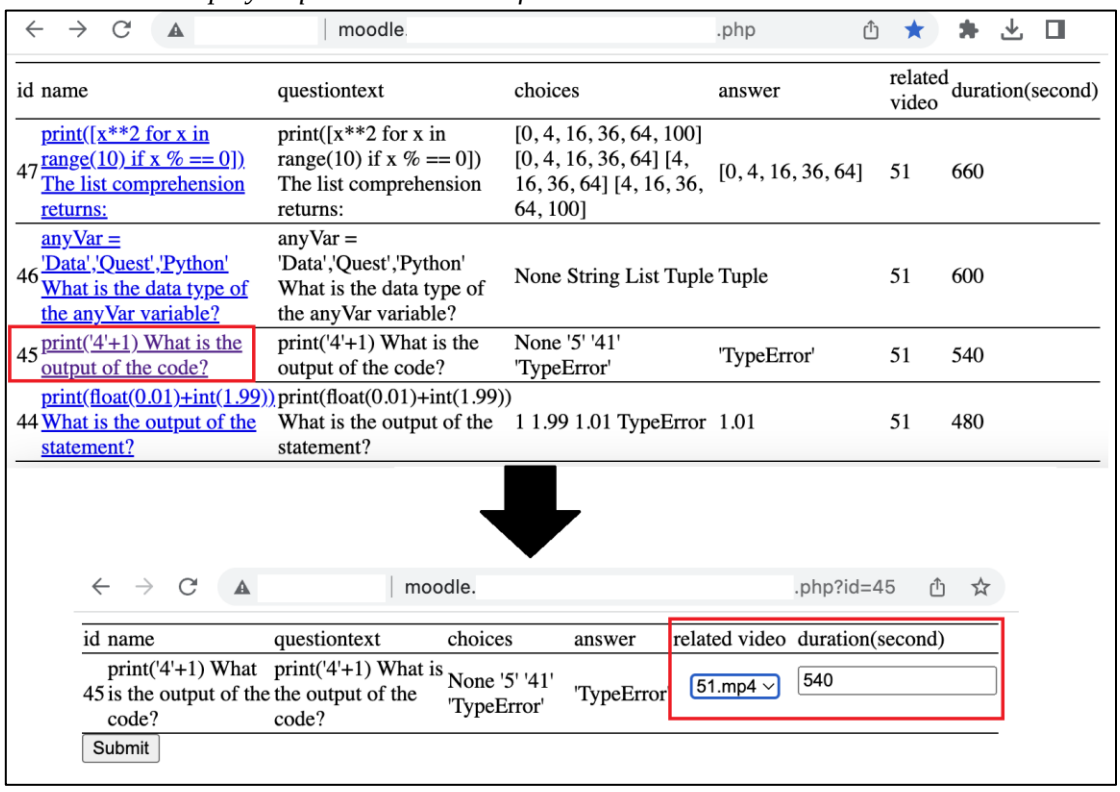
In this study, we designed and developed an interactive video player for supporting formative assessment in the Moodle environment. Moodle is one of the most widely used LMS for blended learning (Üstün et al., 2021; Ustun & Tracey, 2021), distance education, flipped classrooms (Üstün et al., 2022), or other online learning purposes in schools, universities, and other sectors.

The tool's video player component was created using JavaScript and HTML5. Using MySQL queries, interaction data is written to the database. The PHP programming language facilitates data transfer between the server database, assessment items, and video player. Multiple-choice questions in the Moodle question bank can be added using the tool at any point in the video timeline. Markers indicating specific questions can be added to the video timeline, specified in seconds. The student can view each question by directly clicking on a marker. The video pauses at the question marker on the timeline.

Questions associated with the Moodle question bank are displayed with options on the screen below the video (Figure 1). Thus, students can answer the formative assessment items and receive immediate feedback such as "correct answer, congratulations" or "wrong answer, try again". Students can answer the question repeatedly until they provide the correct response. The students' attempts to answer the questions are saved as a log, including interactions such as video play, pause, or seek. Instructors can view all student interactions and their performances in video-based assessments. Teachers and students must sign into the Moodle LMS to create interactive video materials. The multiple-choice questions in the Moodle question bank are listed on a page, including question texts, choices, correct answers, related video material names, and question display time. Teachers can edit the linked videos and the times when the questions are shown by clicking the question name.

