Learning by Tagging – Supporting Constructive Learning in Video-Based Environments

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Abstract: Using video-based learning materials is a common practice in online learning scenarios today. However, the passive consumption of educational video resources tends to go with low engagement of the learners. Adding interactive features to videos might have the potential to overcome this deficit and might lead to more active learning. We have developed an integrated learning flow that incorporates four interactive features supporting constructive learning: video tagging, flashcards, concept maps, and in-video quizzes. We integrated these features into an exisiting blended learning course and evaluated their respective adoption and acceptance in a user study to gain first insights into the general motivation to use the employed features for individual learning.

Keywords: interactive video, video-based learning, in-video quizzes, video-tagging, concept map, flashcards, constructive learning, H5P, blended learning.

1 Introduction

Nowadays, a wide range of web-based environments offer video-based learning activities. YouTube as an online platform where users publish their own video resources [Mo18] is not primarily intended for instructional learning, whereas Massive Open Online Courses (MOOCs) are better suited [BS15]. For common known problems of high drop-out rates in MOOCs, lack of motivation and engagement are identified as possible reasons [LAW13, MLM13]. To facilitate interaction with videos and support constructive learning, it seems to be beneficial to promote engagement and student activities [Za17]. We focus on enhancing video-based learning through a more active way of information processing and elaboration of the learning content. According to the ICAP framework, learners are more engaged in active, interactive or constructive modes of learning than in passive learning [CW14]. Also, Zhang et al. [Zh06] state that active video watching can have a positive influence on the quality of learning outcomes. Our motivation is to analyze the effect of interactive videos on learning efficiency and engagement. For this purpose, we integrate four features into an existing blended learning course of the University of Duisburg-Essen: video tagging, flashcards, concept maps, and in-video quizzes. The level of integration includes interoperability between learning tools on an artefact level, particularly in the reuse of learner-generated content, as well as the interfacing with standards for logging and learning repositories. The added value of the system lies in

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promoting engagement and individual knowledge construction via tagging, concept maps, flashcards and quizzes using technologies of Moodle[2] and H5P[3].

2 Related Work

Inherently, learning with videos is a passive-receptive form of learning. In order to learn more effective and persistently, cognitive active engagement with the learning material proves to be more beneficial [Ko15, Mi17]. The ICAP framework defines cognitive engagement activities on the basis of learners' behaviors and assumes learning to be deeper and more sustainable the more cognitively active learners engage with the learning material [CW14]. In terms of the effectiveness of video-based learning, Yousef et al. [YCS14] analyzed research published in 2003-2013 and showed positive effects of video-based learning on learning outcome, interaction, and learnersô satisfaction. Active engagement with the content and the creation of own artefacts like texts or concept maps can foster knowledge construction and improve learning outcomes [Za17]. To support engagement with videos, a variety of activities like in-video quizzes [Ko16], video annotations [Mi17], flashcards [HD11] or concept maps [VZ10] can be used.

Quizzes can have positive effects on learning outcome and efficiency [Ko16], like memorizing information [RB11] or expanding domain knowledge [Jo10]. Using open accessible technologies like H5P, quizzes can be embedded into videos conveniently. Tags or video annotations can be useful for the active appropriation and elaboration of learning content. Mitrovic et al. [Mi17] show that a platform for active video annotation leads to higher engagement in the sense of ICAP framwork and improves the learnersôconceptual knowledge. Bateman et al. [Ba07] use two kinds of collaborative tags. Tags are either created by text mining methods or by the learners themselves. A high degree of consistency between system tags and user tags shows that learners can identify tags presenting key concepts of a knowledge domain and suggests tags to be a useful supporting mechanism for constructive learning. As another tool for video annotation, the SIVA suite allows both authors and end users to add annotations [LL15]. The system allows users to add supplementary information like images, text, or pdfs. The annotations can be set at specific times and apply to either the duration of the entire video, a specific sequence, or to single objects within the video. In terms of the effectiveness of flashcards, Hartwig and Dunlosky [HD11] show that 60 % of college students stated using flashcards as a regular study technique. Repeated testing and monitoring of the own learning process in a more active way as opposed to e.g. reading a text seems to be an advantage of using flashcards for learning [HD11, KBR09]. The transformation from tacit to explicit knowledge is relevant for the organization of knowledge [No94]. Concept mapping as a technique for visualizing relationships between concepts regarding a topic can support the externalization of knowledge and is used to gain deeper understanding of a specific domain [Zh06]. If implemented thoughtfully, ñconcept maps can be versatile tools to support knowledge integration processes towards a deeper understanding of the relations

