Collaborative Annotation of Recorded Teaching Video Sessions

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Keywords: Collaborative Annotation, Learning Video, Note-taking, Web Application.

Abstract: Driven by technology advances the availability of digital video recordings of live training sessions increases at a fast pace. The goal of our research is to better understand the impact of these digital artifacts on the individual (and possibly collaborative) note-taking process of learners. In this paper, we develop a conceptual framework describing the augmentation of teaching sessions by computer-supported tools. We use the framework to describe related work and to outline our research design that involves the development of a minimum viable collaborative annotation tool and the study of the effects of variations in tool functionality (like visibility of annotations, kinds of annotations, or form of annotations) on the learning process. The scientific contribution of the conceptual framework and tool are to serve as a starting point for empirical research by us and others who analyses the effect of variations in collaborative annotation tool design.

1 MOTIVATION AND INTRODUCTION

Today a number of computer-supported solutions aim to improve student learning behavior and performance in the classroom environment. The main enablers for these changes are availability and price reduction of broadband internet as well as portable hardware, like, smartphones, laptops and tablets (Alvarez, 2011). For example, using mobile and web services, without interruption of the teacher's presentation, students have the possibility to interact between each other simply texting on Facebook or Twitter (M.D. Roblyera, 2010) (Gabriela Grosseck, 2008), to give a live feedback to the teacher (Veronica Rivera-Pelayo, 2013) and to collaborate on the presented material (Kam, 2005).

Another important change is that today teaching sessions are often recorded, that allows students to re-view the presented material as many times as they need. According to a survey conducted at the beginning of 2013 at the Technical University of Munich, 86% of the students considered the possibility to watch lecture video recordings as important or very important (Technische Universität München, 2013). 1353 students took part in this survey. About two-thirds of the participants claimed that lecture recordings are used by them for follow-up of the courses and for exam preparations. Only 2% of the students stated that audio recordings were sufficient.

Another technology-enabled change in the educational system is the concept of Massive Online Open Courses (MOOCs). Students interested in a particular subject have the ability to acquire freely available qualitative educational content (Lane, 2013). MOOCs also build on the idea of teaching sessions but address a much wider audience outside of the classroom and also make heavy use of video recordings.

As a result, the amount of educational digital content and tools for handling this content grows rapidly. In institutions where teaching session attendance is not mandatory, new educational solutions and services create a free-market environment enabling students to vote with their feet to attend lectures live, to watch teaching sessions online, or to skip lectures entirely (Scott Cardall, 2008). This is an example of a significant change of behavior introduced through digital media.

It remains unclear, how learners post-process educational content and what kind of services they use. Our research goal is to understand how learners annotate educational videos, to develop a minimum viable tool to assist students in this process and to study the effects of the tool on the behavior of instructors and learners. In the future, we plan to study effects of changes of the tool design (visibility

Matthes F. and Shumaiev K..
Collaborative Annotation of Recorded Teaching Video Sessions.
DOI: 10.5220/0004964205760581
In *Proceedings of the 6th International Conference on Computer Supported Education* (CSEDU-2014), pages 576-581
ISBN: 978-989-758-020-8

Table 1: Activities and content involved in a recorded live teaching session without additional computer-based tool support.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	Plan timing of teaching session. Prepare teaching material. [Provide hand-out.]	Present teaching material. Interact with students. Record video.	Publish recorded video.
	Learner	[Process hand-out.] [Take notes.]	Follow presentation. [Interact with instructor.] [Interact with other learners.] [Take or review notes.]	[Watch recorded video] [Review notes.] [Share notes with other learners.]

of annotations, kinds of annotations, form of annotations, etc.) as well. In this position paper, we present the concepts underlying the tool, our research questions and existing work regarding the augmentation of teaching sessions in a unifying conceptual framework. The goal of this position paper is to get early feedback from the academic community in computer-supported education.

2 A CONCEPTUAL FRAMEWORK FOR DESCRIBING AUGMENTED TEACHING SESSIONS

This section introduces a conceptual framework to explain the *augmentation* of teaching sessions by video recording and annotation processes. We use this framework to describe related work and to explain our tool. In addition we clarify our terminology and link our concepts to existing research.

We use the general term *teaching session* to describe a lecture, an exercise session, a seminar or any kind of meeting where an instructor presents *teaching material* (educational content) to one or many learners. We call any teaching material made available by a teacher to a student a *hand-out* and any content created by a student a *note*. An *annotation* is a note added to a special part of teaching material.

In Table 1, we schematically illustrate a conceptual framework where **rows** introduce *actors* participating in the process. Up to now we only distinguish between two kinds of actors: *instructor* and *learner*.

Columns represent *phases* which help to describe the synchronous and asynchronous interactions (information flows) between actors over time. The *preparation* phase includes the set of activities aimed to prepare for the live teaching session. The live teaching session phase subsumes the synchronous interactions between actors and their interactions with possible content. The post-processing phase covers all actions performed by actors with content created in the first two phases.