Figure 1.

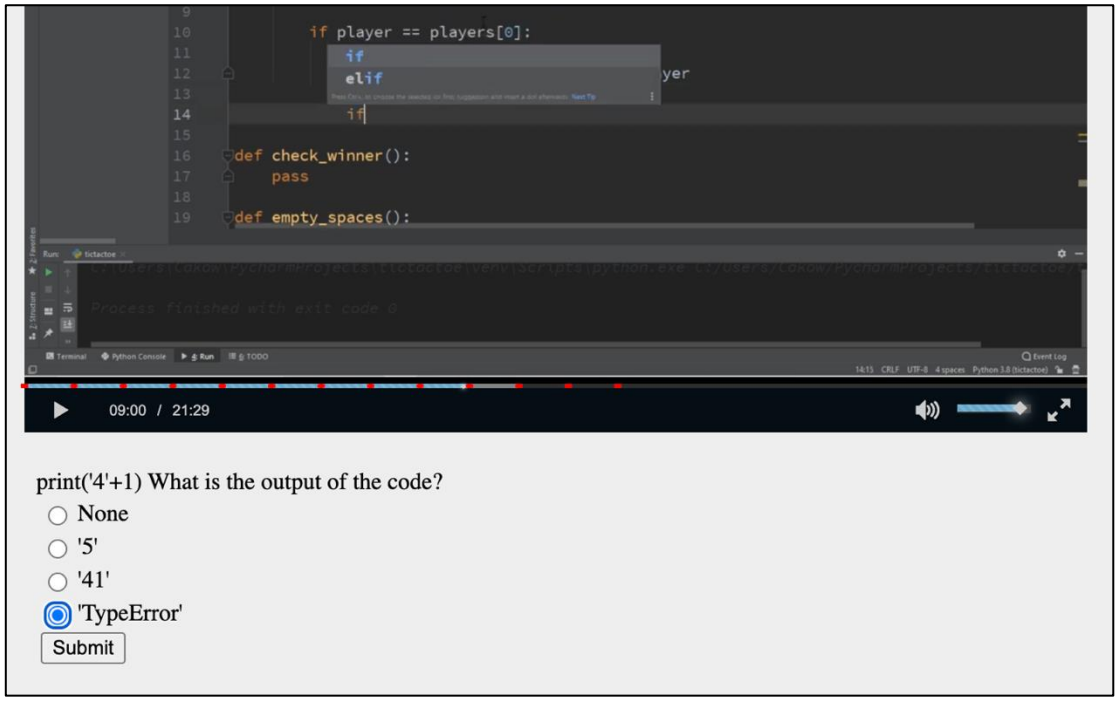
Interactive video player question bank interface



The interactive video player is embedded in the student interface. The tool generates a random ID number for the files submitted to the server to prevent students from accessing video materials through external links. Once students log in to the Moodle LMS, they can access the video link through the weekly course view. In the tables in the Moodle database, video file information, user information, and session information are recorded during the video viewing process. Teachers can also export students' item interactions and video-watching behaviors from the Moodle database as log files.

Figure 2.

Interactive video player student interface



The Interactive Video Player interface consists of three main parts; (1) the video player section where the video player and markers are located, (2) the section where the formative assessment items associated with the video markers are located, (3) the instant feedback area based on the selected options (Figure 2). The video player section allows users to watch videos, view the video duration and the current video time, and use video controls such as play, pause, adjust volume and screen size. In addition, it enables the students to seek forward or backwards while watching a video or to view the assessment items by directly jumping to the question time (by clicking on the marker). The question display area shows the student the items in the question pool at video time. In the feedback area, the answers to the questions are given with the knowledge of whether they are right or wrong. Based on the feedback, the student can either press the "play" button to keep watching the video or seek over the timeline to try to clear up any misunderstandings.

In summary, the tool that is integrated works with Moodle LMS and makes sure that the assessment items in the question bank show up at the correct times on the timeline in the student video-watching tasks. So students can receive instant feedback and increase their interaction. The teachers can investigate students' interactions with videos and their responses.

Interaction Data

The Interactive Video Player records students' formative assessment and interaction behaviors with videos in a new table created in the Moodle database by adding a single-line record for each behavior. These log records include the Moodle user ID, date and time stamp, interaction type, detailed information about the interaction, and video ID. Each interaction performed represents one row in the related table. In the interaction detail, information about question attempts and video interactions is provided (Figure 3).

