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Interactive Video Player for Supporting Learner Engagement in Video-Based Online Learning*

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This study sought to design and develop an interactive video player (IVP) capable of promoting student engagement through the use of online video content. We designed features built upon interactive, constructive, active, passive (ICAP), and crowd learning frameworks. In the development stage of this study, we integrated numerous interactive features into the IVP intended to help learners shift from passive to interactive learning activities. We then explored the effectiveness and usability of the developed IVP by conducting an experiment in which we evaluated students' exam scores after using either our IVP or a conventional video player. There were 158 college students who participated in the study; 76 students in the treatment group used the IVP and 82 students in the control group used a conventional video player. Results indicate that the participants in the experiment group demonstrated better achievement than the participants in the control group. We further discuss the implications of this study based on an additional survey that was administered to disclose how usable the participants perceived the IVP to be.

Keywords : Interactive video player, ICAP framework, Crowd learning, Video-based learning, Video engagement

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Introduction

With the modern exponential growth of online learning in both formal and non-formal learning contexts, video lessons are rapidly becoming a primary source of learning for students (Giannakos et al., 2016). In such video-based online learning environments, learners spend a large amount of time watching video lectures (Sablić et al., 2020). Video-based online learning has been touted for allowing learners to study at their own paces without the constraints of time and space; they can repetitively watch videos until they gain mastery of the topics that are addressed in the video (author, 2021). Asynchronous online courses offered via contemporary online-learning platforms such as Massive Open Online Courses (MOOC) are rapidly expanding thanks to their flexibility (Lucas et al., 2014).

A typical learning scenario in video-based learning is that learners watch instructional videos in which their instructor speaks from behind the screen and then provides them with online activities. Because learners' knowledge acquisition is dependent on their understanding of the topics being taught in the lecture videos (authors, 2021), it is important for instructors to provide them with timely support during video-based learning (Hung et al., 2018). Given the asynchronous nature of video-based learning, however, it is hard for learners to expect real-time feedback from instructors (Thomas et al., 2017). For that reason, students who are not ready for self-regulated learning are likely to supplement their engagement with video lectures. According to Davis et al. (2017), only 5-10% of MOOC learners complete their chosen courses. A majority of these learners indicated that the uninvolved nature of the instructor-led lectures and the lack of interaction made it difficult to persevere in their video-based learning (Fiorella & Mayer, 2018). College students who are enrolled in online courses also face challenges in sustaining their engagement in video-based learning due to the limited in-person interactions. Students' sustained engagement is an integral part of video-based learning for knowledge acquisition; therefore, keen attention should be paid to strategies for boosting student engagement with additional learning content (Hampton & Pearce, 2016).

In response to the need for improving video-based learning, prior studies have suggested instructional strategies that can boost student engagement with video lectures (see, for instance, de Barba et al., 2016; Eisenberg & Fischer, 2014; Hsin & Cigas, 2013). For example, researchers have highlighted the advantages of interactive learning activities that are designed to support video-based online learning such as short quizzes, online forums, and virtual agents (Guo et al., 2014; Zhang et al., 2006). Some have suggested that instructors use social cues to draw the attention of learners in video lectures (e.g., Stull et al., 2020; Vytasek et al., 2020).

Despite efforts that have been made by researchers to enrich video-based learning environments, the successful implementation of instructional strategies is reliant on instructor skills and experience with enrichment tools (Dumford & Miller, 2018; Halverson & Graham, 2019). In order for video-based learning to be consistently engaging, interactive features can be embedded in video players to support learner-content and learner-learner interactions (Chatti et al., 2016). According to Seo et al. (2021), interactive features on video players have the potential to support students' cognitive engagement with content. Contemporary interactive video players do support a modicum of interaction between learners and content through separate features such as an interface for chatting (e.g., Etherpad). In typical video-based learning environments, students are expected to engage in solo learning, and learning activities requiring learner-learner interaction are seldom implemented (Clarke, 2013). For instance, a chatting feature is only beneficial in the context of real-time video streaming. Given that video-based learning is typically intended for asynchronous online classes, it is important to facilitate intellectual interaction between learners in an asynchronous manner. Furthermore, little is known about how to design and develop interactive video players that can support video-based learning. A lack of design guidelines reflecting learning theories may be preventing video-players from being adapted for a variety of learning contexts.

