

Implementation and Evaluation of Digital E-Lecture Annotation in Learning Groups to Foster Active Learning

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Abstract—The use of video lectures in distance learning involves the two major problems of searchability and active user participation. In this paper, we promote the implementation and usage of a collaborative educational video annotation functionality to overcome these two challenges. Different use cases and requirements, as well as details of the implementation, are explained. Furthermore, we suggest more improvements to foster a culture of participation and an algorithm for the extraction of semantic data. Finally, evaluations in the form of user tests and questionnaires in a MOOC setting are presented. The results of the evaluation are promising, as they indicate not only that students perceive it as useful, but also that the learning effectiveness increases. The combination of personal lecture video annotations with a semantic topic map was also evaluated positively and will thus be investigated further, as will the implementation in a MOOC context.

Index Terms—eLectures, tele-teaching, video annotation, collaborative learning

1 INTRODUCTION

THE fastest-growing areas of educational development in the world are online and distance learning [1]. In the United States, 6.7 million students were enrolled in at least one online course in the Fall Semester of 2011. This means that more than 32 percent of all higher education students were taking at least one online course [2]. Research supports the claim that e-lectures, i.e., video recordings of lectures, play a key role in online education [3].

Due to lecture recording systems (like tele-TASK [4], Opencast Matterhorn [5], Camtasia Studio¹ or Lecturnity²) becoming easier and faster to use, the number of educational videos grows rapidly. Even a small computer science institute may have thousands of lecture videos or video snippets available [6]. The enormous amount of resources and learning content combined with the limited time to deal with all this information presents one of the main challenges for learners today. Quickly grasping the content of a lecture video is a major issue, as well as searching through the whole video for specific or even unspecific information. This is the case because videos are multimedia content; it is thus not a trivial undertaking to search or index them. Administrative metadata is often a solution to the searching and filtering issue from the institutions providing the content [5]. However, this solution is time and cost intensive.

Possible solutions includes two main ways to approach this problem. The first is automatic metadata harvesting. Image data from videos as well as audio data from lectures can serve as the basis for metadata extraction [5], [6]. Audio transcription and optical character recognition (OCR) technologies can be used to extract textual data from the video. The next challenge presents itself quickly with this approach, because it is necessary to find the most essential information within this large amount of unprioritized data in order to make the extracted material usable. Methods such as video indexing functions Like automatically extracted slides [5] provided in a timeline format, a lecture structures extracted from the lecturers' slides and enhanced with direct links to the video [7], as well as keywords [6], can all serve this purpose.

The second approach entered the development stages with the introduction of Tim O'Reilly's Web 2.0. He introduced the idea of user communities in which users create and share their own web content with a group of people. The main advantages of this idea for tele-teaching are that people work together in communities, are actively engaged and having fun. Also, large amounts of new metadata that are not part of the lecture video can be created by the participants. This collaboration with other students and active student engagement have major benefits from the didactical point of view. This is especially the case with e-lectures. Students need self-discipline to remain attentive for the whole lecture, because the temptation to just lean back or walk away is quite strong when alone in front of the computer. Research showed that especially the active involvement with the material and the exchange with other learners is important in distance learning. Since a key component in web-based learning is particularly the written interaction [8], we developed a lecture video annotation functionality that supports students' creation of a digital manuscript [9]. The hypothesis is that this tool will help students to become

1. www.techsmith.de/camtasia.html

2. www.lecturnity.de

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active and engaged with the content and also facilitate the search process in the video. The present study will introduce this digital manuscript feature and evaluate users' experiences with it.

The main focus of the research presented in this article is to identify whether digital video annotation provides added benefits and to make recommendations as to which features improve learning and experiences with video annotations. This is necessary, because up to now the user perspective on lecture video annotation has not been taken into account in much of the previous research and development projects. First of all, the evaluation aims at showing that digital video annotation improves learning effectiveness when using lecture videos. Second, individual annotations are compared with annotations from learning groups. Third, several principles from the culture of participation are employed and evaluated to make a statement about their usefulness. Finally, one further method designed to provide added value to users of the annotations—the enhancement of keywords within the annotation with automatically generated topic maps—is discussed and evaluated. The implementation and evaluations were conducted with the example tele-teaching environment tele-TASK³ [4] and the MOOC portal openHPI⁴ [10] of the Hasso-Plattner-Institute.

2 THEORETICAL BACKGROUND AND RELATED WORK

First, this section will explain the didactical basis and the culture of participation. Thereafter, the definitions for lecture video annotations will be given. Finally, related work in the field of digital video annotation will be introduced.

2.1 Didactical Basis

With the age of e-learning, some of the disadvantages of the traditional learning culture were overcome. Those include the dependence of students on teachers' methods and choice of material, a fixed curriculum and the focus on synchronous learning in groups. Because e-learning technologies support the realization of open and flexible learning scenarios, the new learning culture supports self-organized and constructive learning in fluid networks [11]. The old learning theories of behaviourism, constructivism and cognitivism cannot directly explain these new learning scenarios, because they do not consider the technology-supported side of learning [12], the new information connection and processing possibilities nor the social networking opportunities that arose in the era of the Web 2.0.

Connectivist theory [12] has been adapted to the digital age. It describes learning as the creation of connections between bits of information. Utilizing social web features can support the learners according to connectivist theory. This is the case because knowledge exchange in groups can be very fruitful for learners, since it supports the creation of connections between facts or skills learned. This 'cycle of knowledge' is described in connectivism. It implies that learners contribute knowledge to a learning community, but may also learn from it again. This

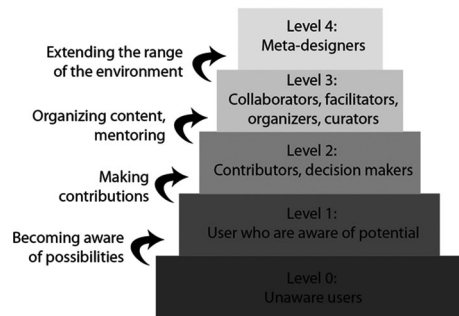


Fig. 1. Levels of participation in the culture of participation according to [14].

beneficial collaborative knowledge creation is the core of the Web 2.0 philosophy.

However, although cooperation has proven to be an effective method for learning, the user participation in collaborative learning environments still remains quite low [9]. The way these systems are designed may be part of the problem. The next section on the culture of participation, therefore, will go deeper into the design of participative systems.

2.2 Culture of Participation

Kimmerle and Cress found out in a study in 2007 [13] that individuals participating in a collaborative process had an information-exchange dilemma. If they provided information to the group, they primarily had worked for no immediate benefit. But, if all participants withheld information, the group could not perform at its best. The researchers proposed a group awareness-tool to solve the dilemma. Students used the tool as opportunity for self-presentation and were more willing to engage if they got feedback from other group members.

