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Introducing a New Approach for Investigating Learning Behavior

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Abstract: The potential of learners' video interactions to understand learning behavior has been recognized in previous research. However, little research has yet been conducted on enhanced video-based environments using behavior sequence analyses. Hence, we developed *Logible*, a sensitive, web-based tool to detect and analyze meaningful behavior sequences of learners interacting with such environments. The tool is based on an iterative method. With *Logible* we were able to visualize learning behavior and emphasize differences in experimental conditions.

Keywords: learning behavior, method development, sequence analysis, video-based learning

Introduction

Today, *enhanced video-based environments* are able to support conceptual understanding and deep processing as they provide – along with basic video control tools (e.g., play, pause, rewind) – new tools that allow to annotate, discuss, or edit videos alone or in groups (e.g., Zahn, 2017). Research on *learning analytics* emphasizes that much can be learned from learners' interactions with such enhanced videos about their learning behavior by analyzing log files that contain logged (inter-)action data (Mirriahi & Vigentini, 2017). However, while previous research has mostly focused on analyses of frequencies of single actions (e.g., by summarizing play clicks) (Mubarak et al., 2020), Sinha et al. (2014) argued that such analyses make it difficult to trace results back to actual learning behavior as hidden information from behavior patterns get lost. They thus recommended to encode meaningful sequences from log files by grouping single (inter-)actions. Yet, such behavior analyses are still rare in previous research on enhanced video-based environments – not least because of the huge effort that needs to be invested to detect and elaborate meaningful sequences from raw log files (Mubarak et al., 2020). We thus developed an interactive web-based tool (*Logible*) that is based on an iterative method and automatically visualizes and analyzes meaningful behavior sequences from raw log files of students learning either individually or in groups of two (i.e., learning setting) and using either hyperlinks or self-written annotations (i.e., learning task). In the present work, we ask: *can differences in learning behavior be made visible by developing a new method and tool using raw log files?* – and hypothesize that differences in learning settings (H1a) and learning tasks (H1b) can be found.

Methods

Logible (making *log* files leg*ible*) was developed based on an exploratory and iterative method using 92 data sets of totally 134 Swiss university students (75% female, $M = 24.18$ years, $SD = 6.78$) who learned about synaptic plasticity with the enhanced video-based environment *FrameTrail* (https://frametrail.org) either individually (N = 50) or collaboratively in dyads using one shared desktop computer (N = 84 individuals in 42 dyads). Participants could either add self-written annotations based on additional predefined informative texts (N = 65) or hyperlinks including these texts (N = 69) directly at appropriate places into the video and change their display time on the video timeline. *FrameTrail* automatically provided raw log files for each individual or collaborative data set containing learners' interactions in chronological array of occurrence. To find meaningful behavior sequences, two experts manually built groups of actions performed in conjunction with each other and defined rules for each of the detected sequences (e.g., mandatory actions of a sequence). The method was continuously improved and finally resulted in 17 behavior sequences (see Figure 1). At the same time, a first prototype of *Logible* was developed that was able to read the log files (see Figure 2) and considered the factors *priority*, *length* (of sequence), and *homogeneity* to detect the most meaningful sequences to be used for further analyses (see black framed sequence in Figure 2). The sequences were then assigned to five *behavior patterns* based on (1) their *intentional level* (i.e., did learners *search* or *find* appropriate places in the video to add an annotation or hyperlink) and (2) their *level of content creation* (i.e., did learners *add* or *modify* annotations or hyperlinks). We used behavior patterns for further analyses as (1) they show a higher contrast capability than sequences and because (2) not all sequences appear in the hyperlink condition (see Figure 1).

Behavior Patterns	Behavior Sequences		Prioritization
	Annotation	Hyperlink	
1. Search and add	1.1 Search position and add annotation	1.1 Search position and add annotation	3
	1.2 Search position and add annotation and adjust time	1.2 Search position and add annotation and adjust time	2
	1.3 Search position and create annotation		2
	1.4 Search position and create annotation and adjust time		1
2. Search and modify	2.1 Search to adjust annotation time	2.1 Search to adjust annotation time	5
	2.2 Search to change/complement annotation text		5
	2.3 Search to change/complement annotation and adjust time		4
3. Find and add	3.1 Find position and add new annotation	3.1 Find position and add new annotation	8
	3.2 Find position and add annotation and adjust time	3.2 Find position and add annotation and adjust time	7
	3.3 Find position and create new annotation		7
	3.4 Find position and create annotation and adjust time		6
4. Find and modify	4.1 Find position and adjust annotation time	4.1 Find position and adjust annotation time	10
	4.2 Find position and add further video information		10
	4.3. Find position and add further video information and adjust time		9
5. Search and navigate	5.1 Rewatch	5.1 Rewatch	12
	5.2 Jump Forward	5.2 Jump Forward	12
	5.3 Skipping	5.3 Skipping	11

Figure 1. Overview of behavior sequences and behavior patterns with prioritization

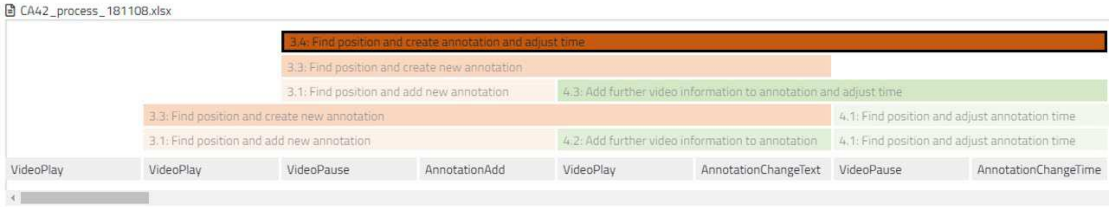

Figure 2. Example of detected sequences of a collaborative group (ID = 42) using annotations in *Logible*.

Findings

A MANOVA with *learning task* and *setting* as between-subject factors and relative values of the five behavior patterns as dependent variables revealed a significant main effect for *learning task* ($F(4, 85) = 4.650$, $p = .002$; Pillai's Trace = .180), as expected (H1b), indicating a difference in the frequencies of behavior patterns between the annotation and hyperlink condition (i.e., *2. Search and modify* ($p = .010$) and *4. Find and modify* ($p = .023$) occurred more often in the annotation condition and *3. Find and add* ($p = .035$) and *5. Search and navigate* ($p = 0.15$) occurred more often in the hyperlink condition). No main effect was found for learning setting ($p > .05$).

Conclusions and implications

This study aimed to develop a new method and tool (based on log files) for gaining insights into learners' behavior when interacting and learning with an enhanced video-based environment. Our approach to detect and visualize meaningful behavior sequences from raw log files was successful and resulted in interesting new insights. Therefore, we conclude that differences in learning behavior can be made visible by applying our method using the newly developed application *Logible*. Future research should increasingly consider sequence behavior analyses when investigating enhanced video-based learning. We encourage researchers to work with our tool.

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