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[2] Moodle Pty Ltd., Moodle Homepage: www.moodle.org (last accessed 29.03.2018)

[3] Joubel, H5P Homepage: www.h5p.org (last accessed 29.03.2018)

and structures of complex ideasò [Sc15]. By interrelating different ideas and knowledge through concept mapping, such cognitive tools can support the integration of knowledge across artifacts and representations [SRW05]. Examples of digital technologies for the construction of concept maps are the Go-lab ConceptMapper [JSG14] or draw.io[4].

3 Approach

3.1 Aim of the Research Project

The aim of this research project is to support interactive learning based on enriched video material. Therefore, we extended an existing blended learning Moodle course for students of computer science related degree course at the University of Duisburg-Essen (Germany). The course uses lecture recordings and comprises activities like quizzes, wikis as collaborative writing assignments, and programming tasks. We extended the course by integrating four features. The existing lecture videos were sequenced into short conceptual units of content with a video length of about 10 minutes and enriched with embedded quizzes and video tagging. To further support constructive learning, flashcards and concept maps were implemented. Our overall research question is whether interactive video watching and constructive learning can be supported by these features. In an exploratory user study, we examined whether learners perceive the features as efficient for learning (learning efficiency) and whether they are motivated to use the features for learning (intention to use).

3.2 Procedure of a Learning Unit

Students start the learning session watching the enriched course videos and answering short questions of the in-video quizzes. Simple recall questions including various types of quizzes (e.g. multiple choice, true/false) are used to maintain the studentsô attention. In addition, students are instructed to use the tagging feature to create tags while watching the videos. We provide two functions of this feature. The matching function comprises tags predefined by the course instructor (instructor tags) which represent key concepts of the video. The studentsô task is to identify a given number of tags. Additionally, students can create own tags (learner tags) they consider as relevant to complement the given key concepts (supplemental function). Based on the created tags, two further kinds of learner artifacts can be created: flashcards and concept maps. Using the tags, in the next step of the learning scenario students create flashcards. Students use text-based content to formulate questions and answers on the front and back side of the flashcard. The feature is implemented to support knowledge retrieval and consolidation. As a last step, students create a concept map, also based on the previously identified tags. The feature is implemented to help organizing and structuring knowledge by visualizing relationships

[4] JGraph Ltd., draw.io Homepage: www.draw.io (last accessed 29.03.18)

between the concepts of the learning unit. Fig. 1 illustrates the features of the overall learning environment as it was used in the study (see section 5).

