

Learning Channels to Support Interaction and Collaboration in CourseMapper

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Massive Open Online Courses (MOOCs) have proved to be revolutionary in the development and widespread of educational technology over the past few years. It has been identified that these systems, despite all the benefits, lack interaction and collaboration around learning materials. This paper explores how to leverage learning channels to support interaction and collaboration in MOOC environments. We present the design, implementation, and evaluation details of learning channels in CourseMapper, a MOOC platform which supports collaboration and interaction around learning materials using collaborative Pdf and video annotations. More specifically, we report on the application and results of a human-centered design (HCD) approach used to systematically design learning channels. Three design iterations with five new users in each iteration (N=15) were conducted from an initial user interview to the final design. After the development, user experience with the system was evaluated with end users (N=10) based on the Technology Acceptance Model (TAM). The evaluation results show that the introduction of learning channels provides a valuable mechanism to support effective interaction and collaboration in a MOOC environment.

CCS CONCEPTS • Human-centered computing → Human computer interaction (HCI) • Applied computing → Education → Interactive learning environments

Additional Keywords and Phrases: Massive Open Online Course (MOOC), Technology-Enhanced Learning (TEL), Collaborative learning, Collaborative annotation, Human-Centered Design (HCD), Learning channels

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1 INTRODUCTION

Technology-Enhanced Learning (TEL) has become increasingly popular across the world with the rapid development of internet and mobile technologies, particularly during the time of COVID-19 in recent years [1]. In this context, Massive Open Online Courses (MOOCs) offer unique opportunities to learners and have been widely used for designing and providing a variety of courses [2, 3]. Furthermore, they help learners build knowledge with a large community worldwide [4]. MOOCs are courses aiming at large-scale interactions among participants around the globe regardless of their location, age, income, ideology, and level of education, without any entry requirements or course fees [5]. One of the key benefits of using MOOCs is that they do not have a set curriculum because they are aimed at a large number of individuals, hence offering flexible and self-paced learning [6, 7]. Furthermore, the property of MOOCs being greatly affordable [8] and cost-effective [9] is one of the reasons for the wide adoption of MOOCs.

In the past few years, the use of MOOCs has facilitated the learning experience with tremendous learning opportunities using a variety of learning materials like Word documents, PowerPoint slides, Pdf resources, and videos. Despite the popularity of MOOCs for online learning, they suffer from several limitations and many concerns and criticism about the use of MOOCs have been raised [10]. The unique features of online learning lengthen the distance between teachers and students, which reduces the interaction and closeness between them [11]. To identify the current research gaps, an extensive review of MOOCs is provided in [13]. Since MOOCs' participants are remote and sometimes far away, it is impossible to implement learning processes based on specific student characteristics because of the number of students participating [12]. Thus, there is a need for solutions to foster interaction and collaboration between MOOC participants by bringing together face-to-face interactions and online learning activities [13]. Moreover, the lack of interactivity between participants and the learning materials is also a major concern in the use of MOOCs. Several studies on the nature of MOOCs address the linear structure of video lectures to present knowledge to learners in a passive way [13]. This highlights the need for new design techniques to increase the interactivity around video and Pdf lectures in MOOCs. In this paper, we address the limitations in MOOCs related to the lack of human interaction and the lack of interactivity with the learning materials. To this end, we propose the concept of learning channels as a way to foster interaction and collaboration in MOOCs through collaborative annotation of Pdf- and video-based learning materials. As a proof of concept, we designed and implemented learning channels within the MOOC platform CourseMapper, following a human-centered design (HCD) approach.

The remainder of this paper is structured as follows. We first outline the background for this research and report on the related work on the annotation of learning materials (Section 2). We then discuss the iterative design process of learning channels in CourseMapper, following an HCD approach (Section 3). In Section 4, we present the evaluation details of the platform, based on the Technology Acceptance Model (TAM). Finally, Section 5 summarizes the paper and outlines perspectives for future work.