Gerhard Fischer substantiated the term 'culture of participation' [14]. He suggested three design guidelines that should be used to open up socio-technical systems for participative work. The first guideline involves different levels of participation (see Fig. 1) that allow different levels of engagement, from consumer to meta-designer to user. The second guideline is a meta-design, which opens up the infrastructure to enable collaborative design. The third guideline is social creativity. Students are enabled to solve problems by collaboration. Learning is briefly discussed as a field of application by Fischer. He states that learners can be encouraged to learn by discussing and developing topics and ideas to develop a shared understanding. They can be further motivated by engaging in explicit problems and genuine activities. Like Kimmerle and Cress, Fischer found that the motivation to participate is intrinsic. The feeling of collaborative creativity and group support, as well as the common purpose, motivates students into further participation [14].

Dick and Zietz [15] used Fischer's guidelines and analyzed different motivation techniques. Social norms, social proof and peer pressure are the most important motivational factors in a culture of participation. When the people within a group watch each other being active, those mechanisms can start working. Awareness tools, therefore, have to be employed by publicly displaying the activities of all

3. www.tele-task.de

4. www.openhpi.de

group members. Instead of trying to make users more active, these awareness tools will make users more conscious of their contributions and thereby stimulate participation [15].

Since written interaction is a key component in online learning [8], and since students can learn more by becoming active, it was our aim to make students more active through writing. As we learned that it is better to enable a participative environment in which students are encouraged to be more active instead of forcing them to be more active, we want to provide a possibility to collaboratively write a digital lecture manuscript and together mark interesting time spots within the video. The next section, thus, will introduce related work in the field of digital video annotation.

2.3 Related Work in Digital Video Annotation

Generally, various types of annotations can be distinguished. First of all, we can make a distinction between manual and automatic metadata generation. With the automatic approach, metadata is harvested from audio and video data from the e-lectures. Video Optical Character Recognition and Automatic Speech Recognition (ASR) techniques are used to extract textual data from the media files. Using the manual approach, we can distinguish between many different subsets. First of all, different groups of people can annotate. Using the media service department to annotate lecture videos is very time consuming and costly. When the lecturers themselves annotate their lecture videos, this is a very time consuming and therefore mostly impracticable approach. The last approach is the annotation by the users. User annotation can also be divided into two methods. It is possible to allow free text annotation, or one can limit the annotation to a certain set of pre-defined vocabulary. The latter approach is mostly used for ontology-based or linked-data-based annotations, as described in [16], where the aim is to limit the vocabulary to known semantic entities and therefore enable machine-readable annotations and semantic searches.

The major disadvantage for students in using pre-defined semantic vocabulary for annotation is that they receive no immediate benefit and it takes them time to create the annotations. This means they do not have a summary or any other outcome they can use for learning and they eventually need to pause while watching the video in order to complete their annotation task, which makes it more time consuming. The question remains whether students would be willing to go through that process as a regular task. This has not been studied so far, though.

Research into standard video annotation functions has been in progress for about 10 years now. Video annotation functions themselves were proven to be beneficial for students by several researchers so far [17], [18], [19], [20], [21]. The first benefit is the easier browsing of the lecture video. Because textual annotations are metadata in addition to the multimedia video, they provide a means with which to browse the video content more quickly and easily. Furthermore, other media formats such as links and images can be used in addition to textual annotations [19]. The annotation process itself is the second benefit for students. Didactically positive processes like the reflection, weighting and

interpretation [19] are included in the annotation process. Therefore, it promotes a deeper understanding of the topic being explained [18]. Collaboration and discussions amongst the students are encouraged as a third benefit. This is the case because these time-based annotations serve as anchored discussions as opposed to forums [18].

Wikis are very popular tools for digital video annotation. The academic search engine Yovisto by Sack and Waitelonis [22] for example, is extended by a wiki. Alternatively, they allow collaborative annotation via tagging of lecture segments. Those tools are the means for further discussions about and explanations of the lecture video. They can be used by either students or lecturers [22]. Their wiki content is not time-based, however, thus revisiting certain points in time where a note was taken is not possible. The tagging feature, on the contrary, is time-based, but is not made for longer texts that can form a manuscript for students at the end. Hermann and Ottmann [23] also describe the integration of a wiki with lecture videos. Their approach is to link a specific point in time within the wiki and begin the discussion about what is taught there. Both users and experts rated this feature very positively. An automatic approach is to copy the content of lecture slides into a wiki and ask students to collaboratively enhance this automatic lecture script, as introduced by O'Neill [24].

Because students are bound to learn on a lecture basis in a university setting anyway, we want to focus on annotation features based on individual lectures. The process of adding specific points in a lecture to a wiki we find too time-consuming, but saving discrete points within the lecture is a real benefit for the later revision and learning process. Therefore, our approach includes an annotation function with wiki-like features, which allows students to work together collaboratively and annotate specific points within a lecture. Annotating the lecture directly allows them to use the annotation as a learning manuscript.

2.4 Definitions

In order to go deeper into the implementation and evaluation of the video annotation features, definitions of the annotations will be given in this section. We deal with both individual and group annotations, thus two different definitions are used. We further differentiate between two functions we developed, a textual annotation feature called a *manuscript* and a quick time marking feature called a *marker*. Whereas the manuscript feature should assist in writing digital notes in the form of a manuscript, the marker function is there to quickly save certain timestamps in the video with a predefined tag added to it.

We define a digital lecture video annotation as a quadruple consisting of the annotated text (T), the content item to which it is attached (C), the timestamp within the content item to which the annotation is added (TS), as well as the user who writes the annotation (U), as shown in Eq. (1)

$$a = (T, C, TS, U). \quad (1)$$

As opposed to the textual annotation, which may contain any free text sentence, the text in the marker function is selected from a predefined set of short texts.

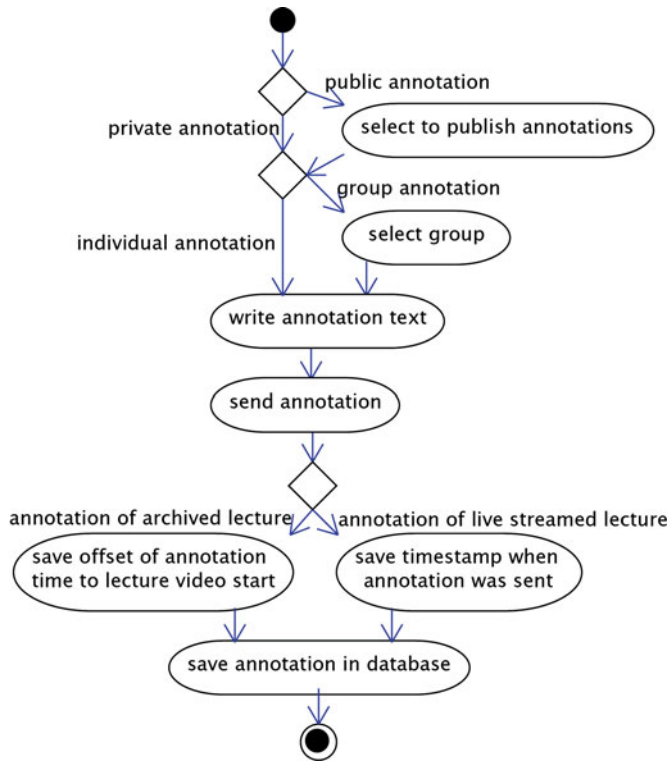


Fig. 2. Activity diagram of the annotation function.