Figure 3.

Interactive video player log data

id	userid	sessionid	time	event	detail	videoid
50117	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673087674	8	298 sec. video played.	51
50118	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673087675	11	300 sec. marker time, video paused	51
50119	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673087676	9	300 sec. video paused.	51
50120	394	32e74781bb5b4419be4d16477ba4e1ef	1673087730	8	72 sec. video played.	51
50121	394	32e74781bb5b4419be4d16477ba4e1ef	1673087781	9	121 sec. video paused.	51
50122	394	32e74781bb5b4419be4d16477ba4e1ef	1673087813	16	121 sec., 51 video ID, 38 question ID wrong answer	51
50124	394	32e74781bb5b4419be4d16477ba4e1ef	1673087829	15	121 sec., 51 video ID, 38 question ID correct answer	51
50125	394	32e74781bb5b4419be4d16477ba4e1ef	1673087831	8	121 sec. video played.	51
50129	394	32e74781bb5b4419be4d16477ba4e1ef	1673087891	9	180 sec. video paused.	51
50131	394	32e74781bb5b4419be4d16477ba4e1ef	1673087950	16	180 sec., 51 video ID, 39 question ID wrong answer	51
50133	394	32e74781bb5b4419be4d16477ba4e1ef	1673087956	16	180 sec., 51 video ID, 39 question ID wrong answer	51
50136	394	32e74781bb5b4419be4d16477ba4e1ef	1673087970	16	180 sec., 51 video ID, 39 question ID wrong answer	51
50137	394	32e74781bb5b4419be4d16477ba4e1ef	1673087973	15	180 sec., 51 video ID, 39 question ID correct answer	51
50138	394	32e74781bb5b4419be4d16477ba4e1ef	1673087998	8	180 sec. video played.	51
50139	394	32e74781bb5b4419be4d16477ba4e1ef	1673088001	9	182 sec. video paused.	51
50140	394	32e74781bb5b4419be4d16477ba4e1ef	1673088006	15	182 sec., 51 video ID, 39 question ID correct answer	51
50141	394	32e74781bb5b4419be4d16477ba4e1ef	1673088009	8	182 sec. video played.	51
50142	394	32e74781bb5b4419be4d16477ba4e1ef	1673088015	9	188 sec. video paused.	51
50144	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673088098	8	300 sec. video played.	51
50145	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673088100	11	301 sec. marker time, video paused	51
50146	404	b6a0fb2d00f91b826c4aa422d9ba77ef	1673088101	9	301 sec. video paused.	51

The raw dataset must be processed to identify the students' strategies during their interactions with the video tasks and assessment items. For this purpose, a data preprocessing tool was developed for the raw data exported. During the data pre-processing, first, the duplicate records were removed. Then, the tool transforms the interactions into quantitative features including the number of video views of the students, video watching behaviors shown in different sessions, video timeline interactions such as play-pause, seek, or marker clicking, number of wrong answers, number of correct answers, and number of question item views. As a result of the preprocessing, the following metrics were discovered regarding the students' interactive video player behaviors:

n_Session: Total number of sessions for watching videos.

n_QuestionMarkerAutoPause: Number of automated pauses by reaching the formative assessment item at a time on the video timeline.

n_QuestionMarkerClick: Number of question views by clicking the marker.

n_QuestionAnswerCorrect: Number of correct answers given to the formative assessment item on the video timeline.

n_QuestionAnswerWrong: Number of wrong answers given to the formative assessment item on the video timeline

n_TotalAction: Total number of interactions (play, pause, seek, etc.) performed on the video.

d_Time: Total time spent watching videos.

n_diffVideoCount: Number of unique video views.

n_VideoLoad: Total number of views of the video page.

n_VideoPlay: Total number of plays obtained by pressing the play button of the relevant video or clicking on a paused video.

n_VideoPause: Total number of pauses obtained by pressing the pause button of the relevant video or clicking on the playing video.

n_VideoSeek: Total number of seeks forward or backward on the video timeline.

n_ForwardSeek: Total number of seek forward behavior on the video timeline.

n_BackwardSeek: Total number of seek backward behavior on the video timeline.