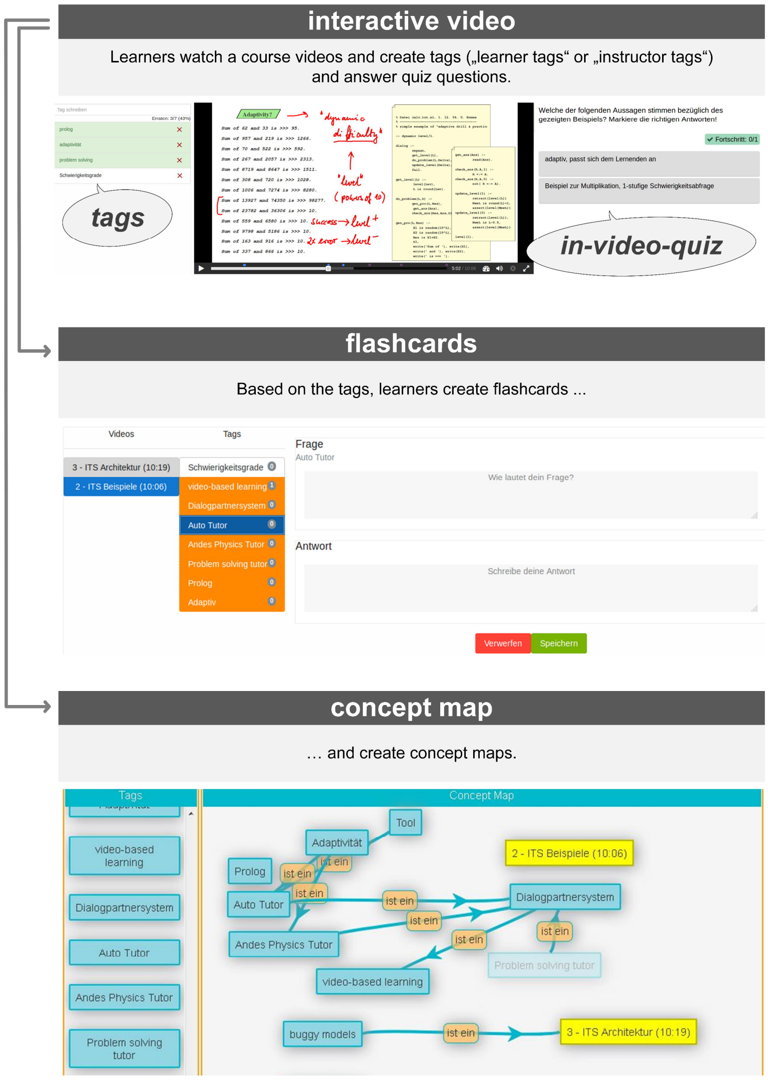

Fig. 1: While watching interactive videos, learners take quizzes and create tags. Tags are used as a basis for the creation of flashcards and concept maps

4 System

The overview of our system, a client-server architecture with Moodle as a learning management system, is shown in Fig. 2. In addition to Moodle, Learning Locker[5] is used as a learning record store (LRS) on the server side for collecting and storing log data in the xAPI format. We implemented H5P extensions that plug into Moodle for interactive features such as video tagging and flashcard creation in order to support our proposed integrated learning flow. H5P is a framework that simplifies the creation of interactive content (libraries) that can be reused in other settings through the modular structure of the framework. In addition, H5P already provides a library that comprises video interactions such as in-video quizzes. Providing interactive functionalities and the possibility of logging user actions as xAPI statements, H5P fits well for our purpose. Additionally, we extended a Moodle plugin of a ConceptMapper [JSG14] in order to interoperate with the video tagging features. Users can access the four features via the web interface of Moodle. In case of the features conducted with H5P, in order to execute the features correctly, the H5P framework will be loaded into the userȇs browser first.

For the tagging feature, we created a new H5P library which uses the interactive video library to present quizzes and add tags when watching a video. To check the matching between a newly created tag and an instructor tag, we used the dice-coefficient to calculate the deviation between tags. With this threshold, spelling mistakes and the degree of difference between very similar tags and very different tags can be considered. If the value of the dice-coefficient was above the threshold of 0.75, the new tag matched the instructor tag. Further, a variable number of synonyms can be added for each instructor tag. Thus, the system is not only able to detect two literally equal tags, but also detect tags with different spelling but similar meaning. Additionally, a corresponding H5P library was implemented for the flashcard feature (flashcard library) which uses the above mentioned tagging library to display the created tags of a learner. In these two libraries the content created by the learner is stored by H5P Moodle plugin[6] in the Moodle database. As there exists no mechanism for the exchange of user generated data between two libraries in H5P in general, we created an interoperability layer for H5P data in Moodle. As a result, the the flashcard library and the concept mapping tool are able to load the instructor and learner tags for each video. With this approach, the H5P Moodle plugin itself does not have to be modified and the libraries can be used in other content management systems.