Cells describe actors' activities (verbs) and content (nouns) involved in these activities. Optional activities are enclosed in brackets [].

Table 1 describes the basic collaborative process of a live teaching session recorded by a video without any additional computer-based tool support.

3 AUGMENTED TEACHING SESSIONS

3.1 Note-taking and Annotation without Use of a Special Tool

Steimle et al. survey 408 learners, where 316 were students in computer science and 92 were students in a pedagogy course (Steimle, 2007). No additional tool for note-taking had been offered to the learners. Table 1 provides an overview of the present study. The study showed that numerous key characteristics of traditional note-taking with pen and paper are comparable with those of electronic notes on a laptop. No differences between the two groups were found in the types of notes taken, both in the post-processing phase as well as in collaborative activities. It should be noted that in the context of this study collaborative activity means sharing hand written notes between students after a live teaching session, for example, to compare each other's notes, or copying notes in case one learner didn't attended the teaching session.

The study identified different types of content

and their combination that were used to take notes on:

- printed slides;
- empty sheets of paper;
- empty sheets of paper and printed slides;
- laptop;
- laptop and empty sheets of paper;
- laptop and printed slides.

Different types of software, that allows to annotate the electronic course slides (e.g. Adobe Acrobat), or word processors and text editors, were used by learners for note-taking on the laptop. The data shows that the ratio between students annotating hand-outs and students taking notes on blank sheets did not change if compared to the students annotating slides on a laptop and students taking notes using text editors.

The authors state that the discipline proved to be an influential factor since laptop use differed largely between the disciplines. In the pedagogy course, laptop use was almost not existent and learners took notes exclusively on paper.

Moreover, different advantages of taking notes on paper and using laptop were identified. Learners taking notes on a laptop valued that:

- notes can be more easily modified;
- it offers a cleaner appearance;
- learners do not have to print the slides;
- a laptop allows them to keep the information in one place.

Those who take notes on paper stated that it is easier and faster than note-taking on a laptop. All participants valued the flexibility of free-form notes on paper.

Another interesting finding was related to the post-processing phase. The results show that in contrast to the follow-up activities after class, students become more active when preparing for the exam.

In conclusion, the following implications for future annotation systems were derived:

- support of handwritten input;
- support of both annotations and notes on blank pages;
- provide enough free space for annotations;
- support of several languages;
- support of collaboration;
- adaptability to the specific context.

This study suggests that note-taking behaviour largely depends on a complex multitude of context aspects. Annotation systems must account for this dependency. Therefore, they must be adaptable in their central functionality (like support for annotations vs. notes on blank pages, input modality, types of the notes and collaborative features) to fit the different user needs and teaching styles in specific context situations.

3.2 Annotation using Special Tool

Kam et al. developed a system for cooperative annotation in lectures (Kam, 2005). Table 2 shows what types of activities and content were involved in the overall process. To save place we do not include activities that were mentioned in Table 1, but it is considered that they were conducted as they are part of a usual educational process. Unfortunately, there is no information available on how the produced notes were used during the post-processing phase, nor about the availability of the teaching session video recordings.

The following activities have been identified when students create collaborative annotations of hand-outs:

- summarizing the entire slide;
- posing questions to provocative bullet points;
- answering questions framed as bullet points;
- appending items to a list of sub-bullet points;
- annotating specific bullet points;
- listing additional ideas, examples, and issues in response to bullet points;
- raising objections and alternative reasoning;
- criticising the choice of images or examples in slides;

Table 2: Activities and contents involved in a teaching session where an annotation tool has been offered to the learners.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	Upload hand-outs to the system. [Give instruction how to use the provided tool.]	[Follow the real-time feedback.]	-
	Learner (with tool access)	-	Annotate the hand-out. Read and comment annotation. [Provide feedback about the speed of the teaching session.]	-

- explaining the meaning of abbreviations; and
- complaining that the proposed design steps in a slide do not apply to the problem at hand, and correcting these.

Learners also added new details to bullet points, especially when they contained examples.

In the collaboration environment learners appear to find it important to explicitly distinguish between teaching material and annotations.

The following implications were derived:

- The need to enable learners to bring the instructor into the loop whenever necessary, such as when learning difficulties surface that students cannot resolve on their own.
- Certain aspects of collaborative note-taking and dialogue are related to social expectations and norms. For instance, some collaboration groups seemingly broke down when the one or two members with tool access were not contributing to the shared note-taking and discussion.

It is noticeable that researchers at that time were struggling with the lack of efficient portable hardware and insufficient cross-platform technology for collaboration. However, the research showed how collaboration on the note-taking process changed the style of notes. Comparison of individual notes and collaborative group notes confirmed that the last one had far more comments, questions and answers. The study has shown that student interactions with presentation slides during teaching session alone are much broader and richer than simply capturing the spoken part of the lecture. Augmented note-taking or in other words annotation of instructors' content is likely to support cooperative learning greatly. Teaching material presented in the collaborative environment such as the instructors' slides can provide learning objects that invite learners to interact with them.