Pilot Study

The pilot study was conducted with second-year medical school students in an elective introductory programming course. The students were given a homework assignment that required them to watch videos and submit their code files. They were given a week to complete each assignment. Students were asked to watch two videos via the developed video player. One with embedded formative assessment questions and the other without interactive features (standard video). The students were first asked to watch a standard video and complete the task of developing a calculator application using Python. The following week, they were asked to watch the interactive video and develop a simple game. Formative assessment items were added to the video timeline for the second task. The game development video has 12 multiple-choice formative assessment questions on the video timeline. The students (N=12) who participated in this pilot study provided 3502 lines of interaction data. Descriptive statistics of the interaction data related to interactive video are given as an example in Table 2.

Table 2.

Sample descriptive statistics of student interaction in the interactive video

Interaction Metrics	Mean	Median	SD
n_Session	1.58	1	.79
n_QuestionMarkerAutoPause	3.42	2.00	4.14
n_QuestionMarkerClick	4.42	2.00	5.90
n_QuestionAnswerCorrect	20.08	20.00	6.42
n_QuestionAnswerWrong	7.25	7.50	4.16
n_TotalAction	123.58	111.50	41.77
d_Time	53.00	50.00	16.17
n_diffVideoCount	1.00	1.00	.00
n_VideoLoad	2.58	2.50	1.17
n_VideoPlay	40.92	31.00	23.43
n_VideoPause	40.67	31.50	23.78
n_VideoSeek	3.25	2.00	4.64
n_ForwardSeek	1.83	.00	4.30
n_BackwardSeek	1.17	.50	1.40

Students were given a single video; therefore, a different video count metric is one (*diffVideoCount*). Students typically finish the task in one or two sessions (*n_Session*). Regarding formative assessment items, it may be claimed that students engage with them frequently (*n_QuestionAnswerCorrect*, *n_QuestionAnswerWrong*). While some students see the questions immediately by clicking the marker (*n_QuestionMarkerClick*), others wait until the video pauses automatically (*n_QuestionMarkerAutoPause*). In addition, students showed more playing and pausing (*n_VideoPlay*, *n_VideoPause*) behavior than seeking forward or backward (*n_ForwardSeek*, *n_BackwardSeek*). Students tend to watch coding video tasks linearly because these tasks often use the demonstration strategy.

The watching behaviors of the paired students (N=9) in the two videos were compared in terms of the main metrics (play, pause, seek). As a result of the Wilcoxon Signed-Rank test (see Table 3), there is a significant difference in the seeking backward variable from the main metrics, such as video play, pause, and seeking forward and backward. The number of seeking backwards in the interactive video task is greater than the number of seeking backwards in the non-interactive videos ($z = -2.88$, $p = .02$). As a result; the Interactive Video Player provides essential information about the monitoring processes for students' videos containing formative assessment. Analyzing the data makes it possible to identify students' video-watching behaviors, make comparisons, and determine their strategies.

Table 3.

Comparison of interaction metrics in interactive and non-interactive video players

Metrics	Non-Interactive Video Player		Interactive Video Player			
	Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks	z	p
n_VideoPlay	3.25	13.00	6.40	32.00	-1.13	.26
n_VideoPause	3.50	14.00	6.20	31.00	-1.00	.31
n_ForwardSeek	4.83	14.50	5.08	30.50	-.95	.34
n_BackwardSeek	1.50	1.50	4.93	34.50	-2.32	.02

Discussion

The objective of researchers is to enhance the interactivity of classroom video materials to engage students better and facilitate their learning. (Fatima et al., 2019; Seo et al., 2021; Yürüm et al., 2022). Including video assessment segments can enhance the learning experience and provide valuable feedback (Mirriahi et al., 2021). Supporting these processes with video analytics can help develop individualized learning environments, identify students' learning strategies (Akçapınar & Bayazıt, 2018), and experience a more effective learning process. Within the scope of this study, a tool has been designed and developed to track the students' question-answering and video-watching behaviors in the video-based learning tasks. Furthermore, this tool is integrated with Moodle LMS question pools and user information. Using the developed script, it is now possible to incorporate formative assessment items from the Moodle LMS question pool into the video timeline. Educators and researchers can also take advantage of this tool.