2 RELATED WORK

In this section, we give an overview on the literature addressing the interaction and collaboration challenges in MOOCs with a focus on the collaborative annotation of video- and Pdf-based learning materials.

2.1 Video Annotation

As a result of significant advancements in internet technologies that provide interactive media-rich material, the demand for online learning has skyrocketed [14]. What's more, incorporating audiovisual materials (such as video or streaming media) and SNSs (social networking services like Facebook and Twitter) into traditional learning environments has created a more engaging experience, encouraged collaboration and clearly produced more interesting outcomes than words on a piece of paper [15]. Learning using videos can be more successful since it allows students to study and review the information several times [16].

Yousef et al. [17] critically analyzed the research on Video-Based Learning (VBL) to present an in-depth understanding of its benefits and effects on learning and teaching. The authors explored how to design effective VBL environments and concluded that annotation tools are the most used design tools in the reviewed VBL literature. Video annotations are the additional notes added to videos that assist in finding, highlighting, analyzing, extracting, and providing feedback without affecting the content itself [18]. Furthermore, it provides an easy way for discussion, reflection on the video content, and feedback [19]. In this context, Chatti et al. [10] emphasized the benefits of video annotation in VBL and MOOC environments and presented a detailed comparison of existing video annotation tools. The authors mainly found that all the reviewed tools support basic features of video annotation, such as providing an annotation panel, video controls, viewing area, custom annotation markers, and external discussion tools. However, only a few tools are providing more advanced features, such as social bookmarking and collaborative discussion panels. Additionally, the lack of integration between these tools and learning management systems (LMS) or MOOCs makes their usage unpractical and out of context [10]. Moreover, existing features of video annotation tools do not allow learners to pinpoint a specific part of a video for questions and discussions in VBL scenarios, limiting their collaboration with peers. Furthermore, the discussions are not synchronized. As a result, learners find it difficult to communicate in certain situations since they cannot access any specific section of the video and refer to it (e.g., to ask questions or make comments). In such circumstances, it's important to consider how learners can be helped to deliver contextual information when they interact with video-based learning materials.

2.2 Pdf Annotation

Traditionally, annotations of printed books are made with a pen, pencil, or a highlighter. But still, these annotations cannot be shared. The concept of web annotation tools to annotate Pdf-based online resources is based on these traditional methods. Collaborative annotation systems are of great benefit to students in improving their learning. A collaborative annotation system with shared annotation and interactive discussion can improve reading attitudes and thus increase reading satisfaction among learners [20]. Sharing strategies in an annotation system can effectively increase the learning rate, as they facilitate the publication of individual knowledge [21, 22]. Furthermore, the annotation could encourage students to organize information and ideas for argumentation, collaborative research, and knowledge building [22]. However, collaborative annotations might lead to information overload. Mechanisms such as sorting, filtering, and ranking students by the number

of their annotations in ascending sequence can help deal with this issue and facilitate interaction between students [23].

Referring to the Pdf annotation techniques in the existing literature, a study conducted in an elementary English reading class showed that annotation strategies such as questioning and prediction lead students to a deeper level of understanding, which improves their reading comprehension [24], thus questioning can also be used for Pdf annotation. After conducting a study to design a user-friendly and effective online reading system, Noe et al. [25] stated that students employed several reading strategies such as underlining important points, highlighting words they did not understand, asking questions about texts, and inserting prompts into texts during the reading process. Marshall et al. [26] stated that actions such as selecting text for circling, starring, drawing, underlining or highlighting, and writing notes in the margin or empty spaces on a document are considered as the main forms of Pdf annotation. The authors further proposed three annotation strategies: underlining or highlighting words, writing an annotation for a specific part of text or figure, and adding notes in the margins [26]. Besides that, Nokelainen et al. [27] introduced another intuitive feature, which is document highlighting and commenting by right clicking the mouse and selecting the desired text area. The survey conducted in [28] to gather the important features of good annotation software, revealed that participants placed more importance on features such as image annotation, insensitivity to document format, keyword search, writing in margins, tagging, writing between lines, writing at the top and pen input. Pen input has the advantage of helping the user to focus on the page, but the problem with using this type of tool for social web annotation is handwriting recognition, which could not be understandable by other learners in a shared document [28]. To conclude, to support collaboration in online learning using annotations, it is important to design a Pdf annotation tool that will be easy to use for making different types of textual annotations [29], sharing these annotations with other participants, and supporting interactive discussion based on these annotations.