When the annotation is shared within a group for collaborative purposes, the following adjustments have to be made to our definition: a textual group annotation is defined as a quintuplet consisting of the annotated text (T), the content item (C), the timestamp within the content item (TS), the user annotating the lecture (U) and the group with whom the user shares his or her annotation (G), as shown in Eq. (2)

$$a = (T, C, TS, U, G). \quad (2)$$

Now that we explained the motivation behind our approach and clarified our definition of the video annotation, details about the implementation will be given in the next section.

3 IMPLEMENTATION

The annotation features are provided for each lecture separately. The first tool is called a digital manuscript, as it supplies the functionality of writing a digital time-based lecture manuscript in a wiki-style environment while watching the lecture video. There are two use cases for students working with e-lectures. First, students might use the lecture recording at any time after the original lecture took place. The students can use the e-lecture to either substitute the original lecture in this case, or to replay the lecture for learning and revision purposes. In order to allow the students to simultaneously watch the lecture recording and write notes on it, the manuscript interface is situated underneath the video player where the lecture is played.

Live streaming is the second use case. While the lecture is in fact taking place, the students have the option of receiving a broadcasted stream from any other location. A live

streaming calendar provides access to the livestream as well as a link to the manuscript interface. The calendar also offers the students an overview of upcoming streamed events. When writing annotations in the live setting, the time is not saved as an offset, but rather an absolute timestamp is stored. The offset relative to the beginning of the lecture is calculated when the lecture is saved in the portal. Live annotations are thereby transformed into portal annotations. Students using the live annotation feature, therefore, may also benefit from the video structuring and search capabilities of the annotation feature.

3.1 Models and Processes

When looking at the annotation function, several different use cases can be distinguished. Those include:

- private and public annotation
- individual and group annotation
- live and on demand annotation

All these use cases can be combined in different ways, as is visualized in the activity diagram in Fig. 2.

They may, for example, be private live group annotations, as well as public individual on-demand annotations. The different use cases are all incorporated into one interface so that the user may choose between the different options at once. Only the differentiation between live and on demand annotation is undertaken by the system using the point of entry the user chooses. If a live stream from the live webcast page is selected, a live annotation is created. If a lecture is played back from the archive of the portal, an on-demand annotation is stored. These two differ only in their time storing mechanisms, as explained in the previous section.

3.2 User Interface

In order to gain insights regarding the key aspects that the annotation functionality should have, a pre-study was conducted [9]. We found out that the ease and speed of the annotation interface is crucial for its success. Formatting options are also desired. In order to make the annotation process faster, therefore, we implemented the *marker* that allows students to set a bookmark at one specific time within the video with one click. Pre-defined default captions, such as *important*, *exam* and *revise* are available. Students can use these as a very rapid input, but they can also define individual markers. The *manuscript* feature with limited WYSIWYG functionality was implemented in order to provide more formatting options (see Fig. 3 for both interfaces).

Whereas the marker creation interface only consists of a listing of the captions connected to a differently colored marker icon, the manuscript creation interface includes a text edit field that is transformed into a javascript field in order to include formatting options. The public option as well as the group selection are also included in the interface. The viewing interfaces are situated underneath the marker and manuscript creation interfaces. As additional features, both of them include links to the editing interfaces at the back end (edit, delete, etc.) and links to directly jump into the video at the specific point in time when the annotation was created-the timestamp for the manuscript and the marker on the timeline for the marker function. The

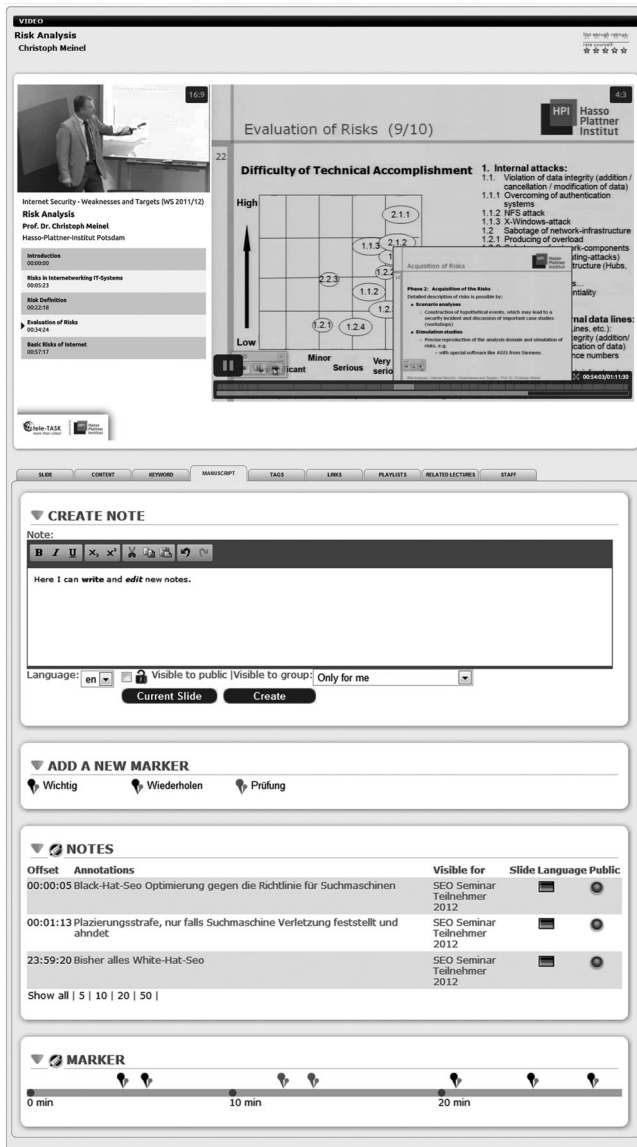


Fig. 3. Interface of the manuscript and marker functions.

manuscript interface additionally includes a screenshot option that saves a small version of the current slide within the annotation. This allows students to also store visual hints along with their textual annotations that should help them to retrieve the desired information more easily at the end. Furthermore, an icon that triggers a pdf export is added. This allows the students to use their manuscripts also for offline learning.

3.3 Culture of Participation

The digital manuscript function for groups supports creating a user group where all members may annotate the video at any point in time. Ultimately, it should allow all group members to see and edit each other's notes. In order to incorporate a culture of participation in this learning scenario, five issues have to be tackled:

- fostering group awareness
- incorporating rewards from the group
- creating scenarios to support problem-solving and online discussion

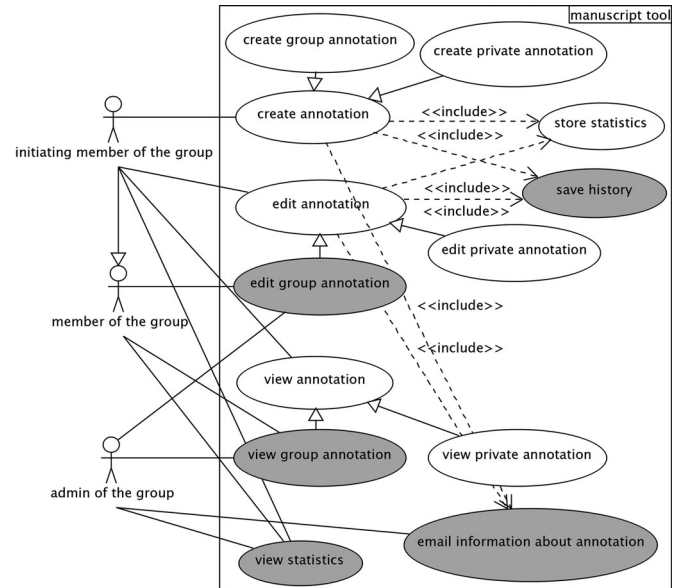


Fig. 4. Use-case diagram of the annotation function with participative elements highlighted.