The tool that has been developed comprises various interaction metrics like play, pause, number of views, and seeks. These metrics are similar to those used to collect video interaction data on Vimeo, Panopto, YouTube, and SocialSkip platforms. It includes formative assessment features like other video analytics tools and superior, unique features that surpass them. First, it contains a video marker and can dynamically add it to the video table for each added question. Thus, different approaches can be revealed while examining video-watching strategies, such as linear watching, progress with direct formative assessment, or watching by seeking forward or backwards. Furthermore, by analyzing the collected metrics, we can evaluate how the strategies are impacted based on whether the questions' answers are accurate. Another note is that this tool was created using PHP programming as an open-source project and seamlessly integrated with Moodle tables. It is possible to incorporate questions from the Moodle question pool into a video uploaded to the Moodle server. This allows for monitoring student interactions and opens avenues for exploring various tasks and evaluation methods Moodle offers in future studies. A significant limitation of the tool is that logging is not possible on the iOS operating system due to its player.

Based on the pilot application results, it was found that student engagement with videos significantly increased when formative features were added to the materials. This indicates that incorporating assessment features can enhance student interaction with educational videos. The findings align with Zamzuri's (2022) study, which noted that active learners engaged more with videos than passive learners. Therefore, we can infer that incorporating formative assessments and videos can promote active learning. Furthermore, Yürüm et al. (2022) noted that students often re-watch key sections in interactive videos. This may have led the students in the pilot study to consider these sections significant based on the feedback they received, resulting in increased interaction. According to Yoon et al. (2021), students with active learner profiles tend to engage with videos and display the behavior of seeking information. In our study, we observed that students tended to watch interactive videos with greater interest and sought less compared to standard non-interactive videos. This suggests that the interactive features of the videos served as a motivating factor for active learning.

In further studies, we will explore how students approach their studies by analyzing their formative assessments and video interactions. Our goal is to understand how these materials aid the learning process and investigate the impact of video-based feedback on their behavior and learning outcomes.

To achieve these objectives, we plan to integrate our tool with different question types (such as matching and filling in the blanks) in Moodle's question pool. This will provide a broader range of questions for students to engage with. Additionally, we will incorporate reporting features for video usage and formative assessments on Moodle. This will enable students to receive automatic feedback based on their learning objectives and progress compared to their peers.

Declarations

Author Contribution: Bayazıt, A.: conceptualization, investigation, methodology, writing - original draft, data curation, data analysis. Akçapınar, G.: conceptualization, methodology, data analysis, writing - review & editing.

Funding: This study was partially funded by the Scientific and Technological Research Council of Turkey (TÜBİTAK) ARDEB 1002, Grant No: 122K549.

Ethical Approval: Approval was obtained from the ethics committee of Ankara University Medical School (I07-429-22, 04 AGU 2022). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent to Participate: All authors have given their consent to participate in submitting this manuscript to this journal.

Consent to Publish: Written consent was sought from each author to publish the manuscript.

Competing Interests: The authors have no relevant financial or non-financial interests to disclose.

References

Ahmet, A., Gamze, K., Rustem, M., & Sezen, K. A. (2018). Is Video-Based Education an Effective Method in Surgical Education? A Systematic Review. *J Surg Educ*, *75*(5), 1150-1158. https://doi.org/10.1016/j.jsurg.2018.01.014

Akçapınar, G., & Bayazıt, A. (2018). Investigating Video Viewing Behaviors of Students with Different Learning Approaches Using Video Analytics. *Turkish Online Journal of Distance Education*, *19*(4), 116-125. https://doi.org/10.17718/tojde.471907

Atapattu, T., & Falkner, K. (2018). Impact of Lecturer's Discourse for Student Video Interactions: Video Learning Analytics Case Study of MOOCs. *Journal of Learning Analytics*, *5*(3), 182-197. https://doi.org/10.18608/jla.2018.53.12

Bakla, A., & Mehdiyev, E. (2022). A qualitative study of teacher-created interactive videos versus YouTube videos in flipped learning. *E-Learning and Digital Media*, *19*(5), 495-514. https://doi.org/10.1177/20427530221107789

Barana, A., Conte, A., Fissore, C., Marchisio, M., & Rabellino, S. (2019). Learning analytics to improve formative assessment strategies. *JE-LKS. Journal of e-learning and knowledge society*, *15*(3), 75-88.

