# A framework for recording, monitoring and analyzing learner behavior while watching and interacting with online educational videos

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***Abstract*—Online educational videos are increasingly used by a great number of educators. Besides the typical linear, non-interactive videos, educational videos today can contain other features such as interactivity and quizzes. This paper provides a framework for recording, monitoring and analyzing learner activity behavior while watching or interacting with online educational videos. More specifically it proposes: (a) a software specific methodology for capturing learner activity data, (b) a data model for storing the activity data, and, (c) modules to monitor and visualize learner viewing behavior.**

***Keywords – video in education, viewing behavior, monitoring, video usage analysis***

## I. INTRODUCTION

Nowadays, educators use online video lectures extensively to assist learning. Video lectures are playing an increasingly significant role in online learning through the various university open courseware initiatives (e.g., Stanford online http://online.stanford.edu, EdX https://www.edx.org, MIT OpenCourseWare http://ocw.mit.edu) and sites maintained by non-profit and private organizations such as Khan Academy (http://www.khanacademy.org). A vast amount of educational videos can also be found in either an organized or unorganized form in video-sharing sites like YouTube and Vimeo. The videos are typically either a recorded lecture that takes place in a classroom or a video lesson that is designed by an educator using various e-learning software tools and relevant hardware equipment (e.g., camera, microphone, draw pad, etc.). Videos created with e-learning software can contain a variety of elements (e.g., animation, sound) and features (e.g., interactivity, quizzes, synchronized PowerPoint presentations etc.). Apart from typical lectures, videos can also be demonstration tutorials aiming to present various procedures such as using a software tool or searching in bibliographical databases [6]

The importance of video usage in education is also depicted by the considerable amount of publications that focus on the topic. Kay [1] provides a literature review on the use of video podcasts in education from 2002 to 2011. He mentions that research in the particular area before 2005 was limited. He argues that the increase of online video usage for entertainment and subsequently for educational purposes was due to two factors. The first factor was the adoption of high-speed Internet access in homes and schools between 2006 and 2010. As Kay observes, this increase in the adoption of high speed Internet was also followed by an increase in the research on video usage in education. The second factor was the appearance, and the ever since growing popularity, of the video sharing site YouTube, which today hosts numerous educational videos in a wide range of subject areas.

Research on video usage in education is growing and a sub field of this research is associated with understanding learner viewing behavior. Several publications in Kays' literature review deal with learner viewing patterns that emerge from watching educational videos (e.g., [2][3]). These studies use mostly surveys, but also focus groups and controlled environment experiments, to obtain information on the learner viewing patterns and for understanding the factors that lead to specific viewing styles. Kay notes that future research in this area could focus on a more detailed analysis of viewing styles and their impact on learning outcomes. To achieve this on a mass scale, tools that assist usage analysis and mining would have to be employed.

The aim of this paper is to introduce a framework that will assist such detailed analysis. In Section II, we present our approach that is software specific and can be applied to all videos created with Adobe Captivate. This approach is also integrated in the sense that it takes into account the fact that today's videos can contain interactive elements and quiz questions. Furthermore in the end it is explained how this approach can be applied to any educational video imported in Captivate. The paper concludes with Section III, where some preliminary findings are presented as well as directions for future research.

## II. METHODOLOGY

The first task to be addressed is finding a way to log learner viewing activity. Previous researchers either used log files from streaming servers [2] or relied on the use of special video players in order to record a wide variety of browsing behavior [4][5]. However developing such players from scratch requires sufficient development time and expertise. According to our research, other methods can be used in order to achieve such a task easier and quicker, for example, by using open source video players and their APIs' (e.g., JW Player). This task can also be accomplished by using the capabilities of popular e-learning tools. E-learning tools with screen capturing capabilities are widely used for the production of educational videos. These tools are either commercial or open source. Adobe Captivate, Articulate Storyline, and, Camtasia are three examples of popular software packages.

Adobe Captivate is the software tool used in the proposed methodology and a certain procedure is followed in the video production and distribution phase in order to capture learner viewing activity. A suitable data model for storing the activity data is also presented.