To address the gaps in research and practice, we designed and developed an interactive video player (IVP) reflecting the theoretical frameworks that have been provided in previous research. Specifically, we first elicited design principles from the interactive, constructive, active, and passive (ICAP) frameworks and the concept of crowd learning for designing an interactive video player. The IVP is expected to support both learner-content and learner-learner interaction in video-based learning. We then applied the identified principles to develop the IVP and validated it through an experimental study. The study also examined how the participants used and perceived the IVP. In summary, we addressed the following research questions.

1. What is the effect of the IVP on student achievements in a video-based learning setting?
2. How do students perceive the usability of the IVP?

Backgrounds

Interactive, Constructive, Active, and Passive Learning in Video-Based Learning

One of the theoretical frameworks that can be used to examine student engagement in video-based learning is the ICAP framework proposed by Chi and Wylie (2014). The levels of student engagement can be categorized according to their observable behaviors. Some students merely focus on receiving information while other students enjoy making contributions to a community of learners (Petrovčič & Petrič, 2014). The different levels of engagement represent the degree to which students participate in intellectual activities and cognitive processing (Speily & Kardan, 2018). That is, when students transition from passively consuming information to actively interacting with other students, we can infer that they are becoming engaged in learning (Angrave et al., 2020).

The ICAP framework specifically is concerned with students' cognitive efforts which are represented by their behaviors. As indicated by its name, the framework differentiates student engagement into four modes: interactive, constructive, active, and passive. A passive mode of engagement describes learners who focus on receiving information from the instructional materials without any putting forth any deeper cognitive efforts. Passive students can be identified by a behavior of only listening to lectures and viewing learning materials (authors, 2021). Likewise, in the context of video-based, the passive mode of engagement is represented by students' behaviors such as viewing video lectures without additional strategies to commit the content to their schemata relevant to a lecture's topic. According to Chi & Wylie (2014), in video-based learning, the active mode of engagement is depicted by students directly involving themselves with important content. Students who are active may try to manipulate learning materials to highlight sections that they think are important (Dunlosky et al., 2013). For example, a student underscoring part of an article provided by teachers can be considered to be an active learner (Dunlosky et al., 2013). In video-based learning, pausing, fast-forwarding, or rewinding video lectures to selectively obtain information can be regarded as active behaviors. Constructive behaviors are observed when students attempt to externalize their novel ideas through taking notes using their own methods and words. In essence, the constructive mode of engagement is characterized by "generating" behaviors such as when students explain concepts introduced in a video lecture to themselves and make comparisons between their prior knowledge and the new information that is addressed in the lecture (authors, 2021). Interactive behaviors contribute to knowledge construction from the social cognitivist's perspective (Pellas, 2014). When exchanging their ideas with peers, students can build upon what they learned from solo learning. The interactive mode of engagement is characterized by behaviors that go beyond solo learning and engage in "dialoguing" through peer-to-peer interaction for the justification and discussion of course topics.

While higher levels of engagement (e.g., interactive) are desirable for in-depth intellectual outcomes, in real-world in-person settings, learning is a more of a transitional process on the continuum (Chi, 2009); it is unrealistic to expect all students to simply engage in constructive and interactive learning activities from the beginning of their education. In fact, Chi and Wylie (2014) stressed that students need opportunities to engage in different levels of cognitive activities in order to reach a mastery of any given topic through cognitive processing. Moreover, it is important to help learners smoothly transition from lower levels of engagement to higher levels (Chen et al., 2015).