Barut Tugtekin, E., & Dursun, O. O. (2022). Effect of animated and interactive video variations on learners' motivation in distance Education. *Education and Information Technologies*, *27*(3), 3247-3276. https://doi.org/10.1007/s10639-021-10735-5

Belarbi, N., Chafiq, N., Talbi, M., Namir, A., & Benlahmar, H. (2019). A Recommender System for Videos Suggestion in a SPOC: A Proposed Personalized Learning Method. Big Data and Smart Digital Environment, Cham.

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science education*, *85*(5), 536-553.

Brinton, C. G., Buccapatnam, S., Chiang, M., & Poor, H. V. (2016). Mining MOOC Clickstreams: Video-Watching Behavior vs. In-Video Quiz Performance. *IEEE Transactions on Signal Processing*, *64*(14), 3677-3692. https://doi.org/10.1109/Tsp.2016.2546228

Chatti, M. A., Marinov, M., Sabov, O., Laksono, R., Sofyan, Z., Fahmy Yousef, A. M., & Schroeder, U. (2016). Video annotation and analytics in CourseMapper. *Smart Learning Environments*, *3*(1), 10. https://doi.org/10.1186/s40561-016-0035-1

Chen, G. W. (2020). A visual learning analytics (VLA) approach to video-based teacher professional development: Impact on teachers' beliefs, self-efficacy, and classroom talk practice. *Computers & Education*, *144*. https://doi.org/10.1016/j.compedu.2019.103670

Choe, R. C., Scuric, Z., Eshkol, E., Cruser, S., Arndt, A., Cox, R., Toma, S. P., Shapiro, C., Levis-Fitzgerald, M., Barnes, G., & Crosbie, R. H. (2019). Student Satisfaction and Learning Outcomes in Asynchronous Online Lecture Videos. *CBE Life Sci Educ*, *18*(4), ar55. https://doi.org/10.1187/cbe.18-08-0171

Chorianopoulos, K. (2018). A Taxonomy of Asynchronous Instructional Video Styles. *International Review of Research in Open and Distributed Learning*, *19*(1), 294-311. https://doi.org/10.19173/irrodl.v19i1.2920

Clow, D. (2012). The learning analytics cycle: closing the loop effectively. Proceedings of the 2nd international conference on learning analytics and knowledge,

Coakley, A., Bailey, A., Tao, J., Liou, Y. L., Champlain, A., Ander, M., & Lake, E. (2020). Video education to improve clinical skills in the prevention of and response to vasovagal syncopal episodes. *Int J Womens Dermatol*, *6*(3), 186-190. https://doi.org/10.1016/j.ijwd.2020.02.002

Crook, A., Mauchline, A., Maw, S., Lawson, C., Drinkwater, R., Lundqvist, K., Orsmond, P., Gomez, S., & Park, J. (2012). The use of video technology for providing feedback to students: Can it enhance the feedback experience for staff and students? *Computers & Education*, *58*(1), 386-396. https://doi.org/10.1016/j.compedu.2011.08.025

Cummins, S., Beresford, A. R., Davies, I., & Rice, A. (2016, April 25-26, 2016). Supporting Scalable Data Sharing in Online Education. Proceedings of the Third (2016) ACM Conference on Learning@ Scale, Scotland, Edinburgh, UK.

Dohms, M. C., Collares, C. F., & Tiberio, I. C. (2020). Video-based feedback using real consultations for a formative assessment in communication skills. *BMC Med Educ*, *20*(1), 57. https://doi.org/10.1186/s12909-020-1955-6

Evi-Colombo, A., Cattaneo, A., & Bétrancourt, M. (2022). Procedural knowledge acquisition in a second-year nursing course. Effectiveness of a digital video-based collaborative learning-by-design activity using hypervideo. *Journal of Computer Assisted Learning*, *39*(2), 501-516. https://doi.org/10.1111/jcal.12758

Fatima, S. S., Ghias, K., Jabeen, K., & Sabzwari, S. (2019). Enhancing Cognitive Engagement of Pre-clinical Undergraduate Medical Students via Video Cases and Interactive Quizzes in Problem-based Learning. *Cureus*, *11*(1), e3832. https://doi.org/10.7759/cureus.3832

Gartmeier, M., Pfurtscheller, T., Hapfelmeier, A., Grunewald, M., Hausler, J., Seidel, T., & Berberat, P. O. (2019). Teacher questions and student responses in case-based learning: outcomes of a video study in medical education [Article]. *BMC Med Educ*, *19*(1), 455. https://doi.org/10.1186/s12909-019-1895-1

