Journal of Engineering Science and Technology Review 11 (2) (2018) 174 - 181

Research Article

JOURNAL OF
**Engineering Science and Technology Review**

www.jestr.org

# Augmented Interactive Video: Enhancing Video Interactivity for the School Classroom

**I. Kazanidis[1], G. Palaigeorgiou[2], A. Papadopoulou[3] and A. Tsinakos[1]**

[1] *Computer and Informatics Engineering Department Eastern Macedonia & Thrace Institute of Technology, Kavala, Greece*
[2] *Department of Primary Education, University of Western Macedonia, Florina, Greece*
[3] *LearnWorlds LTD, London, UK*

Received 22 December 2017; Accepted 12 February 2018

***Abstract***

Over the past number of years the employment of video for learning has increased significantly. Recently, video-based learning platforms have also been enhanced with interactive functionality in order to transform learning with videos from a passive into an active learning activity that facilitates learners' engagement. However, when interactive videos are presented inside the classroom, they again once become inflexible learning media with minimal interactivity options for the students, since only the instructor interacts with the video. In this paper, we propose a classroom augmented interactive video (CAIV) approach that combines AR technology with the interactive video's capabilities that transforms the projected interactive video screen into a shared canvas for personalized and collaborative learning interactions. The approach is based on offering augmentation opportunities for specific video frames that are displayed on the classroom video projection screen. The augmentations may include a variety of interactive activities that stimulate students' interest and triggers active participation through their mobile devices. We propose three interaction categories for CAIV'; instructor interactions, student interactions and classroom interactions, and we elaborate on how typical interactive video characteristics such as teachers' and users' annotations, hyperlinks, navigational options, video analytics, summarization and embedded questions could be enhanced in this approach. The CAIV approach aims to retain the powerful features of interactive videos in the classroom to advance self-regulated learning, social interaction and student engagement.

*Keywords:* video-based learning, interactive video, augmented reality, classroom collaboration, interaction types

## 1. Introduction

During the past few years the employment of video for learning has significantly increased [1]. Nowadays, expressive and effective videos for almost all learning subjects can be rapidly and cost-effectively developed and deployed across multiple platforms and devices. The proliferation of video points to the need for learning through face-to-face human texture. Video-based learning techniques and practices have been assimilated by various educational settings, such as Massive Open Online Courses (MOOCs), "flipped" (or "inverted") classrooms, informal education settings, etc. Most learners know about and exploit video-based online courses repositories such as *Khan Academy*, *Coursera*, *Lynda*, and *Udemy*. Several studies have underlined the nurturing value of videos since they have the ability to affect motivation and attitudes [2] and increase interest in studying a new subject [3].

However, video sometimes fails to satisfy the individual learning needs. For example, learners are unable to control the learning pace [4] or collaborate with their colleagues. Despite the technological developments, video-based content is still presented in its original form, as a linear flow of scenes [5]. Learners have to follow a strict and predetermined data stream that may be irrelevant to their characteristics, interests and prior knowledge. Although video-based learning has been used extensively in many educational settings, its learning effectiveness remains questionable because users engage with the video content in a rather passive manner [6-7]. Increasing user interaction may be key to transform video-based learning from a passive to an active learning activity [8]. Interactive video has been introduced exactly for addressing those basic video insufficiencies by providing different learning paths, inducing reflection via embedded questions, and by enabling other user interaction, such as for example, the ability to annotate. Although, interactive video can become an engaging and effective learning tool for individuals or pairs of learners, when it is presented inside the classroom, it once more reverts to an inflexible learning media due to minimal group interactivity options.

This paper proposes an alternative approach for in-classroom video-based collaborative learning via interactive videos and Augmented Reality (AR). This is based on augmentation of specific video frames as they are displayed on the classroom video projection screen. These augmentations can include a variety of interactive activities that stimulate the students' interest and triggers them to participate actively via their mobile devices. In section 2, we make a short introduction to AR technology and how it is used in formal and informal educational settings. In section 3, we highlight the value of educational interactive video. The proposed approach of augmenting interactive video,

*E-mail address: kazanidis@teiemt.gr
ISSN: 1791-2377 
doi:10.25103/jestr.112.23

along with its potential educational benefits are presented in section 4. The paper concludes with a short discussion on how the specific approach may become an interesting canvas for delivering intriguing and effective interactive learning experiences in the classroom.

## 2. Augmented Reality in Education

A commonly accepted definition of AR approaches it as a system or visualization technique in which a real-world context is dynamically overlaid with coherent real time location or context sensitive virtual information [9-10] that coexists in the same space as real world objects [11]. AR technology offers a learning platform that enables engagement for an authentic exploration of the real world. According to Chen et al. [12], three types of AR applications exist, which are categorized according to the augmentation triggering type: marker-based, marker-less and location based. The first type is based on specific markers that may exist overlaid or next to real-world objects in order to offer augmentations. Marker-less AR is based on the automatic recognition of real-world object shapes. Finally, the location-based AR provides information according to the user's geographical location. Augmented information varies from simple text to videos, 3D objects or even complicated interfaces for collaboration, e-commerce, etc.