3.3 Web-based Tagging of Recorded Teaching Session

Shen et al. describe a web-based system that allows learners to collaboratively annotate a video stream using predefined tags (Shen, 2011). The video stream was broadcasted from the live teaching session. The authors argue that the cognitive gaps between different learners' note-taking are apparent, even though they are annotating the same teaching session slide. The collaborative learning may increase the redundancy rather than create learning efficiency. Due to this hypothesis and proposals of other researches (Bateman, 2007), the authors assume that collaborative tagging is one of the solutions that can improve collaborative annotation. In Table 3 we describe which actions and contents are involved in the overall process of the system.

The main feature of the system developed by Shen et al. (2011) is a wave-shape timeline chart where learners are able to see which predefined tags (good, question, disagree, etc.) that were used during a teaching session. That allows identifying hot spots of the recorded video and does not require a text input.

3.4 Collaborative Annotation Tool for Recorded Teaching Session Video

In this section we introduce our tool that is based on the idea of having a specific collaboration environment for the different phases of the teaching process: the live teaching session and the post-processing phases (see Table 4 on the next page). The activities and contents of Table 4 extend the activities and contents of Table 1.

The processes of note taking during the live teaching session may differ from the one in the post processing phase since in first case learners should follow the instructors' presentation and don't have much time to write long notes, while in the second case the recorded video can be stopped or replayed. As we observe from the previous studies, it was not convenient for learners to start using a tool for collaborative note-taking during the live teaching session until they got an instruction how to use it (Kam, 2005). At the same time, in the study of

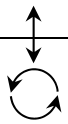
Table 3: Activities and contents involved in a teaching session where a special tool for tagging and video viewing has been offered to the learners.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	-	Broadcast video stream. Record the video.	-
	Learner	Access system.	Add tag to streaming video. View tag intensity chart.	View recorded video. Navigate through recorded video using tag intensity chart.

Table 4: Collaborative annotation for recorded teaching session video (see text).

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	-	View annotation.	View and create annotation.
	Learner	-	Create and view annotation.	Create and view annotation.

Table 5: Possible synchronous and assynchronous collaboration via video annotations. Arrows show possible synchronous and assynchronous collaboration.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*			
	Learner			

Steimle et al. (2007) learners use on their own standard software to annotate presentation slides or simple text editors to take notes. Therefore, the user interface for taking notes during a teaching session should have a similar user interface to commonly used software; in this case the tool will be easy to adopt.

To enable the transition of annotations during live teaching session to the post-processing phase we will synchronize the video stream with notes taken when the particular frame of the video was captured.

The most challenging part of the annotation system will be the collaborative aspect. As it will influence the user interface and have to be implemented in a way clearly understandable for users. Moreover, various collaboration scenarios have to be revised. In Table 5 we show possible collaboration activities related to the annotations during the overall process. Using this table we can observe what actors have to be present in the system and what rights for collaboration they will have during each phase.

As shown in Table 4 and Table 5 our minimal viable tool will only contain a small set of functionalities and collaboration scenarios. That is done on purpose, since at the beginning of our study we would like to evaluate only the basic functionality and avoid creating possibly unused and distracting functionality.

4 FUTHER RELATED WORK

There are a few researchers as well as commercial projects that study (video) annotation and retrieval processes during meetings in *enterprise* environments. Their results are relevant because a meeting with a presenter and an audience is similar to a teaching session.

Nathan et al. focus on the ability of people to retrieve information from a meeting, and provide a special tool for collaborative annotation of live meetings (Nathan, 2012). As repositories of such recorded video meetings grow, the value and utility of these stores will depend on providing tools that help users to quickly browse, find and retrieve elements of interest. Given the long time (and high costs) required to view a recorded meeting in its entirety, there is a need for tools that assist in efficient information retrieval. This is particularly true for people who missed a meeting, who frequently choose to learn about the proceedings from a colleague (Banerjee, 2005), rather than invest the time viewing its recording.

5 CONCLUSION AND FUTURE WORK

In this paper we presented the design of a minimum viable web-based tool for collaborative video annotations of teaching sessions based on findings of existing research and development regarding augmented teaching sessions. For this purpose we developed and used a unifying conceptual framework based on three phases, two types of actors, and activities using four types of artifacts (teaching material, hand-outs, notes and annotations).

The scientific contribution of the tool and the

framework are to serve as a starting point for empirical research by us and others that studies the impact of variations in tool design (like the visibility of annotations in different phases, kinds of annotations and notes, form of annotations, and design of the user interface) on the behavior of the learners and also of the teacher.

We are currently implementing the tool using standard web technologies and are designing the experiments (research questions, hypotheses and measurement techniques) to be carried out in an iterative and incremental way starting with the minimum viable tool in the near future.

In our future work, we want to allow learners to create both, private and shared notes. This allows the learner to search only private notes.

Navigation should allow learners to jump from a particular annotation to the exact time of the video when it has been created.

A further extension would be to support two different ways of note representations in the system: One interface for "static" notes (relating to the whole teaching session) and another for annotations displayed dynamically (synchronized with the video).

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