3 HUMAN-CENTERED DESIGN APPROACH

To better understand the needs and issues faced by the students while interacting and collaborating within a MOOC environment and to improve the design of interaction and collaboration mechanisms in our MOOC platform CourseMapper, we applied an iterative human-centered design (HCD) methodology. Designing with HCD requires that the user is involved from the very beginning and is regularly consulted for the evaluations of incremental prototypes, to ensure that the needs and requirements of the user are taken into consideration throughout the design process [30]. There are four different activities in the HCD process, namely Observation, Ideation, Prototyping, and Testing, which are iterated with each cycle yielding more insights and getting closer to the desired solution [30].

3.1 Observation

This study aimed to get to know the end-users, i.e., students and teachers using online platforms for learning and teaching, and develop a more profound knowledge of their current practices and needs. To this end, we conducted semi-structured interviews with five participants. The interview subjects were two university teachers and three students studying either bachelors or masters in any discipline. All of them were familiar with online learning tools, e.g., LMS, MOOC. The interviews were conducted online, due to the COVID-19 pandemic and its restrictions. Each interview focused on current practices and experiences with online learning, interactions with different online learning tools, goals and motivations behind using the tool, and what problems are the

users facing with these tools. The interviews lasted for 15 to 20 minutes and were audio-recorded and transcribed with participants' consent. Based on the interviews, we gained a better understanding of the end-users needs from an online collaborative learning tool and we formulated the following design goals:

(DG1) Interaction with learning materials: The students mentioned that during traditional learning, they used to take notes, highlight and underline words on their books, papers, and tablets. One student mentioned *"I can not download videos on my laptop due to limited memory so I want to watch them online and take notes"*. But in online learning, they miss this option to add personal notes on learning resources, whether it be Pdf or video material. *The students should be able to interact with the learning materials through annotation.*

(DG2) Interaction with peers: The students need a platform where they can study together or prepare for exams in groups. For that, they highlighted the need for a discussion forum where they can discuss the learning resources and answer each other's queries. A student mentioned *"I am usually unable to join group study meetings due to my work schedule, I want to see what they discussed during group study sessions"*. *The students should be able to collaborate with their peers and see discussions related to each learning material.*

(DG3) Interaction with teachers: Students complained that there is a lack of communication with the teachers. A student mentioned that, *"Sometimes we send a question to the teacher via email but they reply very late or did not reply at all"*. On the other hand, one teacher mentioned that, *"Usually there are a lot of emails, and sometimes it's possible to miss an urgent question from a student"*. *Students and teachers should be able to interact, directly and quickly.*

(DG4) Sharing: Another important aspect that can foster collaboration among students is resource sharing. A student mentioned that, *"Sometimes a file or a video sent by a friend is more helpful than the lecture material and I want other course participants to have it as well"*. Furthermore, there is a need for a platform that supports discussion and resource sharing altogether. One of the students said, *"In one semester, I had to use 5-6 different platforms because every teacher had his preference. In my desktop there were a lot of icons for all these apps. This was very annoying"*. *The students need a platform where they can share external resources related to a lecture with each other along with discussing these resources at the same place.*

(DG5) Awareness, search, and filtering: All participants highlighted the potential information overload problem in online learning tools. One student stated that, *"I want to receive notifications on what is going on in a topic that I'm interested in"*. Another student mentioned that, *"Sometimes, I just want to see contributions by specific users, for example teacher's answers to a question"*. *The system should provide awareness, search, and filtering mechanisms to help users deal with the information overload problem.*