- engaging more students as coordinators and collaborators
- involving students as meta-designers.

How group awareness can be fostered is visualized in a use-case diagram (see Fig. 4). It makes a distinction between the administrator of the group, who has the most rights, consuming members of the group and group members who create an annotation. The parts of the diagram marked grey are elements that help create a culture of participation. First of all, it must be ensured that the authors of the contributions are obvious when a group of people are working on the same annotation. Since four different states for the annotations are possible—private, visible in the group, public and not linked to the group, as well as public and visible in the group—a rights management system makes sure that private annotations cannot be seen by group members, that only publicly available annotations can be viewed by users outside the group, and that only members of the group are actually able to change annotations within the group. This rights management, as well as the group awareness functions, have been implemented and are available via the web interface.

On the one hand, rewards from the group can be supported by tracking the contributions. If a version control system is utilized, the group members are more aware that their contribution is being judged, because their inputs are countable and publicly visible. Also, notifications about the latest contributions should be offered. On the other hand, counting all contributions in a statistic that is visible to all group members will allow for control of individual group member participation in terms of both quality and quantity. Awarding an extra status boost for well-performing group members, as well as a voting system to select the best group members are further options for how group reward can be implemented. Voting can also be implemented on the annotation-level in order to enable quick and easy low-level feedback. Those last-mentioned triggers for group reward are part of a

research field that has recently opened up: gamification [25]. These mechanisms are also of benefit to the teacher as well in terms of grading the students. If participation is defined as part of the learning target the statistics may be used for student evaluation. A second form of assistance for grading is textual group feedback.

Problem solving and online discussion can also be incorporated into an open and flexible annotation system. As Reinhart et al. [21] explained, the teacher may plant some seeds, so to speak, to trigger these processes. One scenario includes the teacher asking questions within the lecture. It is the students' task, then, to discuss these questions and document their discussion within the digital annotation. Second, students might even post questions when annotating a live lecture. At the end of the session, the questions are answered in a pre-defined time slot.

Different methods to engage more students as coordinators and collaborators can be imagined. For example, students should be encouraged to form their own groups and collaboratively write a manuscript that they can use for learning and further discussion. However, the teacher could also create a learning group. One possible use case is a seminar in which students present different topics in a talk. Those presentations would need to be recorded. In the tele-teaching environment, the annotation interface could be used by the fellow learners for discussion and questions.

The annotation environment itself is the means with which to give learners the freedom to act as meta-designers. When it is designed in a freer and more open manner, the user has the opportunity to adapt the environment according to his or her needs and use it in a way that works well for his or her context and learning style. More precisely, besides simple textual annotations it should be possible to include files as well as structure and design. A wiki-like environment would fulfill those needs. One obvious scenario from the students' perspective is the utilization of the annotation environment as a tool for the collaborative creation of a lecture manuscript. This manuscript can serve as a means of exam preparation, as a summary of the topic, and also as a later point of entry for further research and learning. The issue of extended research is addressed in more detail in the next section.

3.4 Providing Added Value for the Users—Extraction of Semantic Metadata

Students deciding to work with the annotation tool should be provided with added value for their learning process in connection with the annotations they make. This is desirable because the students already use this technology in order to support their learning and reflection process and the technology may aid them even further in this process. This added value is the next step in our work and consists of extracting of additional semantic information from the user-generated annotations and the integration of this additional information with the annotations in the manuscript function. The integration of contextual semantic information into the users' annotations will allow the users to do further research and browsing while taking their own work as the starting point.

The semantic information provides another benefit as well. Because video is a multimedia format, its content is

not easily searchable. There are three options to make it searchable, namely, the administrative generation of metadata, the utilization of user-generated metadata and the automatic generation of metadata. The administrative generation of metadata is cost- and time-consuming. Because user-generated metadata is very rare, as explained in the first chapter, the last approach is exploited quite often. It includes OCR and ASR techniques that extract textual information from the audio and video data of the e-lecture. Alternatively, the Semantic Web offers possibilities to retrieve additional information to the existing metadata. When important keywords are known, the semantic context, including related words, synonyms, super- or subordinate words can be deduced with the help of Semantic Web technologies. This way, it is possible to determine links between words and automatically extract words that have a connection to each other. Furthermore, it is possible to weight these connections and determine how close two words are to each other. This additional knowledge can enhance the search and filtering possibilities and give added value to the users by offering an overview of a topic along with all its related topics or sub-topics.

In order to retrieve semantic information, tools from the Semantic Web have to be used. The Semantic Web vision was created by Tim Bernes-Lee. It involves the aim that all knowledge should be presented in a machine-readable way. It is represented by concepts and vocabularies. Each part of the knowledge description is a triplet. This concept is based on Description Logic and allows machines to 'reason' with the data. According to the vision, the machines will thus be enabled to answer semantically comprehensive queries for people that human knowledge has not found the answer to so far.

The presentation in a machine-readable format is not trivial. In order to be able to experiment with those new technologies and reason with data, a large dataset was necessary. The Linked Data initiative was founded by several researchers in order to provide exactly this dataset. Linked Data is basically a technique for publishing resources and their descriptions on the web. It is based on two main technologies: uniform resource identifiers (URIs) and the resource description framework (RDF). The descriptions of a certain resource can be found under a certain address, which is the URI. The format in which the description is presented is RDF. Information about the resource, as well as links to related resources, are contained in the RDF description. [26] SQL-like languages, such as SPARQL [27], can be used to query Linked Data. DBpedia is one project within the Linked Data initiative. They convert the content of the popular online encyclopaedia Wikipedia into structured knowledge in order to make the information accessible to with Semantic Web mechanisms. DBpedia is a very large dataset, which can be downloaded or used via a sparql web interface.