To support a clear seperation of concerns regarding the logging of learning activities and to enable learning analytics, we use an xAPI-compliant LRS. Moodle as such only logs core events such as resource access logs and does not log in-video activities like seeking or play/pause. Therefore, the xAPI statements were intercepted in the learnerȇs browser and sent to the LRS (see Fig. 2), where the data of both Moodle and H5P is integrated. It also simplifies the combination of log data with those from other sources, enabling holistic logging of data from different software and providing a more modular scaling of the entire application. In addition to the creation of flashcards based on tags, the learner was also

[5] Learning Locker: www.learninglocker.net (last accessed 08.03.2018)

[6] H5P Moodle plugin: www.github.com/h5p/h5p-moodle-plugin/issues/153 (last accessed 29.03.2018)

given the opportunity to create concept maps. For our purpose of supporting individual learning, we modified the ConceptMapper by adding the interoperability layer in order to retrieve the video tags and to present these tags as predefined concepts in the user interface of the ConceptMapper.

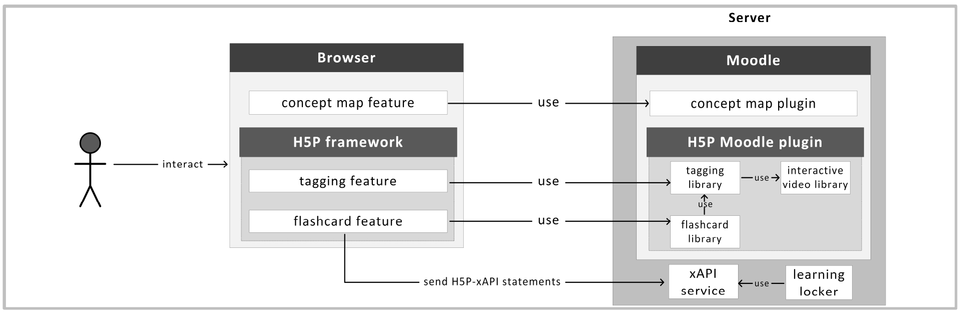

Fig. 2: Architecture of the implemented software

5 Evaluation

5.1 Experimental Design

Goal. We conducted a study to evaluate the learning environment and to determine to what extent the participants perceive the learning environment with the integrated features as useful and beneficial for learning. The participantsô evaluations were obtained via a questionnaire and a system user study. As this paper primarily focuses on perceived subjective evaluations of the implemented features, the main purpose of this study is to gain a first impression of these features.

Participants. We recruited 10 students (7 female, 3 male) from University of Duisburg-Essen (age: $M = 24.60$, $SD = 3.81$, 21-34 years). None of the participants had any previous experience with online courses. Eight participants reported to have previous experiences with video-based learning and the average motivation to use online learning material was high ($M = 5.65$, $SD = 0.65$). Learning resources that were used by the participants dominantly were videos (7 participants) and flashcards (8 participants). The evaluations of the learning efficiency of videos and flashcards were high (videos: $M = 4.57$, $SD = 0.54$; flashcards: $M = 4.88$, $SD = 0.84$). The participantsô prior knowledge of the topic of the lecture content was low ($M = 2.67$, $SD = 1.66$).

Materials. Based on an existing Moodle course of the University of Duisburg-Essen (ñdesign of interactive teaching/learning systemsò) we integrated four features for interactive and constructive learning as described in section 3 (tagging, quizzes, flashcards, concept map). To assess usability, satisfaction, learning efficiency, and the intention to use these features for future learning, we implemented a web-based questionnaire. To analyze usability and user experience, we implemented the System

Usability Scale (SUS, [Br96]), the User Experience Questionnaire (UEQ, [LHS08]), and the ISONORM 9241/110-S [PR08]. In the SUS and ISONORM, low ratings mean low usability/user experience values. The UEQ measures items using two poles on one dimension (e.g. complicated vs. easy). For the system test, one chapter of the existing learning course (ñinteractive tutoring systemsò) was modified.