Based on the ICAP framework, we intended to create an IVP that would support all four modes of engagement in such a way that novice learners begin their education by watching video lectures and progress toward more interactive activities. As opposed to learning activates that are possible with contemporary video players, which are primarily focused on playing video content, learning activities that are possible on the IVP include the manipulation of information, the generation of ideas, and peer-to-peer communication; that is, we expected the IVP to satisfy students' instant learning needs which exist between the four modes of engagement.

Crowd Learning

While the ICAP framework offers guidance for how the features of an IVP can support a range of learner activities, there remains a need for individual learner to learn from external resources. In designing the IVP, we recognized "crowd learning" as a useful concept that could explain how individuals can maximize their learning benefit by harnessing resources shared by other learners (Kalisz, 2016). A "crowd" is defined as a large number of people gathered together in a disorganized or unruly way. In the era of digital technology, the term "crowd" also represents people who contribute to collective work via a variety of digital platforms (Howe, 2008).

"Crowdsourcing" is the typical example of how a crowd can play a role in collective work (Dron & Anderson, 2009). Crowdsourcing is the process of an individual connecting with a large group of people via the internet in order to achieve a shared goal (Kittur et al., 2013). Crowdsourcing is often adopted as a model for individuals or organizations to obtain cumulative knowledge (Burger-Helmchen & Penin, 2010) and solutions to problems (Vukovic et al., 2011). Crowd learning is defined a form of crowdsourcing aimed at facilitating collective learning among students (Dron & Anderson, 2009). Although crowd learning and collaborative learning sounds similar, crowd learning is differentiated from conventional collaborative learning in that a crowd network is temporarily formed for a particular topic and is thus relatively loosely held together (Anderson & Magruder, 2012). Therefore, an individual learner can temporally engage in a particular network and, once they accomplish their learning goal, they can explore other networks (Gašević et al., 2019).

Although the peer connection in a crowd learning network is weak, each learner can be a source of valuable information for others, ultimately leading to mutual knowledge construction (Surowiecki, 2005). Crowd learning represents a new form of communication involving multiple intelligences in which an individual learner becomes a contributor to collective work (Dron & Anderson, 2009). Wikipedia, for example, is characterized by numerous crowd-based elements and builds on contributions made by public groups (Doan et al., 2011). Another example of a crowd learning network includes the Popular Highlights feature on Amazon Kindles. The feature shows e-book readers passages that have been highlighted by more than 10 people, thus encouraging readers to pay more attention to them. Through this process, readers can create mental notes on important sections of a text.

In video-based learning, it is difficult to facilitate interaction between learners due to the asynchronous nature of the environment (Thomas et al., 2017). The lack of interaction in video-based learning could be compensated by providing learners with the ability to build on other learners' ideas and the traces that they have left behind when watching a video lecture (Woo & Reeves, 2007). By doing so, the learners can begin with notion about what part of the video lecture they need to pay attention to. For example, if learners can see annotations made by other learners who watched a lecture ahead of them, they can look at how other people built their mental models when learning from the video's content. As such, the process of observing others' learning traces can afford learners the opportunity to socialize their thoughts (Rosenthal & Zimmerman, 2014). Psychologically, learners may feel stable when being able to compare their understanding of and ideas about a video's content to those of others.

In this study, we recognized the potential of crowd learning as a tool with which to help learners supplement their learning by observing how others learned from the same content. This form of observational learning, students share their thoughts with others who are studying the same content asynchronously, is expected to facilitate students' interactive behaviors; interaction that occurs during crowd learning would help to address the problems that result from a lack of interaction in asynchronous video-based learning. In that regard, we embedded several features in the IVP that support crowd learning as well as the network of "Interaction" that is highlighted within the ICAP framework. Specifically, we wanted learners to be able to view which part of video lectures other learners focused on and what comments they made.