Giannakos, M. N., Chorianopoulos, K., & Chrisochoides, N. (2015). Making Sense of Video Analytics: Lessons Learned from Clickstream Interactions, Attitudes, and Learning Outcome in a Video-Assisted Course. *International Review of Research in Open and Distributed Learning*, *16*(1), 260-283. <Go to ISI>://WOS:000357189200014

Ifenthaler, D., Schumacher, C., & Kuzilek, J. (2023). Investigating students' use of self-assessments in higher education using learning analytics. *Journal of Computer Assisted Learning*, *39*(1), 255-268. https://doi.org/10.1111/jcal.12744

Kim, J., Guo, P. J., Seaton, D. T., Mitros, P., Gajos, K. Z., & Miller, R. C. (2014). *Understanding in-video dropouts and interaction peaks inonline lecture videos* Proceedings of the first ACM conference on Learning @ scale conference, Atlanta, Georgia, USA. https://doi.org/10.1145/2556325.2566237

Kulasegaram, K., & Rangachari, P. K. (2018). Beyond "formative": assessments to enrich student learning. *Advances in Physiology Education*, *42*(1), 5-14. https://doi.org/10.1152/advan.00122.2017

Lacey, K., & Wall, J. G. (2020). Video-based learning to enhance teaching of practical microbiology. *FEMS Microbiology Letters*, *368*(2). https://doi.org/10.1093/femsle/fnaa203

Liao, C. H., & Wu, J. Y. (2023). Learning analytics on video-viewing engagement in a flipped statistics course: Relating external video-viewing patterns to internal motivational dynamics and performance [Article]. *Computers & Education*, *197*, N.PAG-N.PAG. https://doi.org/10.1016/j.compedu.2023.104754

Liu, Z., Yin, H., Cui, W., Xu, B., & Zhang, M. (2021). How to reflect more effectively in online video learning: Balancing processes and outcomes. *British Journal of Educational Technology*, *53*(1), 114-129. https://doi.org/10.1111/bjet.13155

Mirriahi, N., Jovanovic, J., Lim, L. A., & Lodge, J. M. (2021). Two sides of the same coin: video annotations and in-video questions for active learning. *Etr&D-Educational Technology Research and Development*, *69*(5), 2571-2588. https://doi.org/10.1007/s11423-021-10041-4

Mohammadhassan, N., & Mitrovic, A. (2022). *Investigating the Effectiveness of Visual Learning Analytics in Active Video Watching* (Vol. 13355). Springer International Publishing. https://doi.org/10.1007/978-3-031-11644-5_11

Montayre, J., & Sparks, T. (2018). As I haven't seen a T-cell, video-streaming helps: Nursing students' preference towards online learning materials for biosciences. *Collegian*, *25*(5), 487-492. https://doi.org/https://doi.org/10.1016/j.colegn.2017.12.001

Mubarak, A. A., Cao, H., Zhang, W., & Zhang, W. (2020). Visual analytics of video-clickstream data and prediction of learners' performance using deep learning models in MOOCs' courses. *Computer Applications in Engineering Education*, *29*(4), 710-732. https://doi.org/10.1002/cae.22328

Nicol, D., & Macfarlane-Dick, D. (2004). Rethinking formative assessment in HE: a theoretical model and seven principles of good feedback practice. *C. Juwah, D. Macfarlane-Dick, B. Matthew, D. Nicol, D. & Smith, B.(2004) Enhancing student learning though effective formative feedback, York, The Higher Education Academy*.

Park, E. E. (2022). Expanding Reference through Cognitive Theory of Multimedia Learning Videos. *The Journal of Academic Librarianship*, *48*(3), 102522. https://doi.org/https://doi.org/10.1016/j.acalib.2022.102522

Rice, P., Beeson, P., & Blackmore-Wright, J. (2019). Evaluating the Impact of a Quiz Question within an Educational Video. *TechTrends*, *63*(5), 522-532. https://doi.org/10.1007/s11528-019-00374-6

Rodríguez-Martínez, J. A., González-Calero, J. A., del Olmo-Muñoz, J., Arnau, D., & Tirado-Olivares, S. (2023). Building personalised homework from a learning analytics based formative assessment: Effect on fifth-grade students' understanding of fractions. *British Journal of Educational Technology*, *54*(1), 76-97.