AR was initially introduced as a training tool for airline and air force pilots during the 1990s [13]. However, only in recent years has AR technology gained significant momentum in education, since it no longer requires expensive hardware and sophisticated equipment, such as head-mounted displays [14]. By employing built-in mobile or desktop cameras, GPS sensors, internet access, and today's powerful mobile devices, AR systems have become affordable to the general public [16], while its idiosyncratic features draw the attention and motivate the engagement of z-generation students [17]. Consequently, AR is increasingly popular [18] and is perceived in the Horizon Report [19] as a soon-to-be-adopted educational technology for schools and classrooms.

AR technology is used today at every level of education, from K-12 [20-21] to tertiary [22-23]. Some of the most popular educational fields that adopted AR include Science [14], Ecology [24], Natural Sciences [18, 25], Physics [26], Chemistry [27], Astronomy [28], Mathematics [29], Geometry [30], Social Sciences [31], Reading Comprehension [32] and Writing Skills [33]. According to recent studies, AR can increase long-term memory, enhance problem-solving skills, motivation, student collaboration [32] and learning satisfaction [34]. From an instructional perspective, Fotaris et al. [21] indicated that the main advantages of AR game-based learning experiences are knowledge gains, increased motivation, augmented interaction, and enhanced collaboration.

Although educational videos are very popular learning tools, as far as we know, they have not been used as triggering platforms for AR applications. In addition, AR technology has not been studied through the lens of interactive video, despite its effectiveness in different educational settings (in-class, distance education, blended learning).

## 3. Interactive Video in Education

According to Palaigeorgiou et al. [35], videos can help learners to visualize how something works by presenting information that is difficult to explain via text or static photos. Videos constitute an audiovisual learning tool that enriches real-world examples with contextual details. It is important that students can access repeat scenarios and information not always easily attainable in other formats. For example, videos capture real-world events that are unusual, dangerous and involve interactions among people or animals that may be difficult to reproduce in a classroom setting [2]. Videos can also simulate an event such as a laboratory experiment, engage in role-playing, demonstrate a process and participate in virtual field trips [36]. As stated above, videos are not a silver bullet and it is well-known that watching a linear video may provoke a passive and unconstructive learning experience.

According to Dimou et al. [37], interactive videos use a non-linear structure with several calls for actions that motivate students to pay full attention to the learning material, while enabling a quick review of any part of the video as many times as is necessary. They can be considered as "videos that are capable of processing user input to perform related actions" [38]. The first interactive video was implemented only in 1989 [39]. Since then, various types of interaction overlaid and next to the video have been developed [40]. Additionally, the costs, both in terms of time and money needed to create highly engaging interactive video content has decreased dramatically. New interactive video tools are easy to use and the interactivity features can be built on top of common video services such as YouTube or Vimeo. In a matter of seconds, a video can become interactive to provide an engaging experience, without the need for the time-consuming video editing process.

Schoeffmann et al. [41] classifies video interaction methods into several categories, such the ability to annotate or label segments or objects in a video, the ability to interact with others in a synchronized way, to interact with objects, to provide internal navigation, to filter video content and to generate overviews of the content. Sauli et al. [42] propose six similar key features for educational interactive video: the in-motion aspect of the video images sequences, the ability to traverse a non-linear path, the interactive markers that give access to supplementary learning material, the possibility to add annotations in a video while watching it, shared annotations among students, and embedded questions.

Several studies have proved that interactive videos can increase students' motivation [43], satisfaction [44-46], and also learning performance [43,46-48]. Video interactivity is flexible, motivating [49] and entertaining [50], while the afforded exploration enhance students' self-regulation [48,51] since students have the opportunity to select their own paths and maintain a pace that fits their personal needs and understanding. All of the above contribute to an advanced educational experience with enhanced learning outcomes and knowledge retention [6-7].

## 4. Classroom augmented interactive video

It is commonly accepted that interactive video brings additional value to video-based learning. However, when interactive videos are presented inside the classroom, they become once again inflexible learning media with minimal interactivity options for the students since only the instructor interacts with the video. Students remain passive viewers, following at the instructor's pace, as happens in the traditional lecture-based format. It is an intriguing challenge to explore how the projected interactive video could be modernized into a shared canvas for personalized and collaborative learning interactions between the students and the class instructor.

In this study, we propose a Classroom Augmented Interactive Video (CAIV) approach that exploits and combines AR technology, well-established video interaction types and the characteristics of classroom-based instruction, to transform the students from passive learners into active contributors, and the instructors from knowledge transmitters to classroom orchestrators.

According to the CAIV approach, all the students in a class share a common projection screen and have the ability to interact with the video using their mobile devices, exploiting AR technology. Interactions are applied when students point their mobile device camera at the projection screen, and undertake such tasks as answering questions, taking notes, reading supplementary material, etc. In addition, an augmented video progress bar providers a visualization of the history of interactions, becomes a reflection tool for the instructor, and each student's personalized navigation tool within the video.