Framework for Designing an Interactive Video Player (IVP)

We designed the IVP in a way that would allow it to support the learner activities that are highlighted in the ICAP and crowd learning frameworks. Specifically, the ICAP framework offered an insight into what types of learner activities should be encouraged in video-based learning in order for students to obtain desirable learning outcomes. However, the goal of video-based learning not only involves interactive viewing activities (e.g., exchanging ideas with peer learners) but also requires constructive (e.g., taking a note), and active (e.g., rewinding) activities in a balanced way (Seo et al., 2021). Furthermore, learners should, to a certain extent, have a basic understanding of the video content in order to participate in interactive activities in a constructive and intellectually meaningful way (Woo & Reeves, 2007). In consideration of the comprehensive nature of video-based learning, we designed the

IVP to give equal weight to the different modes of engagement.

Additionally, the concept of crowd learning served as a lens through which we examined the possible features for interactive activities. We intended to include a feature in the IVP that would allow learners to see other students' notes and annotations at any time during lecture, learning from previous viewers' observations of the material. The asynchronous interaction between different learners across the boundary of time collects incremental information that is expected to help learners access collective information relevant to a video or lecture's topic.

With the IVP, we intended for students to begin by simply viewing videos (i.e., passive) and to then learn how to manipulate the video content by using embedded features such as rewinding and fast-forwarding (i.e., active). While actively

Table 1
Features and functionality of IVP

Framework	Functionality	Feature
Receiving (Passive)	▫ Viewing videos	▫ Playing
Manipulating (Active)	▫ Managing learning at one's own pace ▫ Initiating study at a chosen time ▫ Exploring video content in real time ▫ Marking for later learning ▫ Searching for targeted information through filtering	▫ Pausing ▫ Playing ▫ Fast-forwarding or rewinding ▫ Moving lecture slides while watching video ▫ Filtering (Search for targeted annotations made by other learners) ▫ Bookmarking
Generating (Constructive)	▫ Externalizing thoughts immediately during learning through self-explanation	▫ Annotation (for taking notes on video content)
Dialoguing (Interactive)	▫ Exchanging ideas with peers/crowd	▫ Commenting on others' annotations (for asynchronous interaction) ▫ Viewing others' annotations ▫ Viewing others' highlights

manipulating content, students are able to externalize their thoughts and progress toward constructive activities such as note-taking (i.e., constructive). Such behaviors unfold once learners elaborate on what they learn from the video's main content and are ready to shift to constructive activities. Since real-time interaction is not feasible in video-based online learning, asynchronous interaction-based activities such as viewing and editing others' notes ensure the interactivity of the IVP (i.e., interactive). Observing how previous students interacted with a video's content provides viewers with direction for their own learning; although students do not interact in real time, they are able to cognitively connect. Though it may at first be a linear process progressing from passive to interactive learning, video-based learning that occurs on the IVP ultimately become a cyclic process. Table 1 lists the features that have been included in the IVP to help students smoothly transition between the different modes of engagement.

Methods

To validate the effectiveness of the IVP's features, we examined the effect of the IVP on student achievement (Research question 1). We additionally conducted a survey to explore students' perceptions of the IVP regarding its usability (Research question 2).

Participants and Design

For the primary study, we invited college students to participate in the study by posting relevant information on the university's website and social networking service (SNS) channels; students who were interested in the experiment sent an email or SNS message to the research team. Out of 158 participants, 76 were randomly assigned to the experimental group (IVP) and 82 were randomly assigned to the control group (non-IVP). All participants were undergraduates; 75 participants (47%) were men and 83 (53%) were women. Of the 158 total participants, 73 (46%) were majoring in the humanities and social sciences while 85 (54%) were majoring in the natural sciences or engineering.