### *A. Capturing user viewing activity data*

Captivate can publish the final movie in a number of formats (e.g., swf, avi, exe) but swf is the format that will be used in the current methodology. Captivate contains a feature called Widgets that allows movie properties and events triggered by the movie or the user to be captured. Captivate Widgets are programs written in Actionscript that can be embedded in the published Flash movie. These scripts can capture various movie properties and events. Typical events triggered by a Captivate movie are: (a) the on_start event triggered at the start of the movie, (b) the on_slide_enter and on_slide_exit events triggered when the movie enters or exits a slide, (c) the on_Pause and on_Resume events triggered when the movie pauses or resumes, (d) the interactiveitem_submit event triggered when an interactive item such as a click area or a text box is clicked or filled in respectively, (e) the question_submit event triggered when a question is submitted, and, (f) the on_stop event triggered when the movie reaches the end. When these events occur, a number of properties can be captured concerning the movie, the interactive items and the quiz questions performed by the learner. These properties can be seen in the database schema described in subsection C. These movie properties captured by the Widget on specific movie events can then be passed into a PHP program in order to be stored into a database (such as MySQL, Postgresql, etc.). Flash programs written in Actionscript run on the client and cannot directly interact with Databases such as MySQL that reside on the server. To by-pass this problem a "mediator" program written in a server side language is used. The "mediator" program takes care of the communication with the database.

### *B. Defining Movie sections*

Besides the various movie properties, a movie can be split into sections in order to help the educator determine which segments of the movie students view.

In the proposed methodology a section can be defined as a sequence of slides having the same label. The video creator determines sections by entering slide labels at editing time. The recommended way to define sections is on topic basis and by using appropriate descriptive labels and a section number (e.g., "1 – An Introduction to the Excel functions"). It is also recommended that sections do not have substantial differences in length. Determining which sections a learner views is an efficient way of getting more insight into learner viewing behavior. Most studies that log user activity behavior are limited to indicators related to the videos started by a user (with no indication of the video portions viewed) and to time (e.g., average time the learner spent on videos). Only recently, YouTube has released two metrics in YouTube analytics that indicate the times that a specific point in the video is viewed by the audience. These metrics are called absolute and relative "audience retention".

### *C. Database schema.*

As already mentioned educational videos created by e-learning software can contain interactive items and quizzes and this paper attempts to provide an integrated approach for capturing and storing all kinds of activity data derived from watching and interacting with educational videos.

The database information is split into two types. First, we have the "initial information" such as the number of videos and the characteristics of each video, and the "session information" that is inserted into the database whenever the videos are being viewed by learners. The initial information is necessary in order to have a reference point for any statistical analysis and mining task.

The initial information is inserted once in the beginning by an initialization procedure. After the video production process is finished a widget is embedded in every video with a task to capture the initial information. The videos are first run by the creator for this task to be accomplished. After the initial information is gathered, another widget is inserted to every video with the task to capture session information from the learner sessions.

**Initial Information**: The tables in the database contain initial information about the videos, the video segments that each video is divided into, the elements that exist in interactive simulation videos, and, the quiz questions that may exist in any video.

**Videos** (video_id, name, description, totalframes, lastslide, timeElapsed)
**Video_Sections** (video_id, section-id, title, slidenumber, frame, timeElapsed)
**Quiz_questions** (video_id, question_id, questiontype, questionmaxattempts, questionmaxscore, slidenumber, frame)
**Interactive_elements** (video_id, element_id, name, slidenumber, frame)

**Session Information**: Session activity information is information obtained from learners viewing the videos. A user session is defined as the period starting from user login and until the user exits the web page with the educational videos. The session information is stored into the following tables:

**Users** (user_id,username, password, firstname, lastname)
**Sessions** (sessionid, user_id, ip_address, startdate, starttime)
**Session_videos** (s_vid, sessionid, video_id, startdate, starttime, timeElapsed)
**s_video_sections** (s_sectid, s_vid, section_id, pause, resume, stop, slidenumber, frame, date, time, timeElapsed)
**s_int_elements** (s_elemid, s_vid, element_id, isSuccess, date, time, timeElapsed)
**s_quiz_questions** (s_qid, s_vid, question_id, questionAnswered, questionAnsweredCorrectly, questionattempts, questionscore, date, time, timeElapsed)

### *D. Technical aspects*

In our methodology videos are accessed through a web page. Users are given accounts and a login procedure must be followed in order to have access to this web page (cookies are used on login). Videos can only be viewed online and technical care has been taken to prohibit downloads and to ensure that there is a connection to the database throughout sessions. If no connection is established then the video cannot be viewed.