All of the above may potentially transform the educational video into a classroom orchestration platform. The CAIV approach proposes three levels of augmented interactions.

- The first level is a function of the video narration and includes activities that are common to all the students in the class. Its main aim is to motivate participation and to maintain student focus. At this level, all students are asked to make an action, for example, to answer an embedded question, using their mobile device, followed by a viewing and discussing of their classmates' answers.
- The second level of interactivity promotes differentiated learning. Students can ask for more details on demand, have the opportunity to deepen their understanding by studying more on their mobiles and can adjust their learning pace by following a more personalized content path over the commonly displayed content.
- The third level of interactivity concerns student autonomy in regards to their study model. Students can make their own annotations, take notes and a lot more, in order to interact with the content in their preferred way.

The CAIV approach requires that each student has a mobile device, with the specific augmented reality application installed. This application needs to offer educational content, as well as the appropriate interactive tools that are synchronized with the presented interactive video whenever the student points the mobile device at the projection screen.

### 4.1 Interactions Categories

If we revisit the interaction possibilities of CAIV based on the subject who can initiate an interaction, then we can identify three interaction categories:

- **Teacher's Interactions category (TI)** refers to actions that are available only to the teacher. The teacher becomes the ambassador of the learners when the presented video stops and calls for an action. The teacher has the primary responsibility for navigating the commonly watched video, for selecting video content and for giving answers to the posed questions. For these interactions, students have only the option to discuss the various alternatives with their teachers.
- **Students' Interactions category (SI)** refers to personalized actions that are triggered by the students individually. Students using AR can keep personal notes, add annotations or bookmarks, and study supplementary learning content in their own time. These opportunities define a personal space of interactions that promotes self-regulation.
- **Classroom Interactions category (CI)** refers to actions requiring the participation of all students in order to be considered complete. This category includes interactions that concern the entire classroom; e.g. answering a poll or an embedded question or commenting content anchored to a specific video frame, etc. These interactions formulate a shared space of interaction, where students have to negotiate an understanding between them.

The main difference of CAIV, in comparison to typical interactive video authoring tools, is that when you add an interactive activity, you have to specify the "user role" that should be responsible for completing it, by selecting one of the above three categories.

Figure 1 shows the proposed architecture along with the related interactive activities. In particular, the teacher interacts with the interactive video system (IVS) using a personal computer. On the other hand, students scan the presented video using their mobile's camera and develop personalized interactions with the IVS.

### 4.2 Interactions types

Modern interactive video learning environments use a variety of interaction types. A small number of researchers have attempted to classify the possible interactive features of educational interactive videos. Schoeffmann et al. [41], as mentioned earlier, classified video interaction into seven types: Video Annotation, Video Browsing, Video Navigation, Video Editing, Video Recommendation, Video Retrieval and Video Summarization. Seidel [52] analyzed 118 educational video environments and discovered forty patterns of interactivity. Thirteen of them refer to macro interactions (which refer to the overall presentation of a video) and the rest to micro interactions (which refer to in-video behavior) [53]. Upon studying extensively the interactive video literature and some of the most popular commercial interactive video systems, we consider the following interaction types as the most adequate for the CAIV approach.

**Embedded questions**

Embedded questions are probably the most often used feature of educational interactive videos. Providing questions with a feedback mechanism offers a workable model for effective conceptual and procedural information processing [54]. Questions foster a more profound engagement and also serve as assessment tools. Students prefer watching videos with embedded quizzes [45] while embedded questions enable learners to outperform those who with semi-interactive and non-interactive video conditions [55]. Pedagogically, embedded questions usually belong to one of the following categories [51]:

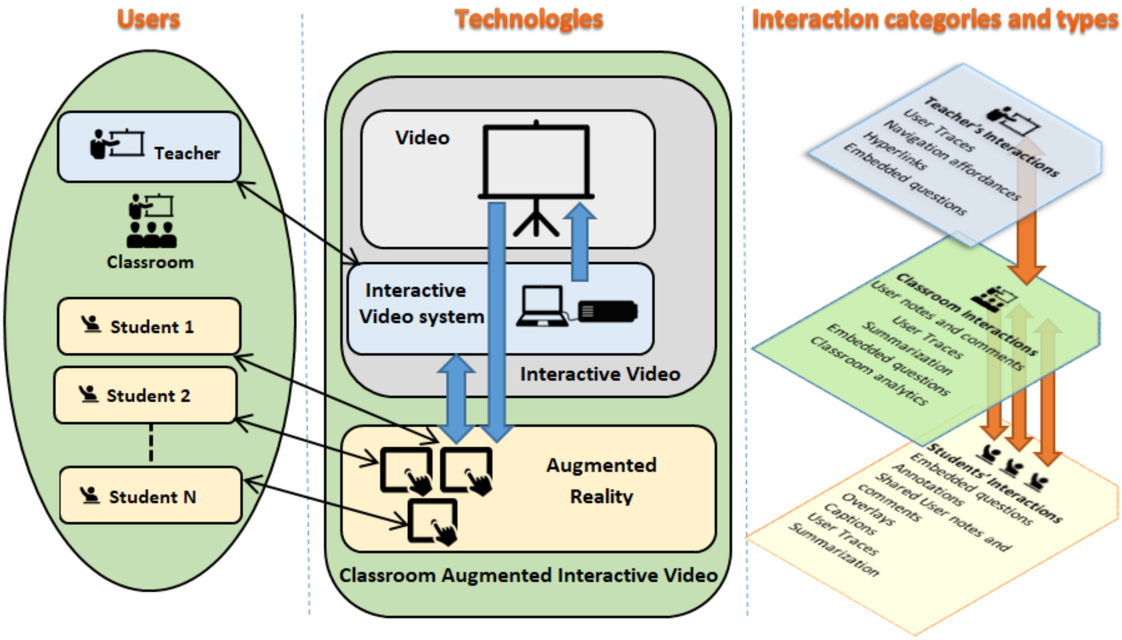


**Fig.1** Proposed approach architecture and interaction categories and types

- *Rhetoric questions* intend to reveal beliefs, opinions or misconceptions on a subject. Rhetoric questions don't always need to be answered; they may just serve to stimulate critical thinking.
- *Inductive questions* ask students to interpret hypotheses based on their prior knowledge. Inductive questions aim at building explanations and reinforcing knowledge.
- *Assessment questions* aim at evaluating understanding in order to decide on how to proceed in the video.

The main issue when sharing such questions in the classroom is that students are not able to follow a learning path that derives from their personal answers, they cannot receive feedback that is related to their way of thinking, but they are stacked with the choices made by their instructor or classmates.

In CAIV, answering questions becomes a two-step process: initially, students raise their mobiles, answer the questions presented and recieve adequate personalized, interactive and instant feedback; afterwards, students view their classmates' answers on the common projection screen and the answers' variety can become an interesting triggering point for metacognitive processes. In opposition with typical classroom response systems, in the CAIV approach, the questions are inferred from the video content and are strongly connected with what will follow in the video, immediately after the students answer. Hence, they are more context sensitive and effective.

**Annotations**

Video annotations allow learners to make annotations in specific frames or segments of a video. Annotations can be either images, icons, emoticons, drawings or text. Through annotations, learners have the opportunity to visualize their thoughts, unfold their creativity and also create personal navigation elements. The annotations are automatically synchronized with the time they were created and work as reflection triggers. Bookmarks can also be included to this interaction type. They allow users to easily revisit external content or specific video frames. Annotating the video promotes a feeling of video ownership in the viewer, and usually results in a more active engagement. Most of the time, interactive video platforms provide annotation mechanisms and video navigation tools that help users to accurately select the annotation targets [41].

In a CAIV approach, annotations keep their initial value in the classroom, allowing the users to enrich the video with personalized annotations. Students can point their mobile's camera at the common video projection screen and add the desirable information, either by drawing on the mobile touchscreen or by inserting multimedia content such as images, emoticons, etc. Since it is difficult to display all the classroom annotations simultaneously, this interaction type is proposed mainly for individual use.

**Shared user notes and comments**

Shared notes and comments enable learners to maintain social video-related notes that include textual information, or follow a peer annotation or peer assessment approach [52]. In a peer annotation approach, learners are asked to provide and share information in the context of a specific educational task. The interactions of this type are used to let learners express their opinions, thoughts and preferences regarding specific parts of the video. These textual entries range from simple self-authored notes to collaborative threaded discussions [56].

In the CAIV approach, these interactions can retain their collaborative character and get the form of a backchannel, which functions as a secondary conversation taking place at the same time as the video progresses. For example, students' comments can be projected onto the common video screen and trigger constructive discussions while the video is playing.

**Overlays**

Overlays are added by instructors and present supplementary visual information in a time-dependent layer on top of the video. They are placed close to their corresponding visual contents [52] and are synchronized over a specific timeframe. These overlays can be either common to all the viewers or appear individually according to user needs and preferences. Usually, overlays can be available on demand at any time or at the end of the video.

In the proposed approach, the overlays are displayed concurrently, through the AR application running on the students' mobile devices and on the common screen, and can be exploited, both individually and collectively. The overlays can provide details on the video subject (e.g. a hyperlink to a related webpage or video), which are adapted to students' characteristics (e.g. native language) and preferences (e.g. display a specific information category). Overlays can also work as simultaneous media presentation, providing a multi-view option to the students (e.g. students can see the presented slides on their mobiles).

**Captions**

Since videos are often dedicated to a diverse audience, with different language competencies and abilities, the use of captions is recommended [52]. Interestingly, the captioning mechanism can also be used as a method for providing different levels of textual content to the learners, according to their understanding or learning needs.

Obviously, captions loose some of their functionality in a classroom setting, but in the CAIV approach, these captions are moved from the shared interactive video level to the augmented interaction level, offering a personalized video experience.

**User Traces**

User traces is a valuable interaction for self-reflection in a typical interactive video. They visualize the parts of the video that students have often, rarely or not at all been watching. User traces allow learners to find the sections of the video that have not yet been viewed, or view the scenes they found highly interesting. Learners can also compare their usage behavior with their peers. Additionally, user traces help educators obtain an overview of the total acceptance of a specific video and know which specific scenes draw the students' attention.