Procedure. In the pre-questionnaire participants answered questions regarding socio-demographic information and prior experience with online courses, video-based learning as well as content-relevant knowledge. For the subsequent testing of the learning environment, they were supplied with written instructions how to use the learning environment and each individual feature. Each participant watched two videos and answered the embedded quiz questions. While watching the video, students created tags (instructor tags and learner tags). Afterwards, participants formulated flashcards and created a concept map based on the tags. After testing the learning environment, participants completed the post-questionnaire for the evaluation of the overall learning environment and the individual features. The study took about 60 minutes to complete.

Analysis. We collected quantitative as well as qualitative data. In order to evaluate the data, we used Aqua Data Studio[7] (Version 18.5) to analyze the log data and SPSS 25 for Windows (IBM SPSS Statistics) to analyze the data from the web-based questionnaire to derive first implications concerning the studentsô subjective evaluations of the new features regarding our research questions.

5.2 Results

General perception of the learning environment was measured with usability and user experience questionnaires. Further, we assessed the motivation to use online learning material and the general satisfaction with the course and the features.

General Perception of the Learning Environment. The overall perceived usability and usefulness of the learning environment was moderate to good (SUS: 63.5 %, ISONORM 9241/110-S: 87.6 %). The UEQ revealed good values for attractiveness (1.017), perspicuity (1.675), efficiency (0.825) and dependability (1.050). Stimulation (0.775) and novelty (0.700) of the course were rather low (values from -0.8 to 0.8 indicate neutral evaluations, values > 0.8 indicate positive evaluations). Participants reported a moderate satisfaction with the overall learning environment (M = 3.48, SD = 0.69). The motivation to use the four tested features in future learning settings was high (M = 3.70, SD = 0.82).

Evaluation of the Features. Overall, the participants evaluated the in-video quizzes, tagging and flashcards as good. The concept mapping tool was rated on the lowest rank in all categories (satisfaction, learning efficiency, intention to use) (see Tab. 1) and thus revealed the highest need for optimization of all features.

[7] AquaFold, Aqua Data Studio: www.aquafold.com/aquadatastudio (last accessed 15.02.2018)

	General evaluation*	**Satisfaction***	**Learning efficiency***	**Intention to use***
Quiz	*M* = 6.18 (*SD* = 0.75)	*M* = 4.60 (*SD* = 0.70)	*M* = 4.30 (*SD* = 0.48)	*M* = 4.60 (*SD* = 0.52)
Flashcards	*M* = 5.81 (*SD* = 1.19)	*M* = 4.00 (*SD* = 1.05)	*M* = 4.30 (*SD* = 0.48)	*M* = 3.70 (*SD* = 1.25)
Tagging	*M* = 5.60 (*SD* = 1.28)	*M* = 4.30 (*SD* = 0.68)	*M* = 3.70 (*SD* = 0.82)	*M* = 3.90 (*SD* = 0.99)
Concept Map	*M* = 3.80 (*SD* = 1.42)	*M* = 2.20 (*SD* = 0.79)	*M* = 2.90 (*SD* = 1.10)	*M* = 2.20 (*SD* = 1.14)

*Response formats: General evaluation (1 = very bad, 7 = very good), satisfaction (1 = not satisfied, 5 = very satisfied), learning efficiency (1 = not at all, 5 = very), intention to use (1 = not at all, 5 = very).