Materials and Apparatus

To test the IVP, we provided all participants with a multimedia lesson about proposition that was designed by mathematicians and instructional designers. Since the lesson discussed the basic proofs of mathematical logic, we employed subject stimuli of presymmetry, existence propositions, and binominal propositions. The lesson displayed the learning objectives, the main lecture explaining the mathematical concepts of proposition, and exemplary problems about the propositions followed by problem put forth for students to solve. The lesson was about 12 minutes and 30 seconds; an appropriate running time to maintain student engagement (Guo et al., 2014). The lesson covered two types of mathematical statement quantifiers (i.e., [∀, ∃] and [∃, ∀]; ∀ is a universal quantifier, and the ∃ represents an existential quantifier).

While the control group used a conventional player that equipped with basic functions such as play, pause, rewind, forward, speed change, seek, move slide, change volume, and adjust screen size buttons, an experimental group used an IVP that enhanced with interactive features such as create, reply to, and view comments. Participants in IVP were able to add bookmarks to find important learning sections or view bookmarks while watching each video class. The IVP showed the participants a list of learning activities such as comments and bookmarks so that they can monitor the learning progress while watching video classes. The IVP featured four sections: a video section, a lecture slide section, a bookmark and comment library section, and a video annotation section based on a timeline. Figure 1 shows the prototype of the IVP and Figure 2 shows the developed interface of the IVP used in this experiment.

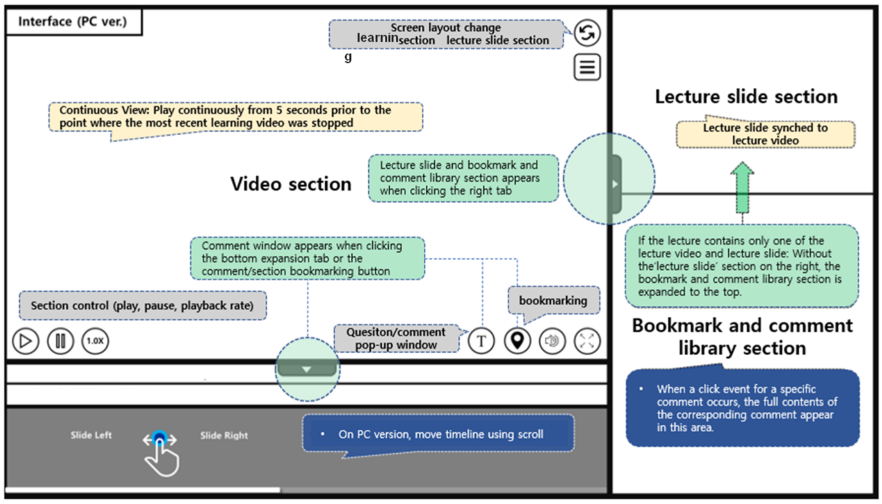

Figure 1. Prototype of the interactive video player.