In the proposed approach, user traces enable the creation of classroom traces. Student interactions with the video (e.g. number of likes, number of comments, notes, etc.) can be analyzed by the IVS and feed the classroom trace. Consequently, the traces can be personal or classroom oriented. Classroom trace will be used more by instructors, while the user traces will be moved to the augmented level for personal use. In the CAIV approach, the teacher has the option to monitor the classroom trace, obtain an overview of the class progress and adequately orient his discussions with the students. On the other hand, student traces can promote easy navigation and self-regulated learning.

**Navigation affordances**

According to Meixner and Gold [57] there are two main categories of navigation in interactive video: navigation at the end of scenes (branching) and global navigation (table of contents). Branching enables users to drive their experience, skip content, and study information at a self-determined pace. Global navigation provides the option to quickly and accurately access specific points in the video of special interest to them. Another type of global navigation is the temporal tag, which appear as anchors over the video progress bar.

The use of navigation affordances in the classroom setting will still be useful in the CAIV approach; instructors are able to offer navigational options, not only for themselves but also for the learners, who may decide to visit or skip a specific part of the video, based on how their understanding develops.

**Hyperlinks**

Typically, interactive video hyperlinks are presented as overlay buttons at specific time points of the video and can be discerned in a) internal video links, which enable students to navigate the video contents faster, b) external video links, which point to other educational resources and aim at encouraging students to further explore the presented topic, c) inter-course links, which offer the possibility to jump to different learning activities of the course (if any) in order to remember or learn more about a specific subject matter.

All three types of hyperlinks retain their educational value in the augmented interactive video setting for all classroom stakeholders. The links can be useful both for the instructor, who can still redirect the focus of the whole classroom on what he considers best for the status of his students, and for the students, haveing the ability to pick up the mobile and discover content that better aligns with their interests or understanding.

**Summarization**

Summarization is a method that enhances the learners' engagement with video content since it produces a short clip or a textual outline of the entire video. This short but informative summary of the video helps learners organize information better and reduces the time spent on revisiting the contents. Summarization techniques can be either automatic (videos can be summarized based on a color and utterance, image processing, text or keyword extraction techniques) or non-automatic (viewers can select parts of the original video manually). The latter can be considered as a constructive and knowledge-building experience since students have to think and link several video segments in a meaningful way for them.

Summarization in the augmented video classroom acquires a slightly different role. On one hand, it offers an overview of what happened on the shared video screen with the instructor's choices and the traces of the collaborative actions (such as the answers of the classroom in an embedded question). For example, a summary could automatically include the frames where the instructor paused the video. On the other hand, summarization can also be of use in the augmented app allowing learners to either watch a summary, taking into account their selections and preferences, or manually create their versions of the video summary.

**Classroom video analytics**

Educational researchers use video analytics to disclose hidden patterns of student behavior. Electronic behaviors on interactive video offer a rich digital footprint that can be collected and analyzed to establish a good understanding and assessment of interactive video design and its learning effects. Today video learning systems, beyond the frequency of video visits and time spent on a video, also provides information about the sections of a video each viewer has watched, re-watched, skipped over, abandons, users' interactions with instructors' annotations, quiz and questions responses, viewers personal annotations, or more abstract indicators, such as the attention level based on reaction times to the interactive components presented during the video.

When an interactive video is presented in the classroom, most of the previous metrics are irrelevant, since the only user who interacts with the video is the instructor. In the CAIV however, there are plenty of behaviors to be monitored that can be organized into two categories: a) classroom interactions with the interactive video that include all common students' interactions with instructors' annotations, b) students' personal interactions with interactive video, which concern either private annotations and notes or explorative actions for learning more about the subject matter. Since the CAIV provokes two possible concurrent learning paths, one decided in the classroom by the instructor and one private for each learner, the instructors would synchronously want to know metrics on the latter for classroom orchestration purposes. By monitoring interaction data, instructors can understand the level of student engagement and interest, and therefore adjust them for more effective learning.

Table 1 provides a summary of the video interaction types and their potential use in the CAIV approach.