Tab. 1: Overview of the feature evaluation

Quizzes were rated as the best feature regarding satisfaction, learning efficiency and intention to use for future learning situations (see Tab. 1). Overall, 62.28 % of the questions were correctly answered by the participants of the study. Results of the questionnaire revealed that users rated the quizzes as ñgood and helpfulò and evaluated the different types of questions as useful (ñI liked the fact, that different types of questions were provided.ò). Regarding the interaction with the videos itself, a high number of seeks was measured for two users (768 seeks, 432 seeks) in contrast to the average number of seeks (75.13 seeks) for the other users. These two users answered more than 74 % of the questions correctly.

Flashcards were also perceived as satisfying and efficient for learning (ñgood ideaò) and ranked second in general evaluation (see Tab. 1). Overall, 13 flashcards per user were created. To analyze which tags were created by the learners or what problems did occur when identifying the instructor tags, we used a word cloud of the created tags (see Fig. 3). On average, students created 32.3 tags overall and identified 10.2 instructor tags for the two given videos (i.e. 22.1 learner tags). Out of these 22.1 learner tags, they used only two tags for the formulation of flashcards. This suggests instructor tags to be a helpful support in the process of creating flashcards. Apart from that, this can be explained by a different visual arrangement in the flashcard feature (instructor tags above learner tags), leading to a higher salience of instructor tags in contrast to own created tags (ñIn other tasks [concept mapping tool, flashcards] the tags were shown in a different order. This was very confusing to me.ò).

Tags ranked third in the general evaluation of the features (see Tab. 1). On average, students identified a moderate amount of the instructor tags (56.19 %). This suggest that instructors need to formulate tags deliberately in order to allow students to identify the key concepts of the video content. Satisfaction with and the intention to use the tagging feature were rated lower than the flashcards. Four participants referred to problems of understanding the functioning of the tags or reported the pausing of the video while tagging as ñannoyingò. Another participant however emphasized the game-like character of the tagging feature, seeing gamification as a method to increase motivation and engagement in learning activities (ñThe tags predetermined by the system provided an incentive to guess the right tags, which gave the whole feature a game-like character.ò).

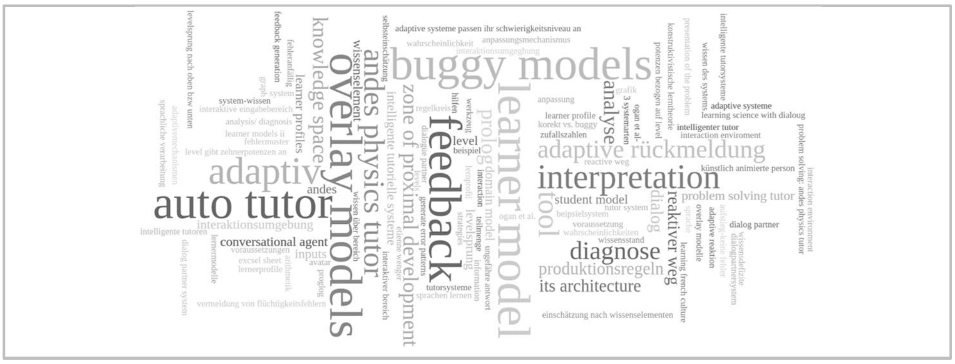

Fig. 3: Word cloud of created learner tags and instructor tags

The concept mapping tool ranks lowest in the general feature evaluation (see Tab. 1). The need for optimization is reflected by the negative comments of eight out of ten participants. The problems can mainly be traced back to technical issues (operability, handling) or insufficient visual presentation of the tool. Further, concept maps are intended to organize knowledge, so the task of creating a concept map whithin the short period of time within the study might be another explanation for the evaluation of the users. One of the comments presents the overall impression quite comprehensively: ñI suppose, it might take long to create a map which meets my expectations.ò As mentioned for the flashcard feature, the use of tags as a basis for the concept maps shows a similar pattern. More instructor tags (76.88 %) were used for the creation of concept maps than learner tags (23.12 %), although more learner tags were formulated during video tagging. Also, more given relations (83.72 %) were used than own relations (16.25 %) between concepts. In general, however, because of a biased subjective evaluation of this features due to technical problems, learning efficiency and the intention to use concept maps cannot be analyzed sufficiently.