Rose, E., Claudius, I., Tabatabai, R., Kearl, L., Behar, S., & Jhun, P. (2016). The Flipped Classroom in Emergency Medicine Using Online Videos with Interpolated Questions. *J Emerg Med*, *51*(3), 284-291 e281. https://doi.org/10.1016/j.jemermed.2016.05.033

Sablić, M., Mirosavljević, A., & Škugor, A. (2020). Video-Based Learning (VBL)—Past, Present and Future: an Overview of the Research Published from 2008 to 2019. *Technology, Knowledge and Learning*, *26*(4), 1061-1077. https://doi.org/10.1007/s10758-020-09455-5

Seo, K., Dodson, S., Harandi, N. M., Roberson, N., Fels, S., & Roll, I. (2021). Active learning with online video: The impact of learning context on engagement. *Computers & Education*, *165*. https://doi.org/10.1016/j.compedu.2021.104132

Stanja, J., Gritz, W., Krugel, J., Hoppe, A., & Dannemann, S. (2023). Formative assessment strategies for students' conceptions—The potential of learning analytics. *British Journal of Educational Technology*, *54*(1), 58-75.

Tripodi, N. (2018). First-year osteopathic students' use and perceptions of complementary video-based learning. *International Journal of Osteopathic Medicine*, *30*, 35-43. https://doi.org/10.1016/j.ijosm.2018.09.004

Üstün, A. B., Karaoğlan-Yılmaz, F. G., & Yılmaz, R. (2021). Investigating the role of accepting learning management system on students' engagement and sense of community in blended learning. *Education and information technologies*, *26*(4), 4751-4769. https://doi.org/10.1007/s10639-021-10500-8

Üstün, A. B., & Tracey, M. W. (2021). An innovative way of designing blended learning through design-based research in higher education. *Turkish Online Journal of Distance Education*, *22*(2), 126-146.

Üstün, A. B., Zhang, K., Karaoğlan-Yılmaz, F. G., & Yılmaz, R. (2022). Learning analytics based feedback and recommendations in flipped classrooms: an experimental study in higher education. *Journal of Research on Technology in Education*, 1-17. https://doi.org/10.1080/15391523.2022.2040401

Üstün, A. B. (2023). Investigating Impacts of Using Mobile Video Lectures on Student Satisfaction and Academic Achievement in Blended Learning. *Malaysian Online Journal of Educational Technology*, *11*(3), 199-210.

Weeks, B. K., & Horan, S. A. (2013). A video-based learning activity is effective for preparing physiotherapy students for practical examinations. *Physiotherapy*, *99*(4), 292-297. https://doi.org/10.1016/j.physio.2013.02.002

Xiu, Y., Moore, M. E., Thompson, P., & French, D. P. (2018). Student Perceptions of Lecture-Capture Video to Facilitate Learning in a Flipped Classroom. *TechTrends*, *63*(4), 369-375. https://doi.org/10.1007/s11528-018-0293-6

Yoon, M., Lee, J., & Jo, I. H. (2021). Video learning analytics: Investigating behavioral patterns and learner clusters in video-based online learning. *Internet and Higher Education*, *50*. https://doi.org/10.1016/j.iheduc.2021.100806

Yürüm, O. R., Taşkaya-Temizel, T., & Yıldırım, S. (2022). The use of video clickstream data to predict university students' test performance: A comprehensive educational data mining approach. *Education and Information Technologies*, 1-32. https://doi.org/10.1007/s10639-022-11403-y

Yürüm, O. R., Yıldırım, S., & Taşkaya-Temizel, T. (2022). An intervention framework for developing interactive video lectures based on video clickstream behavior: a quasi-experimental evaluation. *Interactive Learning Environments*, 1-16. https://doi.org/10.1080/10494820.2022.2042312

Zamzuri, Z. H. (2022). Assessing Students' Focus and Interest Using Youtube Analytics. *Asean Journal of Teaching and Learning in Higher Education*, *14*(1), 47-58. https://doi.org/10.17576/ajtlhe.1401.2022.05

Zaneldin, E., Ahmed, W., & El-Ariss, B. (2019). Video-based e-learning for an undergraduate engineering course. *E-Learning and Digital Media*, *16*(6), 475-496. https://doi.org/10.1177/2042753019870938