We want to use the DBpedia dataset for our extraction of semantic data. The workflow of the algorithm we suggest is visualized in Fig. 5. It starts by extracting relevant keywords that are already known in the Semantic Web. This process is called Named Entity Recognition (NER). It is followed by the disambiguation process. Disambiguation is necessary, because one and the same word might

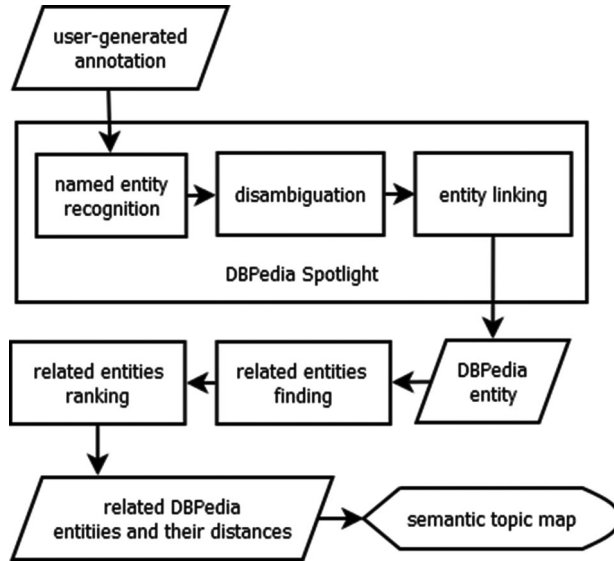


Fig. 5. Workflow of the extraction of semantic relations to lecture video annotations.

have multiple different meanings. For example a *python* is on the one hand a huge snake, but on the other hand also a programming language. The word *python* could also be linked to the British comedy group Monty Python. In order to find the right context and therefore match the right DBpedia entity, the disambiguation process is used. For the disambiguation, the context of the word, in our case, other words in the same part of the annotation, is used to find the right entity. The next step is the entity linking where a keyword from the annotation is linked to an entity in the Linked Data Cloud DBpedia. This link is visualized within the users' annotation to provide him or her with further research possibilities. The NER, disambiguation and entity linking problems have already been solved and published in a service called DBpedia Spotlight [28]. We utilize this service for our approach.

With the help of the semantic network stored in DBpedia, related entities can now be extracted and weighted as a next step. Querying the SPARQL endpoint of DBpedia thereby allows the extraction of all entities that have a relation to an entity that is used as input. In order to limit the number of results, it is useful to filter for some relevant attribute types, like *dcterms:subject*, *rdf:type* and *skos:subject*. Those three attribute types add the entity to classes and categories and thus place them into a larger context. Different information retrieval approaches exist for weighting the connections, such as for example term frequency (TF) together with inverse document frequency (IDF) or the Sørensen-Dice coefficient.

Regarding the individual ranking, the keywords and their most important related words can be integrated into a semantic topic map that allows the users to have an overview of the topics dealt with in a certain lecture and also learn which adjacent topics are connected.

4 EVALUATION

User acceptance is a major and crucial part of the success of the lecture video annotation features. Therefore, several user tests and surveys were conducted in order to evaluate

TABLE 1
Conditions for the Tasks in the Laboratory Study

| Condition | Tools allowed |
|-----------|---|
| 1 | Video only |
| 2 | All indexing tools |
| 3 | Annotation tools (digital manuscript, marker) |

these functions and gather the opinions of the users. Both, qualitative and quantitative data, as well as subjective and objective data, was gathered in order to gain a multi-angle view on aspects of the annotation functions.

This section will begin by explaining the test setup and design for the learning effectiveness study and continue with a user study evaluating individual vs. collaborative annotation. Afterwards, the results of a second study and of the questionnaire with the MOOC participants will be elaborated.

4.1 Evaluating the Learning Effectiveness and the Perception of Lecture Video Annotation Tools in a Laboratory Setting

The learning effectiveness and perception of the video annotation tools were tested in a laboratory setting with a previously prepared setup on a desktop PC. Twelve individual participants were recruited from the male bachelor's or first-semester master's degree students of IT systems engineering at the Hasso Plattner Institute. A website was prepared that included the videos used for each of the two tasks. We used an within-subject design, because the aim was to compare the outcomes in precision and perception of different setups. Each test subject was therefore asked to perform all tasks. Different videos were prepared for each of the conditions (see Table 1). To avoid the influence of tiring and learning effects that might occur over time, we randomly assigned a test video and an order of the tasks to each test person. In order to eliminate the effects of participants' previous knowledge, we started with a recruiting questionnaire. The first task in our user study concerned the further evaluation of the indexing features [7] and will not be part of this publication.

During the second task, the participants watched videos, about 10 minutes long each, and were asked to memorize as much of the content as possible. In one condition, annotations could be written by the participants. Some wrote keywords only, others longer sentences. The annotations also differed in quantity and quality, which is why a larger scale study would be needed to be able to make a statement about the quality of the annotations. After each video, the participant was given a test sheet with three multiple-answer and one open-answer question. When answering the questions, they did not have access to the video or their notes. The participants knew that they were being observed and time was measured while they completed the tasks. A post-test-questionnaire collecting the subjective feedback about the tools concluded the test.

Several different methods were used for the measurements and data collection. First of all, the observation data from the test leader was written down and the time for the

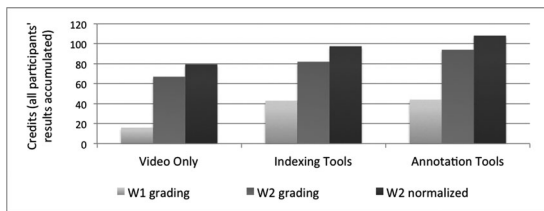


Fig. 6. Evaluation of the learning effectiveness using indexing and annotation tools.

task completion was measured. In order to measure the learning outcome, the test sheets were graded on a point system according to three different methods.⁵ So as to answer the question: *How do students perceive video annotation tools?* a post-test-questionnaire was used. Different facets of each of the tools were questioned with the help of likert-scale items, tables with pro and contra listings and free-text-questions.

An intra-subject design was used for the test in order to allow a reliable comparison between the video-only version and the usage of different tools. Due to the length of the tests, a relatively low number of participants was used. Hence, qualitative as well as quantitative data will be evaluated to get a more profound picture of the usefulness of the functionality and because only limited quantitative data can be derived from the study.

4.1.1 Quantitative Results

First, we compared the learning effectiveness of watching lecture videos without any additional tools to the effectiveness of consuming lecture videos with the help of annotation functions and lecture videos enriched with video indexing tools. The learning effectiveness showed a tendency to be higher when writing digital notes while watching the video (see Fig. 6) in comparison to the video-only version or the video and the indexing features together. A difference in the effectiveness when using indexing features and annotation functions was also observable.

Statistical significance at the $p = 0.05$ level could not be proven given the available data, however. A higher number of test subjects would be needed to ensure reliability. The qualitative results are elaborated in the next paragraph.