### E. *Monitoring and Visualizing the learners activity*

Two modules have been developed in PHP in order to aid the educator in monitoring individual learner activity. The first is a simple view of the database table entries starting from sessions or users and with the ability to navigate to the videos viewed within these sessions, and from there to video sections viewed and to interactive items and quiz questions attempted by the learner (if they exist). Different colors are used to highlight the stop and resume entries as well as the successful and unsuccessful attempts in an interactive video and quiz. The second module is used to visualize learner navigation. The Grapviz (www.graphviz.org) visualization package was used for this purpose. A graph can be created on user demand for the sequence of (a) all videos viewed by the user, (b) videos viewed within a particular session, (c) sections viewed from a particular video, and, (d) interactive items and quiz questions attempted in a video. Again, different colors are used to indicate the pause, resume and stop events as well as the successful or unsuccessful attempts on interactive items and quiz questions. To create a graph, an appropriate input (dot) file is created by the database entries and then Grapviz is called to produce an image file that is then displayed on the Web page. An example of a graph is given in Fig. 1.

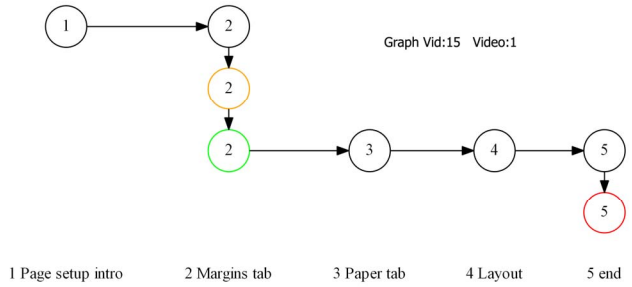


***Figure 1: Visualizing learner navigation***

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In the above graph the movie has paused on section 2 and resumed from the same section. The movie was then viewed till the end sequentially. Section names are displayed in the bottom of the graph. Different graphs with variations in navigation can occur. Dashed lines are used when sections are omitted.

### F. *Metrics*

Various metrics can be derived from our data on user and video level in order to measure student engagement with educational videos and the popularity of videos. An indicative metric on user level is the percentage of viewed sections (unique sections viewed/total sections in videos). A similar metric can be derived for interactive items and quiz questions performed with success. An indicative metric on video level is the percentage of users that viewed the video (number of users that viewed the video/total users). A video is considered as viewed if all (or most) of its sections have been viewed. A section can be viewed completely in one video viewing or in parts amongst a number of video viewings. A more detailed analysis on metrics is in the scope of this ongoing work.

### G. *Applying the methodology into any video*

The described methodology can be applied in any educational video found from various sources (e.g., YouTube). One can insert any type of video in Captivate. The video is inserted initially into one slide after been converted to FLV format. Then, Captivate allows the distribution of the video amongst multiple slides using the Video->Edit Time option.

## III. PRELIMINARY FINDINGS AND FUTURE WORK

For testing the system, a series of video lessons with Adobe Captivate were used. These video lessons were created for supporting the courses "Introduction to Computers and Web page Design" for the students of the Dept. of Public Relations and Communication of the Technological Institute of Western Macedonia. The first series of video lectures were used in the fall semester of 2012-2013.

Some preliminary findings show that only a small number of students view videos regularly and in the proposed order. Most students viewed the videos in the last few days before exams. Moreover, video sections are viewed mostly sequentially. Pausing and resuming is mainly observed for videos that are associated with an assignment. It is assumed that for these videos students stop (and resume) often in order to concentrate on a topic relevant to the assignment. The findings also reveal design problems related to some interactive items that caused an unexpected number of unsuccessful attempts.

The second series of video lessons will be used throughout the spring semester. Our aim is to get insight into student viewing behavior by applying statistical analysis and data mining algorithms on the collected data. Surveys and personal interviews may also be used in combination to examine other factors (which can only be researched by using these methods) that affect learner viewing behavior as well as factors that cause abstention from online video use.

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