(DG6) Monitoring: One teacher mentioned, *"In my online lecture, I am always worried if students are understanding the lecture or not. I need to see their learning activities and discussions to identify if a learning material was clear to them or if they have some problems with it"*. *The system should provide a space where teachers can view students' activities and discussions to monitor their understandability of learning materials.*

3.2 Ideation

Based on the user needs collected during the observation phase, we conducted an online brainstorming session to generate ideas about how to address the formulated design goals (DG). The aim in this initial phase was to collect as many ideas as possible on a given goal and put quantity of ideas over quality. For each DG, every idea was written down on a sticky note. After that, these ideas were discussed following a "pitch and critique" approach. This process requires that participants pitch their ideas to the group and the others should

give both positive and negative feedback. The last step was the voting process to select the best ideas. Each participant had three votes to vote on the best three ideas according to them. Figure 1 presents the results of this ideation phase. Afterwards, six storyboards were created for the top-voted ideas, as depicted in Figure 2. Finally, for each storyboard, a storyboard-walkthrough was performed with the same five users from the observation phase to get their feedback about the ideas and whether they indeed meet their requirements. Overall, the participants liked the idea of collaboratively taking notes on the lecture Pdfs and videos. However, they preferred to discuss the learning materials and share related resources at the same place, rather than using external services, such as Whatsapp and Studydrive. Based on users' feedback, we finalized the ideas by removing disliked ideas and combining the preferred ones.

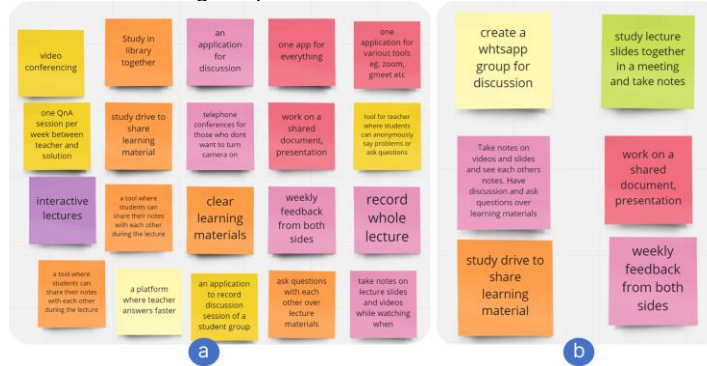


Figure 1: a) Results of ideation session, pitch-and-critique, b) Finalized six ideas after voting

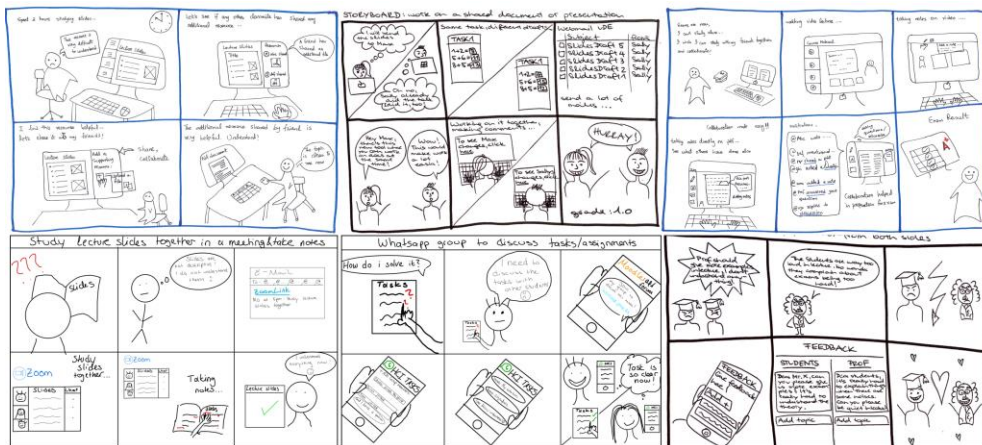


Figure 2: Six storyboards created for storyboard-walkthrough with the users

3.3 Prototyping and Testing

After the observation and ideation phases, the prototyping phase began, starting from a low fidelity prototype to high fidelity and then the final system. We kept close communication with the end-users through all the iterations. Five new users were recruited to give feedback after each iteration and their feedback was addressed in the subsequent design. Figure 3 presents an overview of the iterative design process.