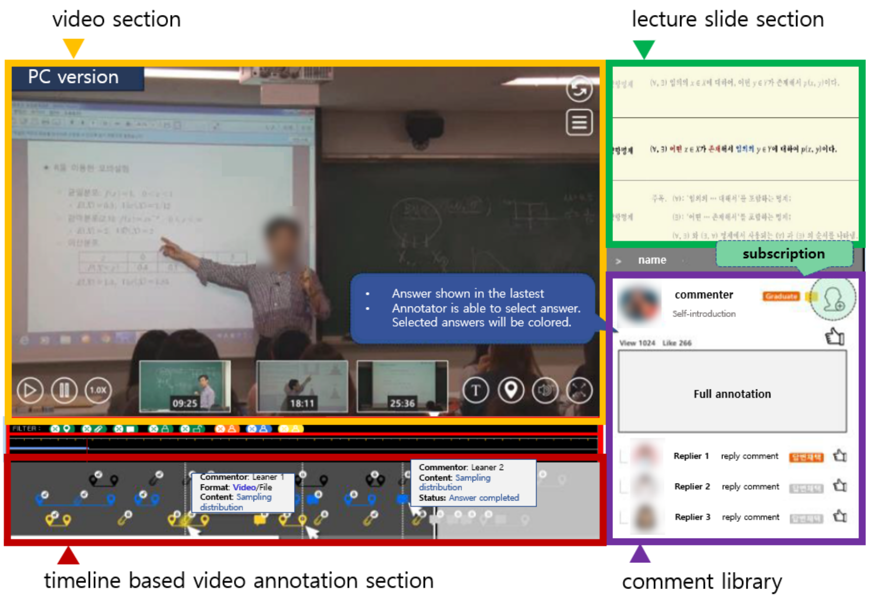

Figure 2. Interface of the interactive video player.

When the instructor uploads a recorded video lecture describing the lecture slides and slides, the video lecture is displayed in the video section and the slide is displayed in the lecture slide section. In default mode, the player synchronizes the slides in the lecture video and slide section, but the learner can move the slides back and forth in the slide section while the video lecture is playing in the video section. This feature is intended to allow learners to browse slides at their own speed for review or preview. Learners can annotate and/or comment while watching the class and view others' comments and/or annotations. However, during the experiment, real-time annotation/comment sharing was turned off to prevent students from viewing other numbers of comments or annotations. Instead, we made a few comments and annotations such as 'A's argument presented here is intended to prove that the proposition S is false' so that participants can read the comments made by others and try to create the comments using the annotation/comment function before the experiment.

Procedures

The research team informed the participants that they would view a lesson about mathematics proposition and that they would answer both pre-test questions before the experiment and post-test questions after the experiment. Once the experiment's setting was ready, the participants began to watch the lesson's video. The only difference between the experiment and control groups was the use of experiment group's use of the IVP. The participants assigned to the control group used a conventional video player with only play and pause buttons.

Measures

Usability survey. We used a survey developed by Nokelainen (2005) to measure the experiment group's opinions regarding the usability of the IVP. The authors proposed 94 Likert-scale items representing two main categories: the IVP's technical usability and pedagogical usability. These two aspects of usability were chosen because the IVP was proposed not only as a technical application but also as a learning platform.

Out of the 20 sub-scales proposed by Nokelainen (2005) in the original questionnaire, we chose accessibility, learnability and memorability, memory load, applicability, goal orientation, and motivation as the sub-scales that were most relevant to our research context. The survey questions asked participants to utilize a 5-point scale to identify the extent to which they agreed with the statements (1 = strongly disagree, 5 = strongly agree). Table 2 provides information regarding each of the 6 sub-scales that were used in this study and example items.

Table 2
An Overview of Survey Scales and Items

Category	Scale	Number of items	Description	Sample item
Technical usability	Accessibility	16	▫ The degree to which the system provides an option for various media elements and considers the needs of users.	▫ The buttons and menus of this video learning player are of good size, so there is no big difficulty when clicking.
	Learnability And memorability	16	▫ The degree to which the system is easy to learn not only for casual and expert user but also for novice learners.	▫ How to use this video learning player was easy to learn.
	Memory load	6	▫ The degree to which the system considers the limited capacity of learners' working memory and minimizes complexity to facilitate learners' information processing.	▫ The main features of the IVP are obvious, so you don't need to remember how to use them.
Pedagogical usability	Applicability	14	▫ The degree to which the system helps users exchange learned knowledge or skills in other contexts.	▫ When learning with this video learning player, I can use the knowledge I knew before.
	Goal orientation	5	▫ The degree to which learners set goals while using an IVP.	▫ I think what I study in this video learning player will help me get better results on the test.
	Motivation	4	▫ The degree to which the system supports learners' motivation throughout the learning process.	▫ This video learning player will help me learn, so I can try using the new features.