4.1.2 Qualitative Results

Details on the perception of the annotation functionality as well as frequently recurring user comments will be

5. To show independence of the results from the grading method, different grading systems were used. In the first (W1) we gave +1 point for each correct and -2 for each incorrect or not selected answer of the multiple-answer questions. In the second method, (W2), +1 point was awarded for a correct answer, -1 for an incorrect one and 0 for a question not answered. In both, each open-answer question was awarded with +2 points. The negative marking was used, although it is not allowed in a German university context, because it is a method of increasing reliability [29], by rewarding partial knowledge and penalizing guessing [30]. A maximum of six points was available for the open-answer questions. One test consisted of three multiple-choice and one open-answer question. The maximum number of correct answers for the multiple-answer questions differed for each video. That is why the third grading method (W2—normalized) uses the weighted results of W2 in order to equalize the maximum number of points between the different test videos.

illustrated in this paragraph. From the feedback and the observations, it was very obvious that usability is the key to the success or failure of the functions. For example, it was necessary to scroll to reach the marker function. This was the reason why it was quite often not used at all by the participants. The feedback in the questionnaire was not too positive, either (see Fig. 7). The observations and comments also revealed that the test subjects wished for the video player and all tools to be on one screen without the need to scroll. Otherwise, the feedback showed that the marker function itself would have been useful for the revision before exams, as well as repeated viewing of the videos at a later point in time. Shortcut keys for three different kinds of markers and tagging of annotations with different marker types instead of using markers themselves were solutions offered by the participants.

Much more positive feedback was given for the manuscript function. A good evaluation was given on average and most students agreed that the function is fast, easy and fun to use (see Fig. 7). The participants had no problems when using the feature of writing digital notes while watching the lecture video, as could be observed by the test leader. Amongst the positive comments given by the participants was the statement that it is fast and easy, and that one can write condensed lecture content which will positively influence the learning and revision process. Furthermore, the direct connection of the annotation to the video position was praised. Also, the participants noted that this digital writing while watching the lecture video had a positive effect on their concentration. Negative comments were given about the usability, the dual pressure when writing and listening in parallel, and the time when the annotation is stored (which occurs after the time the video dealt with the topic). Also, the participants wished for more formatting and editing options.

All in all, we can sum up by confirming that there is a positive tendency for the manuscript function to support better test results after watching a lecture video and that the function is perceived positively by the students. These two results could not be confirmed for the marker function. In a later study we researched the difference between manual and digital annotation, as well as personal digital with digital annotation within a learning group.

4.2 Evaluating Personal and Group Annotations in a Seminar Setting

A second study was conducted in a seminar setting. The search engine optimization seminar was attended by 14 students, 11 male and three female. All of them participated in the study. During the seminar the students had to give presentations that were recorded using our lecture recording system. The aim of the study within the seminar setting was to find out which method of taking notes during the lecture (analogue or digital) is preferred by students and which of the two digital versions (individually or collaboratively in learning groups) students rate more positively. An intra-subject-design was used where each student performed under each of the conditions.

After one initial seminar session, in which the students could login and try out all the tools that were provided in

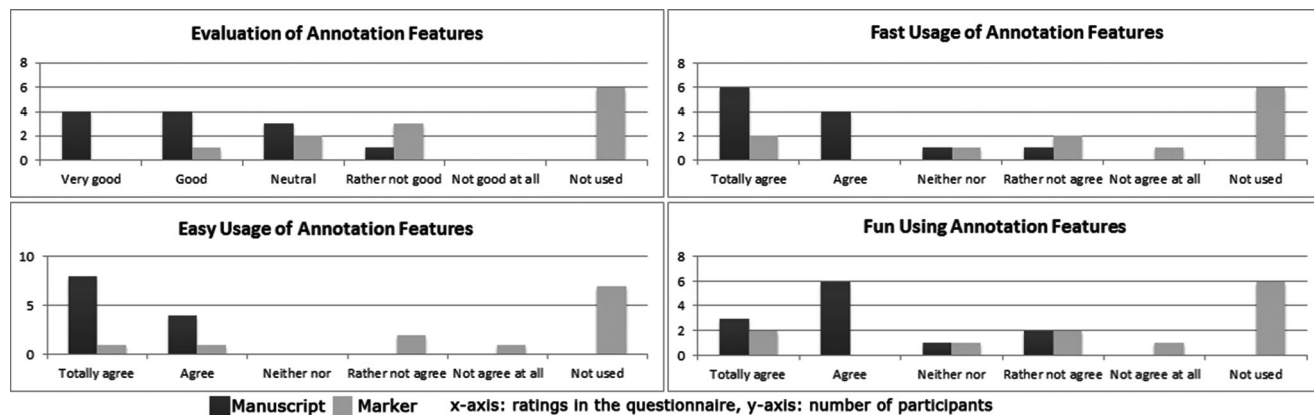


Fig. 7. Evaluation of the perception of different characteristics of the annotation features.

the following sessions, they were asked to write notes while watching the live presentations under the three different conditions listed in Table 2.

After all three conditions were fulfilled, a questionnaire was handed out with several questions comparing the different varieties of writing notes on a lecture.

4.2.1 Quantitative Results

A combination of several questions was used in order to quantitatively evaluate the users' perception of the digital annotation function. Due to the small sample size (14 subjects, including two incompletely answered questionnaires), the quantitative data presented in this section should only be considered as trends supporting the qualitative evidence discussed in the following section, but further evaluations are necessary to confirm them. To strengthen the quantitative information, the individual questions are not elaborated, but are combined into an overall evaluation. This evaluation, together with the user feedback, will be elaborated next. After using a reliability test, some questions were eliminated from the statistical evaluation. The remaining six items belong together with a Cronbach's α of 0.79, which is more than 0.7 and therefore implies that the reliability of the questionnaire is sufficiently high [31]. The test subjects were asked to evaluate the following statements:

- I am satisfied with the digital note writing.
- I like the digital notes function.
- Writing notes with the tool has not distracted me from listening to the talk.
- I think it is helpful to use the time markers of the notes to retrieve a certain point in a video.

TABLE 2
Listing of Conditions for the Individual Tasks in the Seminar Study

| Condition | Tools used |
|-----------------------------|---|
| Analogue annotation | Pen and paper |
| Personal digital annotation | Annotation interface in the portal |
| Digital group annotation | Annotation interface in the portal with the setting visible to the seminar group) |

- Writing digital notes parallel to a live lecture is helpful.
- Writing digital notes while watching a recorded lecture is helpful.

On average, the digital manuscript function was evaluated with a mean of 2.78 (on a scale from 1—best to 5—worst), with a minimum of 2.0 and a maximum of 3.8. This paints a very neutral picture of the manuscript function. Looking at those numbers in more detail (see Fig. 8), one can see that half of the participants (7/14) indeed evaluated it positively (1.0-2.5), six people neutrally (2.6-3.5) and one person negatively (>3.5).

It is very interesting to see, however, that the evaluations were better in general from the participants who did not have problems using the function (see Fig. 9). When the evaluations are grouped by participants who encountered no problems, the subjects answering positively or neutrally evaluated the function with a grade of 'rather agree' (median 2.26/5) and the persons answering negatively evaluating it rather neutrally (median 3.2/5). The individual conditions were not of statistical significance.

The next section will deal with a detailed explication of the single questions on the questionnaire, as well as observations and open-answer feedback from the participants.