**Table 1.** Exemplary interactions in CAIV Aproach

| Interactions | Student's Interactions | Classroom Interactions | Teacher's Interactions |
|---|---|---|---|
| Embedded questions | Students answer questions and get personalized feedback using their mobile devices | Overall students' answers will be presented on the common projection screen | Teacher may add embedded questions that he will need to answer during the lesson. |
| Annotations | students point their mobile devices at the common video projection screen and add the desirable information | | |
| Shared user notes and comments | Students insert their notes and comments on the scanned frame of the video. | Students' comments can be projected on the common video screen as a back channel | |
| Overlays | AR application displays these overlays on students' mobile devices. Information included in the overlays can be details adapted to the students' characteristics and preferences | | Overlays appear also in the shared screen and can be exploited by the instructor |
| Captions | Textual descriptions which offer a personalized video experience. The user can hide them whenever he wants. | | |
| User Traces | Students can identify the parts of the video they have not yet viewed or find the scenes they found highly interesting | User traces feed the classroom trace | Teacher can exploit the classroom trace for initiating discussions or for navigating inside the video |
| Navigation affordances | Students can start a different learning path to the one presented on the shared screen | | Teacher are able to present video segments which they consider as more adequate each time. They also act as students ambassador |
| Hyperlinks | Students have the ability to pick up their mobile and discover content that falls in line with their interests or understanding | | Teacher can redirect the focus of the whole classroom on what he considers best for the status of his students |
| Summarization | Students may view a summary based on their selections and preferences or create their versions of the video summary manually. | Offers an overview of what happened in the shared video screen with the instructor's choices and the traces of the collaborative actions | |
| Embedded questions | Students answer questions and get personalized feedback using their mobile devices | Overall students' answers will be presented on the common projection screen | Teacher may add embedded questions that he will be responsible for answering during the lesson. |
| Classroom analytics | | Detailed analytics may be presented on the projection screen for discussion | Teachers can take advantage of individual and classroom analytics to organize and adjust their instructional approach |

## 5. Conclusions

Although the concept of interactive video is still relatively new, evidence arising from the literature suggest that interactive video is an attractive alternative for guiding student attention, reducing cognitive overload, enhancing learning effectiveness and motivating the students to learn more. However, interactive video's main usage scenario is the individual use of technology platforms such as tablets, desktops or mobile devices and when an interactive video is presented over a projection screen of a typical classroom setting, its potential is being limited. Students cannot participate and interact with it and essentially the interactive video offers only the benefits of its simple linear counterpart. In this manuscript, we presented the CAIV approach which proposes the augmentation of interactive video as a means to retain its powerful characteristics and to advance self-regulated learning, social interaction and student engagement in the classroom.

The CAIV approach proposes tools for classroom activities, individual exploration activities and personal annotation activities, with the use of augmentations over the interactive video screen. Based on who has the initiative to complete an action, we analyzed three categories of interactions, teacher's interactions, students' interactions and classroom interactions. The suggested affordances enable a two-layered learning pace inside the classroom: one that is determined by the instructor and one that is self-regulated by each student. These two interaction spaces support differentiated learning and collaborative learning. However, they may also provoke conflicting situations since a student may select to navigate and study the learning material totally in his own time-space, and hence, will not follow and participate in the classroom interactions. There is a strong possibility of creating two parallel spaces of delivering and interacting with content. There are a lot of similar details to be discussed, but in this manuscript, we describe the CAIV approach as an overall transformation approach of interactive video for classroom usage.

There are some significant limitations to the envisaged approach; the main limitation is the lack of appropriate interactive video systems for classroom environments. Although, there are many interactive video platforms on the market such as LearnWorlds [58], Adways [59] or Wirewax [60] which offer a variety of interactive elements such as annotations, hotspots, video branching, end cards, none of the above targets collaborative learning settings. On the other hand, there are several augmented reality platforms and applications that allow users to create, apply and use intelligent augmentations such as the commercial Blippar [61], Aurasma [62] and Layar [63] or the academic ARTutor [64], however there are no approaches to triggering and coordinating augmentations on the continuously changing video images.