Achievement. We measured achievement by using scores obtained from the participants pre- and post-tests. The achievement test was composed with 24 multiple choice items which measure understanding of the contents. The test items were developed by one subject matter expertise consultants with two instructional designers. The sample item of the achievement test is 'Choose the most appropriate statement for the proposition S in below. We examined what scores the participants received in the post-test against their pre-test scores as the control element. The questions used in both tests addressed the "basic proof of mathematical logic" and were developed in cooperation with university mathematics professors.

Data Analysis

An analysis of covariate (ANCOVA) was conducted to examine the effects of the IVP on participants' achievement. The prior knowledge (i.e., pre-test score) was included as a covariate based on prior studies' arguments (e.g., Cho & Kim, 2013; Martin & Bolliger, 2018) that prior knowledge may influence student engagement and learning performance in the contexts of online learning. We used participants' pre-test scores to establish the participants' levels of prior knowledge.

Results

Research question 1: What is the effect of the IVP on student achievements in a video-based learning setting?

Descriptive statistics. A preliminary analysis was performed to examine whether the control and experimental groups differed on basic characteristics. Participants' prior knowledge related to proposition was generally low as indicated by a score of 24 (M = 13.69; SD = 3.39) and did not differ significantly across conditions (IVP or non-IVP). There were no significant differences between the groups in terms of pre-test score or the proportion of male and female participants.

Analysis of covariance. We conducted an analysis of covariance (ANCOVA) in order to determine whether differences existed in achievement between the two groups (Table 3). Participants' pre-test scores were used as a covariate to establish their prior knowledge. The results of the Levene's test revealed that the two groups had equal population variances (F = .33, p = .57). According to the result of ANCOVA, the participants in the experiment group achieved higher scores in the post-test than the control group when compared against the pre-test scores (F = 72.93, p = < .001).

Table 3
Result of ANCOVA

	Control group (non-IVP) (n=82)		Experiment group (IVP) (n=76)		F	Effect size (η^2)
	M	*SD*	*M*	*SD*		
Pre-test score	13.93	3.51	13.45	3.88	72.93**	.32
Post-test score	13.10	3.27	17.20	3.54		

** p <.001

Research question 2: How do student perceive the usability of the interactive video player?

We conducted a descriptive analysis of the experiment group in order to measure the participants' opinions regarding the usability of the IVP. The descriptive statistics, including the means and standard deviations of all scales in the usability survey, are presented in Table 3. On a scale ranging from 1 (strongly disagree) to 5 (strongly agree), the scores ranged from 3.45 to 3.86; this indicates that the participants had a good overall perception of the IVP. In regard to the IVP's technical usability, accessibility ranked 3.58, learnability and memorability scored, 3.68, and memory load scored 3.86. In the analysis of the IVP's pedagogical usability, applicability was rated 3.62, goal orientation ranked 3.45, and Motivation received a score of 3.86 as shown in Table 4.

Table 4
An Overview of Survey Scales and Items

Scale	Mean	*SD*	Cronbach α
Accessibility	3.58	.48	.79
Learnability & memorability	3.68	.15	.87
Memory load	3.86	.23	.74
Applicability	3.62	.25	.76
Goal orientation	3.45	.30	.72
Motivation	3.86	.09	.69
Total	3.67	.25	0.76

Discussion

In this study, we reported on how to design and develop an interactive video player building on principles suggested within the ICAP and crowd learning frameworks. The implications of this study can be summarized as follows:

First, we documented how to materialize pedagogical principles into an interactive video player in order to facilitate active social learning. While the concepts of ICAP and crowd learning served as frameworks, little was previously known about how to integrate the principles suggested within these frameworks into online education. In fact, a lack of social interaction has been recognized as a limitation of asynchronous video-based learning and a hinderance on student achievement (Angeli et al., 2003). Our results show that the various features, including the crowd learning feature, that were integrated in the IVP helped students achieve better learning outcomes than a conventional video player did. The result may have been caused by the fact that the IVP allows learner to engage generative activities such as highlighting, commenting, rewinding etc. In video-based learning, actively manipulating learning materials to selectively obtain information can be active behaviors which might lead positive learning achievement (Chi & Wylie, 2014). During the COVID-19 pandemic, higher education institutions put forth plans to expand their online courses and create a digital transformation across their campuses (Iglesias-Pradasa et al., 2021). It is anticipated that video-based learning will become the new normal in the post-pandemic era (Morgan, 2020); as such, we should provide students with different supports that are aligned with the new educational setting. The principles and the features applied to the IVP will inform the design of similar video platforms and help facilitate active and interactive learning beyond passive learning. Since we linked each feature of the IVP with an individual principle elicited from the ICAP and crowd learning frameworks, designers and developers can adaptively use some or all of these features for their own contexts.