First iteration, initial design, low-fidelity prototype: The first interactive prototype aims to collect user feedback about the concept of a MOOC platform that incorporates the users' needs identified during the observation phase. Based on the results from the ideation phase and the storyboard-walkthroughs with users, we created an initial design through low-fidelity prototypes. We started by creating paper prototypes, as they are throwable and simple to design. Inspired by the channel concept in popular instant messaging social platforms, such as Slack, Discord, Microsoft Teams, we introduced the concept of **learning channels**, as collaborative spaces in the MOOC platform created for each topic in the course, through which learners can interact with the learning materials, discuss them with peers and teachers, and share related learning resources. We started with designing a simple interface for creating a course, defining topics, adding a learning channel for each topic, and uploading Pdf and/or video learning materials (Figure 3-a1). Then users can annotate these learning materials using different annotation tools (Figure 3-a2) (**DG1**). A discussion panel was provided under the learning material where users can add notes, post questions, or share related learning resources (Figure 3-a3,a4) (**DG2, DG3, DG4, DG6**).

Second iteration, high-fidelity prototype: The paper prototypes were tested with five new users to get their feedback about the concept and initial design. For this purpose, we designed some tasks (e.g., define a topic, add a learning channel) and a semi-structured interview. According to the users, the process of adding annotations to the learning materials was clear. However, in the discussion panel, they wanted to have a way to just view questions or notes. Also, they wanted to add comments addressing a person, for example posting a question for the professor by tagging their name. Furthermore, they wanted to see an overview or list of all courses on one page. We used this feedback in the next design iteration to enhance the low-fidelity prototypes. In this iteration, we created high-fidelity prototypes using Figma. In addition to the panels where users can annotate Pdf and video learning materials using different annotation tools (e.g., highlight, pinpoint) (Figure 3-b2,b4), we added a home page for course overview (Figure 3-b1). We also provided a filter to differentiate between different annotation types (i.e., note, question, related resource) (Figure 3-b5) (**DG5**). Furthermore, a person can be directly addressed by using @ tag in the discussion panel (Figure 3-b3) (**DG2, DG3**).

Third iteration, high-fidelity prototype: We tested the prototype from the previous iteration with five new users and worked their feedback into the third design iteration. In the new high-fidelity prototypes, the interface was further improved by adding icons and colors, where colors were used as an indicator to differentiate between different annotation types (i.e., note, question, related resource) (Figure 3-c3) (**DG1, DG5**). The annotation panel which was initially shown over the video learning material (Figure 3, b4) was moved underneath the video so the user's view is not disturbed (Figure 3-c1,c2). Moreover, as pointed out by two users, we made the timeline selection option in video annotation more prominent (Figure 3-c2) (**DG1**). Furthermore, we extended the discussion panel with more filters and a search option to address information overload (Figure 3-c4) (**DG5**). One new idea that came up from the feedback session was to include a like/dislike functionality in the discussion panel, which we also implemented in this prototype (Figure 3-c3) (**DG2, DG5**). Furthermore, the users suggested to have the possibility to add comments on the annotations. To achieve this, we extended the discussion panel with a separate thread section where users can add comments, replies, and likes/dislikes to the annotations (Figure 3, c4) (**DG2, DG3, DG6**). This prototype was again tested with five new users and their feedback was incorporated into the design of the final prototype.