## References


1. Pappas, I. O., Giannakos, M. N., & Mikalef, P. (2017). Investigating students' use and adoption of with-video assignments: lessons learnt for video-based open educational resources. Journal of Computing in Higher Education, 29(1), 160-177.
2. Koumi, J. (2006). Designing video and multimedia for open and flexible learning. New York: Routledge.
3. Wetzel, D. C., Radtke, P. H., & Stern, H. W. (1994). Instructional effectiveness of video media. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc
4. Haas, S. W., Brown, R.T., Cao, L., & Wilbur, J. D. (2005). Evaluation of the GovStat Statistical Interactive Glossary: Implications for just-in-time help. Proceedings of the 2005 National Conference on Digital Government Research (pp. 291-292).
5. Meixner, B., & Kosch, H. (2016) Creating and presenting interactive non-linear video stories with the SIVA Suite. In Adjunct Proceedings of the 1st International Workshop on Interactive Content Consumption at EuroITV (pp. 160-165).
6. Cherrett,T., Wills, G., Price, J.,Maynard, S., & Dror, I. E. (2009). Making trainingmore cognitively effective: Making videos interactive. British Journal of Educational Technology, 40(6), 1124–1134.
7. Wachtler, J., Hubmann, M., Zöhrer, H., & Ebner, M. (2016). An analysis of the use and effect of questions in interactive learning-videos. Smart Learning Environments, 3(1), 13.
8. Mitrovic, A., Dimitrova, V., Lau, L., Weerasinghe, A., & Mathews, M. (2017). Supporting Constructive Video-Based Learning: Requirements Elicitation from Exploratory Studies. In International Conference on Artificial Intelligence in Education (pp. 224-237). Springer, Cham.
9. Azuma, R. T. (1997). A survey of augmented reality. Presence: Teleoperators and Virtual Environments, 6(4), 355–385.
10. Klopfer, E., & Squire, K. (2008). Environmental detectives -The development of an augmented reality platform for environmental simulations. Educational Technology Research and Development, 56, 203–228.
11. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. Computer Graphics and Applications IEEE, 21(6), 34-47.
12. Chen, C.-M., & Tsai, Y.-N. (2012). Interactive augmented reality system for enhancing library instruction in elementary schools. Computers & Education, 59(2), 638–652.
13. Caudell, T. P., & Mizell, D. W. (1992). Augmented reality: An application of heads-up display technology to manual manufacturing processes. In Proceedings of the twenty-fifth Hawaii international conference on System Sciences, (pp.659-669), IEEE.
14. Atwood-Blaine, D., & Huffman, D. (2017). Mobile Gaming and Student Interactions in a Science Center: The Future of Gaming in Science Education. International Journal for Science and Mathematics Education. 15(1), 45-65.
15. Akçayır, M., & Akçayır, G. (2016). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review, 20, 1-11
16. Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y. & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & Education, 62, 41–49.
17. Tekedere, H. & Goker, H., (2016). Examining the Effectiveness of Augmented Reality Applications in Education: A Meta-Analysis. International journal of environmental & science education, 11(16), 9469-9481.
18. Chen, C.-H., Chou, Y.-Y. & Huang, C.-Y. (2016). An Augmented-Reality-Based Concept Map to Support Mobile Learning for Science. Asia-Pacific Edu Res, 25(4), 567-578.
19. Adams Becker, S., Freeman, A., Giesinger Hall, C., Cummins, M., & Yuhnke, B. (2016). NMC/CoSN Horizon Report: 2016 K-12 edition. Austin, TX: The New Media Consortium.
20. Chiang, T. H., Yang, S. J., & Hwang, G.-J. (2014). Students' online interactive patterns in augmented reality-based inquiry activities. Computers & Education, 78, 97-108.
21. Fotaris, P., Pellas, P., Kazanidis, I. & Smith P. (2017). A systematic review of Augmented Reality game-based applications in primary education. In Proc. of the 11th European Conference on Game-