4.2.2 Qualitative Results

In the questionnaire, participants were asked how they liked the manuscript function and how satisfied they were with it. As a comparison, they were also asked how satisfied they were with manual note taking. From the answers, it is obvious that although most participants liked the digital manuscript function, they were more satisfied with manual note taking (see Fig. 10). Part of the reason was described in the previous section. Lots of students experienced problems that they had not anticipated with the function. Therefore, they were more sceptical towards the function and not as

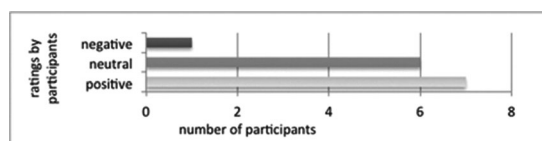


Fig. 8. Ratings in the questionnaire of the manuscript function evaluation grouped by evaluation grade.

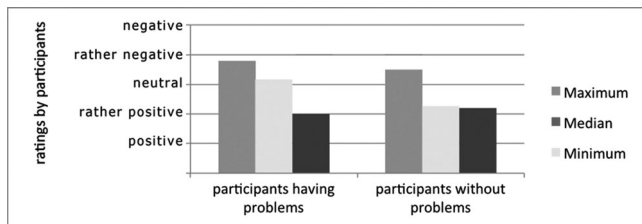


Fig. 9. Ratings in the questionnaire of the manuscript function evaluation grouped by users with or without problems.

satisfied. We think that further improvements in the usability will solve some of the issues the students had.

When asked to compare manual and digital note taking according to the factors of speed and fun as well as their general attitude towards the two types of annotation, the students tended towards the digital annotation. On average, they found it faster and more fun and generally preferred the digital version (see Fig. 11).

From the answers to the other questions and the feedback, it was obvious that a majority of the students (8/13) liked the function of marking a specific point within the video with their annotation in order to be able to retrieve it again later on. And although most of the participants preferred their notes to be searchable (9/13), it is still a major benefit that they are able to print them out (10/14 students agree on that). This means that the optimum note writing environment combines the best of the analogue and the digital worlds. When writing notes, it does not make any difference to the students whether they write them while following a live lecture or parallel to watching a recorded lecture. Also, they subjectively did not write more notes in the digital than in the analogue setup, which surprised us based on our assumption that computer science students were used to writing on a keyboard. The speed of writing is an advantage mentioned by participants, however. While the students indeed see the main benefits of the digital notes, they also feel distracted from following the lecture while at the same time writing a manuscript. Half of the students also experienced problems when using the function, which can be explained by a certain bug that was eliminated for the second test run and usability issues of the function in general. The students wished for further enhancements, such as a formula editor, that was already proposed in [32] and shortcut keys for the marker function. The inclusion of images was another desired feature. Several students also said that the exact time when the annotation is placed is usually too late, because they first have to hear and understand what is being said, then they type and finally send the annotation at the point in the video where

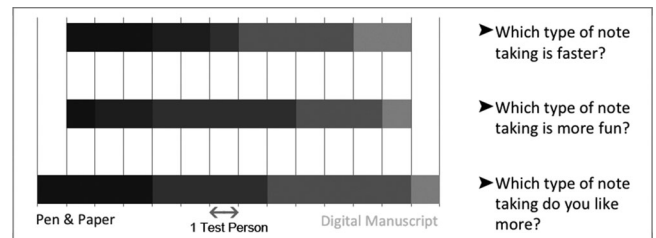


Fig. 11. Comparison of speed, fun and perception of manual note taking with the digital manuscript function.

the speaker has already moved on to another topic. This issue has already been addressed in [33] and will be considered in future work.

The third condition for the seminar participants was manuscript writing in the learning group of the whole seminar, since the manuscript feature can be used in both individual and group modes. 69 percent of the participants (9/13) think digital note writing in a learning group is meaningful, while only 16 percent (2/13) 'rather not' or 'not at all' agree (see Fig. 12).

The majority of positively attuned students (6/9) are so because they can see what the other learners do and they have a good summary of the lecture afterwards. Saving work, because the writing is shared among the students is another key benefit (3/9). Nevertheless, it could be observed that the students were still shy about using the group function. It was observable that they first wanted to see what other students did before they became active themselves. A longer familiarization and trial phase probably would have been good for the test, which was not possible in this seminar scenario.

Due to the positive feedback on both versions of the digital manuscript function, further usability improvements and another round of user testing would be desirable. To sum up, we can say that there is a tendency for users to prefer writing digital notes over manual notes when watching a lecture or presentation and that users have a positive opinion of taking digital notes in a learning group. The next section will illustrate a third testing scenario with a larger number of users. In a MOOC scenario, the students were asked about their perception of the functions without actually having seen or used them.

4.3 Perception of Usefulness of Video Annotation Functions in a MOOC Context

Within the scope of a questionnaire sent out to participants of a German MOOC at openHPI [10], we asked some questions about digital video annotation in a learning context. Out of 2,726 active participants in the course, 42.3 percent

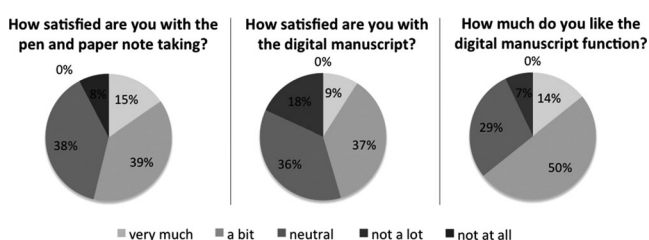


Fig. 10. Comparison of the satisfaction with manual note taking and the digital manuscript function.

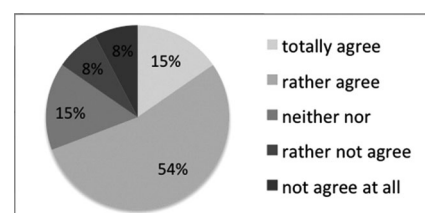


Fig. 12. Answers to the question whether collaborative digital annotation is meaningful.

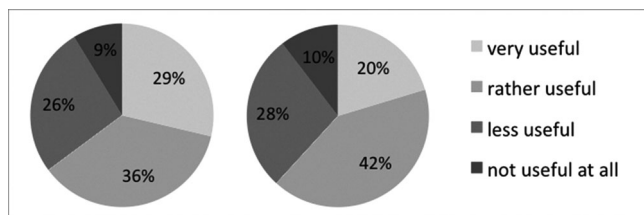


Fig. 13. Perception of the personal annotation (left) and group annotation (right).

took part in the survey. In the MOOC platform, the video annotation functions are not yet implemented. Hence, the aim was to find out the general perception of the annotation features without commenters' having used them before.

We first asked the participants ($n = 1,153$) how they evaluated the helpfulness of personal video annotation in which users can leave notes at any point within the video. 68.3 percent of all users ($n = 788$) replied to that question. And the answers were quite positive with 29 percent (226/788) finding it very useful and 36 percent (285/788) rather useful (see Fig. 13, left). Summing up this shows that 65 percent of all students answering this question see the learning video annotation positively. Only 9 percent (69/788) of people had a negative attitude right from the beginning.

Second, we asked how the participants evaluated the utility of video annotation in groups, in which participants can add notes to any position within the lecture video and share these notes with a learning group. 728 participants replied, with 20 percent (148/728) assessing it as very useful and 42 percent (302/728) as rather useful (see Fig. 13, right). All together, this makes 62 percent of the participants answering with a positive feedback about the video annotation in groups and only 10 percent (76/728) with a really negative perception.