6 Discussion and Conclusion

In general, the conducted study reveals the overall learning environment to support constructive learning. The participants of the study evaluated the learning environment and the features in terms of satisfaction, learning efficiency and their intention to use the system for learning. The in-video quizzes were ranked and evaluated best in all categories and the tagging feature turned out to be a good basis for the creation of flashcards and concept maps. While the in-video quizzes are intended to maintain the learnersô attention and to achieve a first recall of the learnersô knowledge while watching the videos, the tagging feature should foster constructive and deeper learning of the content as it represents the basis for the other features and can provide a game-like character. The tagging feature can help learners to identify the key concept of the videos and link the knowledge semantically when creating concept maps or formulating flashcards.

According to the ICAP framework, we integrated activities to support constructive and interactive learning. Participants of our study can be broadly categorized into more active or less active learners regarding the number of seeks in the videos and the frequency of switching from videos to flashcards or concept maps. More active learners show higher rates of correctly answered quizzes in contrast to less active learners. Further, more active learners used more tags and relations for the creation of their concept maps. Regarding the flashcards, no difference between learners could be found. However, more active learners evaluated the flashcard feature as more positive in contrast to less active learners.

The findings for the tagging feature were unexpected. More active learners created fewer own tags and performed worse regarding the identification of given instructor tags. We would have expected more active users to create more own tags and identify more instructor tags correctly than less active users. The majority of the participants preferred instructor tags rather than learner tags to create flashcards. This can be interpreted as participants perceiving the instructor tags to be more relevant than tags created on their own. This might imply that instructor tags present a good basis to structure the formulation of the flashcards. On the other hand, almost half of the instructor tags could not be identified by the learners correctly. A possible interpretation is that the students had problems extracting the right information regarding the key concepts of the video. Further, time-related aspects need to be considered when designing a learning environment. Participants spent about 5 to 10 minutes tagging a 10 minutes video in our study. Therefore, a corresponding amount of time should be taken into account for the tagging feature when designing a learning environment.

Although the conception of the features and the learning environment seem to be an appropriate way to support individual learning in a video-based learning environment, there are some limitations. Due to the small number of participants in the user study (N = 10), the results are preliminary. In our study, the participants followed given instructions to test the four features within the learning environment. For a more valid analysis of the acceptance and effects of the systemȸs features, an observation over a longer period of time is required, e.g. over a whole semester during which students complete the overall course (with other activities like collaborative wikis or weekly quizzes) without given instructions how to proceed with the course activities. We experienced H5P as a great tool for extending existing online learning environments with interactive content because of its modularity and the concept of reusable components. One problem, however, was the missing support of H5P for content sharing between the libraries. For an extension of the features for collaborative learning, content sharing however is essential.

Our aim was to support individual constructive learning, i.e. constructive and artifact-generating activities like creating tags, flashcards, and concept maps. For more authentic learning contexts, supporting collaborative learning seems to be a useful extension of the implemented features. These extensions include collaborative tagging, collaborative creation of concept maps, and recommendations of flashcards to other learners of the course. Further, for visualizations of learnersô performances and to support learners as well as instructors, dashboards based on learning analytics can be used. For example, a reversed tag cloud could help in visualizing tags which could not be identified by the learners, and instructors can revise their instructor tags to help the learners identify the key concepts of the videos. In sum, we extended an existing blended learning course by four features to support individual constructive learning. Overall, the results of this first exploratory study point in a promising direction. Video tagging provides a suitable basis and structural support for the creation of concept maps and flashcards. The combination of video tagging and other learning features like flashcards or concept maps seems to be a good way to motivate students to actively watch videos and reuse their created artifacts as guidance for further learning content. An extension by collaborative aspects and recommendation features seems to be a promising course for future research.

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