Based Learning (ECGBL 2017). Graz, Austria, 5-6 October, 2017. (pp. 181-190)
22. Ferrer-Torregrosa, J., Torralba, J., Jimenez, M., García, S., & Barcia, J. (2015). ARBOOK: Development and assessment of a tool based on augmented reality for anatomy. Journal of Science Education and Technology, 24(1), 119-124
23. Kazanidis I., Tsinakos A., Lytridis, C. (2017). Teaching programming using Augmented Reality and collaborative game based learning. International Conference on Interactive Mobile Communication, Technologies and Learning. IMCL2017, Thessaloniki, Greece
24. Hwang, G.-J., Wu, P.-H., Chen, C.-C., & Tu, N.-T. (2016). Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations, Interactive Learning Environments, 24(8), 1895-1906.
25. Stefandi O., Tsinakos A, Karamanoli P. (2017). Blended Learning Theory and Practice, Development of a Collaborative Game for Enhancing the Educational Process in Classroom, Proceedings of the 2nd World Conference on Blended Learning (pp 52-60).
26. Cai, S., Chiang, F., Sun, Y., Lin, C. & Lee, J. (2016). Applications of augmented reality-based natural interactive learning in magnetic field instruction. Interactive Learning Environments, 25(6), 778-791.
27. Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of augmented reality simulation system application in a chemistry course. Computers in Human Behavior, 37, 31-40.
28. Zhang, J., Sung, Y.-T., Hou, H.-T. & Chang, K.-E. (2014). The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. Computers & Education, 73, 178-188.
29. Sommerauer, P., & Müller, O. (2014). Augmented reality in informal learning environments: a field experiment in a mathematics exhibition. Computers & Education, 79, 59–68.
30. Laine, T., Nygren, E., Dirin, A. & Suk, H. (2016). Science Spots AR: a platform for science learning games with augmented reality. Education Technology & Research Development, 64(2), 507–531.
31. Efstathiou, I., Kyza, E., & Georgiou, Y. (2017). An inquiry-based augmented reality mobile learning approach to fostering primary school students' historical reasoning in nonformal settings. Interactive Learning Environments, 26(1), 22-41.
32. Tobar-Muñoz, H., Baldiris, S., & Fabregat, R. (2017). Augmented Reality Game-Based Learning: Enriching Students' Experience During Reading Comprehension Activities. Journal of Educational Computing Research, 55(7), 901-936.
33. Wang Y.-H. (2017). Exploring the effectiveness of integrating augmented reality-based materials to support writing activities, Computers & Education 113, 162-176.
34. Huang, T.C., Chen, C.C., & Chou, Y.W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. Computers & Education, 96, 72–82.
35. Palaigeorgiou, G., Malandrakis, G., & Tsolopani, C. (2017). Learning with Drones: flying windows for classroom virtual field trips. In Advanced Learning Technologies (ICALT), 2017 IEEE 17th International Conference on (pp. 338-342). IEEE.
36. Yousef, A. M. F., Chatti, M. A., & Schroeder, U. (2014b). The state of video-based learning: A review and future perspectives. Int. J. Adv. Life Sci, 6(3/4), 122-135.
37. Dimou, A., Tsoumakas, G., Mezaris, V., Kompatsiaris, I., & Vlahavas, L. (2009). An empirical study of multi-label learning methods for video annotation. In Content-Based Multimedia Indexing, 2009. CBMI'09. Seventh International Workshop on (pp. 19-24). IEEE
38. Alzahrani, N. M. (2016). Student-summarized videos in an Adaptive and Collaborative E-learning Environment (ACES) (Doctoral dissertation, University of Sussex).
39. Brondmo H. P., & Davenport., G. 1989. Creating and viewing the Elastic Charles—A hypermedia journal. In Hypertext: State of the ART, Papers Presented at the Hypertext II Conference, R. McAlesse and C. Green (Eds.). Intellect, York, England, 43–51. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.85.5291&rep=rep1&type=pdf.
40. Meixner, B. (2017). Hypervideos and Interactive Multimedia Presentations. ACM Computing Surveys (CSUR), 50(1), 9.
41. Schoeffmann, Klaus & A. Hudelist, Marco & Huber, Jochen. (2015). Video Interaction Tools. ACM Computing Surveys. 48. 1-34.
42. Sauli, F., Cattaneo, A., & van der Meij, H. (2018). Hypervideo for educational purposes: a literature review on a multifaceted technological tool. Technology, pedagogy and education, 27(1), 115-134.
43. Chen, Y. T. (2012). A study on interactive video-based learning system for learning courseware. Research Journal of Applied Sciences, Engineering and Technology, 4(20), 4132-4137.
44. Bolliger, D. U., & Martindale, T. (2004). Key factors for determining student satisfaction in online courses. International Journal on E-Learning, 3(1), 61-67.
45. Woll, R., Buschbeck, S., Steffens, T., Berrang, P., & Loviscach, J. (2014). A platform that integrates quizzes into videos. Proceedings of the European MOOC Stakeholder Summit (pp. 155-159).
46. Meixner, B. (2014). Annotated Interactive Non-linear Video. (Doctoral dissertation, University of Passau).
47. Langbauer M. and Lehner F. (2015). An Interactive Video System for Learning and Knowledge Management. In Proceedings of 2015 International Conference on Enterprise Systems (pp. 55-56). IEEE.
48. Palaigeorgiou, G., Chloptsidou, I., & Lemonidis, C. (2017). Computational estimation in the classroom with tablets, interactive selfie video and self-regulated learning. In Interactive Mobile Communication, Technologies and Learning (pp. 860-871). Springer, Cham.
49. Wong, W. L., Shen, C., Nocerna, L., Carriazo, E., Tang, F., Bugg, S., Narayanan, H., Wang, H. & Ritterfeld, U. (2007). Serious Video Game Effectiveness. In Proceedings of the International Conference on Advances in Computer Entertainment Technology (pp. 49–55). ACM.
50. Leeder, D. (2000). From linear lecture to interactive multimedia module: A developer's perspective. Education Media International, 37(4), 219–224.
51. Papadopoulou, A., & Palaigeorgiou, G. (2016). Interactive Video, Tablets and Self-Paced Learning in the Classroom: Preservice Teachers Perceptions. International Association for Development of the Information Society.
52. Seidel, N. (2015). Interaction design patterns for spatio-temporal annotations in video learning environments. Proceedings of the 20th European Conference on Pattern Languages of Programs.16, ACM.
53. Schwan, S. (2000). Video in Multimedia-Anwendungen. Gestaltungsanforderungen aus Kognitionspsychologischer Sicht. In Psychologie und Evaluation II. Neue Medien, Psychologiedidaktik und Evaluation in der Haupt- und Nebenfachausbildung. Bd. 5, G. Krampen and H. Zayer, Eds. Deutscher Psychologenverlag, Bonn, 55–72.
54. Tweissi, A. (2016). The Effects of Embedded Questions Strategy in Video among Graduate Students at a Middle Eastern University (Doctoral dissertation, Ohio University).
55. García-Rodicio, H. (2014). Support for learning from multimedia explanations. A comparison of prompting, signaling, and questioning. Journal of Educational Computing Research, 50(1), 29-43.
56. Colasante, M., & Douglas, K. (2016). Prepare-Participate-Connect: Active learning with video annotation. Australasian Journal of Educational Technology, 32(4), 68-91.
57. Meixner, B., & Gold, M. (2016). Second-Layer Navigation in Mobile Hypervideo for Medical Training. In International Conference on Multimedia Modeling (pp. 382-394). Springer, Cham.
58. www.learnworlds.com
59. www.adways.com
60. www.wirewax.com
61. www.blippar.com
62. www.aurasma.com
63. www.layar.com
64. Lytridis C., Tsinakos A., Kazanidis I. (2018). ARTutor-An Augmented Reality Platform for Interactive Distance Learning. Education Sciences.; 8(1):6.