With regard to the culture of participation design guidelines, users ($n = 558$) were asked what would motivate them the most to use a digital manuscript function. The wiki functionality and the newsfeed were the most popular functions, with 36.2 percent (202/558) and 34.05 percent (190/558) replying with 'yes', 'totally' or 'rather yes'. A bit less than one-third of the participants replied with 'no, not at all' or 'rather no' and about 25 percent had a neutral opinion (see Fig. 14).

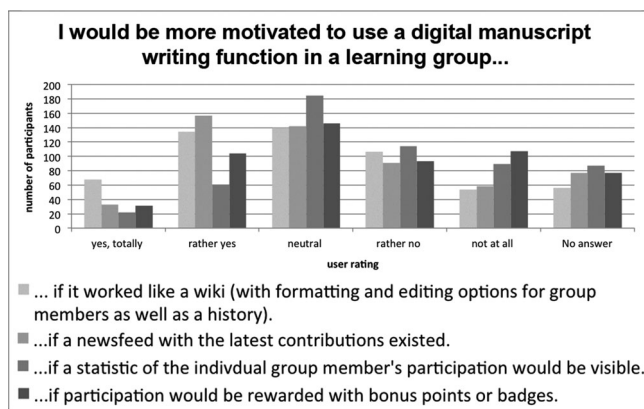


Fig. 14. Motivation factors for collaborative annotation.

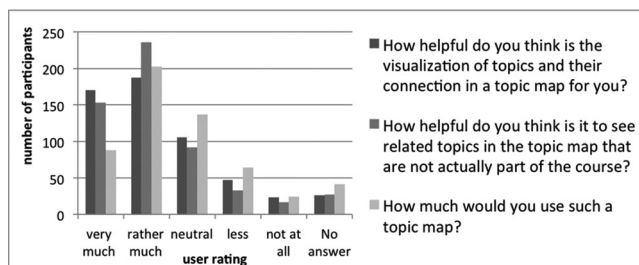


Fig. 15. Evaluation results in a MOOC scenario concerning the users' interest in topic maps.

Against the suggestions of the design guidelines of the culture of participation, the visibility of the performance of individual group members has a somewhat negative effect on the users' motivation to engage. 36.38 percent (203/558) answered 'rather no' or 'no, not at all' and 33.25 percent (185/558) had a neutral opinion. This shows that publicly displaying the individual's performance is not a feature desired by the majority of the participants of this MOOC who answered the questionnaire. Nevertheless, the question of whether those functions actually help the learning process and especially the collaboration amongst users remains unanswered and should be considered in further research. When initially being required to use the culture of participation tools, students might first realize their benefits only while using them.

Regarding the reward system of badges, the picture is not as bad, but surprisingly also not positive either. Those results also show that the opportunity for self-presentation within the group or gamification in order to show one's achievements only attracts a limited number of participants. One explanation for the diversity of opinions and the reluctant attitude towards the culture of participation principles could be the age distribution of the MOOC users, with nearly 50 percent being over 40 years old. Especially the older generation might take a more conservative stance towards current methods like gamification. The conclusion is, on the one hand, that the publication of the individual's accomplishments, either via newsfeed, rankings or badges, should always be optional and users of the MOOC should not be obliged to use them. On the other hand, there are ways to still introduce these methods to people in order to overcome their reluctant attitude and show them their opportunities.

This feedback shows us that the general attitude towards using digital video annotations, personally or in a group, is very positive. Therefore, it is worthwhile to also implement it in a MOOC context and conduct further evaluations there.

4.4 User Interest in Topic Maps

The participants of the previously mentioned MOOC were asked how helpful they considered a semantic topic map and how often they would use it.

Fig. 15 shows the evaluation results of the questionnaire. A majority of the participants (63.98 percent—357/558) think that the visualization of topics and their connection in the form of a map would be helpful for them. Even more participants (69.71 percent—389/558) would like to see relations to topics that are not specifically addressed in the

course. A majority of the participants (52.15 percent—291/558) additionally answered that they would use the topic map ‘very much’ or ‘rather much’. This short quantitative study shows that there is quite a lot of potential for the adoption of a topic map in a MOOC context. The users especially showed interest in related topics and in gaining an overview of the current topic.

In order to judge the connection between personal video annotations and topic maps, we asked 21 students who tried out both tools to rate whether the connection of them makes sense to them. 38 percent ‘totally agreed’ and 38 percent ‘rather agreed’ that it made sense to combine these tools. One person ‘rather did not agree’ and one person ‘not at all’. The others rated it indifferently. This pre-study, therefore, suggests that an association between these tools is somehow helpful to the users. More details should thus be researched in more extensive user studies.

5 CONCLUSION AND FUTURE WORK

In this paper, we have introduced a collaborative video annotation function and illustrated several user studies and questionnaires we conducted to test this function. From the students’ feedback, it is obvious that this kind of participative feature is desirable in a distance learning setting. Students favour the manuscript feature that allows them to have searchable notes with a timestamp that enables them to jump into the video at the desired points for revision. Also the learning effectiveness when watching e-lectures showed a tendency to be higher when students used the manuscript function in addition to watching the video. Nevertheless, a further need for modifications to the functions has been revealed.

First, we plan to make a number of improvements to the manuscript and marker functions. Primarily usability adjustments to the user interface have to be made. All functionalities need to be on one screen, making scrolling obsolete. The viewing area might therefore be placed beside the input area. Furthermore, the marker function should be enhanced by providing shortcut keys for important pre-defined system markers. The formula editor is an enhancement for the manuscript feature. Because several students also said that the exact time when the annotation is entered is usually too late, we plan to utilize the automatic segmentation function and always assign the annotations to the time span of the matching segment.

Further challenges in connection with the development of the annotation feature include knowledge management issues. The aim is to make the annotations easily searchable, and other existing metadata reusable in the annotation context, and also to reuse the annotations themselves as well as allow the students to keep their data. The search can be enabled by including the user-generated data within the search index. Reusing existing metadata might involve, for example, the feature that the text from the automatically created lecture structure (data retrieved from the slides by OCR techniques) can easily be copied into the manuscript. Allowing the students to also store their data outside the portal is possible by having several export functions. We started by implementing a PDF export, but other data like csv or standard text are options for further development.

When it comes to reusing the annotations themselves, the extraction of further semantic metadata is the next step. A quick overview of this possibility was demonstrated in this article. Further evaluation and details of the implementation remain to be presented.

As one of our studies was conducted in a MOOC context, we want to conclude this article by providing an outlook on the challenges of digital video annotation in a MOOC context. When it comes to such a large crowd of users mostly unknown to each other, user engagement features have to be pushed much more. The building of learning groups has to be promoted and active users have to be rewarded. Gamification elements are a proper way to do so. Also, implementing further elements to enable a culture of participation is a step in the right direction. Especially when dealing with collaborative annotation, performance and availability are major issues that need to be addressed to meet the user’s expectations.

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complexity and efficient OBDD-based data structures and algorithms.

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