Moreover, the developed IVP can be a remedy for low levels of learner-learner interaction in video-based learning. There is a body of research that has examined ways to facilitate interactive learning. For example, Mitrovic et al. (2017) integrated an annotation feature into a video player so that students could record their learning progress. The participants who were assigned to the study's experiment group used the player and were yielded better learning outcomes than the participants in the control group who did not use the annotation feature. However, prior studies did not provide direction for facilitating learner-learner interaction in video-based learning environments. Although some researchers proposed course activities such as online forums (e.g., Martín-Monje et., 2018) or peer coaching (e.g., Marthin-Ramos et al., 2018) in order to facilitate interaction between students, these methods are tied to particular courses. Given the fact that more and more online courses are being offered, crowd learning will continue to be an innovative model that can be applied without time and space constraints. The IVP is also differentiated from other interactive video players that mainly focus on learner-content interaction. Our results show that interactivity enhanced by the crowd learning features led students to engage in observational learning and the construction of collective knowledge. The concept of observational learning stems from the social cognitive theory and posits that learners can benefit from observing other people as a social model (Bandura, 2008). By doing so, learners can identify important principles for completing learning tasks. Observational learning helps to reduce learners' unnecessary cognitive loads, especially when novice learners are unfamiliar with a learning task (Mierowsky et al., 2020). The observation of a social model is also known to increase students' self-efficacy (Ashuri et al., 2018). In the same vein, the relatively high sub-scale scores of memory load and motivation in the usability survey that was administered in this study reveals that the participants believe the IVP as reduced their cognitive load and boosted their motivation.

However, there are limitations that were discovered in this study regarding the IVP that need to be addressed by future research. First, we found that the perceived usability of the IVP as reported by the participants did not reach an ideal level (i.e., strongly agree) on the scale; the scores obtained from the sub-scales of the usability questionnaire ranged from 3.5 to 4 points (neutral and agree respectively). While the student rating still indicated favorable opinions toward the IVP overall, it is important to further investigate which specific aspect of the IVP the participants may have been unsatisfied with. For example, the accessibility score (3.58) in the technical usability category was relatively low. It can be inferred that the participants had difficulty familiarizing themselves with the features embedded in the player. In the pedagogical usability category, the scores of learner control (3.17) and goal orientation (3.45) were low. Considering the survey items for the sub-scales, the participants might have been overwhelmed by the comment and annotation features offered for crowd learning. While the features were found to enhance student achievement, future research should examine ways to reduce students' confusion. For example, future research can investigate student log traces recorded within the IVP in order to understand how they used the features embedded in the video player. In-depth interviews or observations would also help to reveal user experience with the IVP as well as provide detailed information as to how we can improve the usability of the IVP. Second, it is important to obtain more empirical data to conceptualize students' behaviors. For example, it would be beneficial to analyze the content of the comments that students left in the IVP; this would reveal how the participants contributed to both crowd learning and the construction of collective knowledge. Third, this study was conducted in a controlled laboratory setting; thus, it is possible that this environment did not perfectly duplicate a real-world setting. For example, this one-time experiment may have not given participants enough time to become proficient in using all of the IVP's interactive features. Future research should be conducted in a more natural environment allowing learners to use a video player for a longer period of time.

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