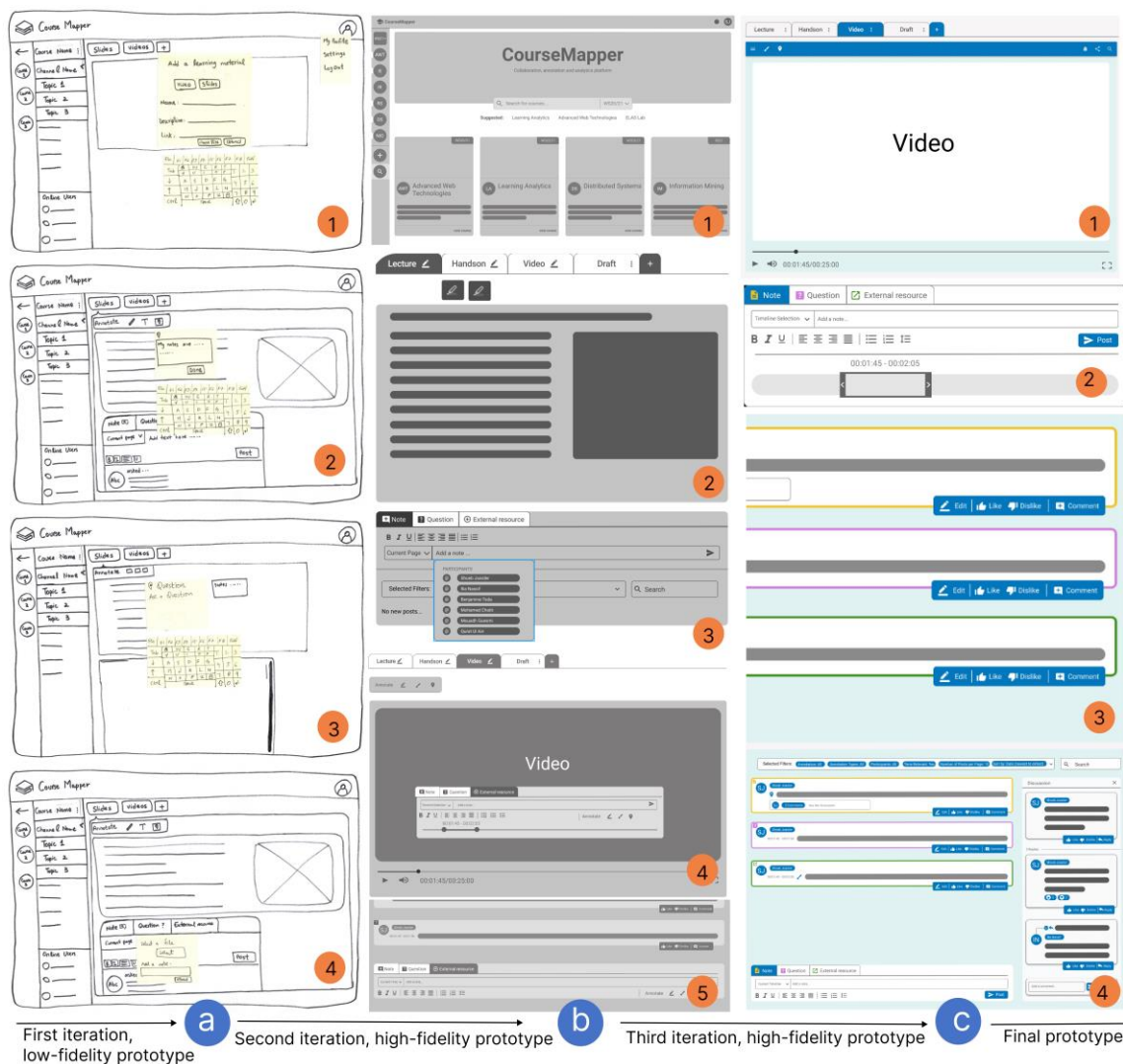


Figure 3: The three iterations of our prototype after addressing feedback towards our defined design goals in each step: a) initial design of the paper prototype, b) first high-fidelity prototype, c) second high-fidelity prototype

3.4 Final Prototype

Based on the previous iterations and following the feedback from the users, we designed and implemented a final prototype of the learning channels in CourseMapper with user interface components to support the design goals. In general, it consists of: a *course management screen* where the users can see the list of available courses, an *annotation screen*, where users can see possible annotation tools, and a *discussion screen* where

users can see notes, questions, or related learning resources. Below, we describe in detail the user interfaces (UI) in each of these screens.

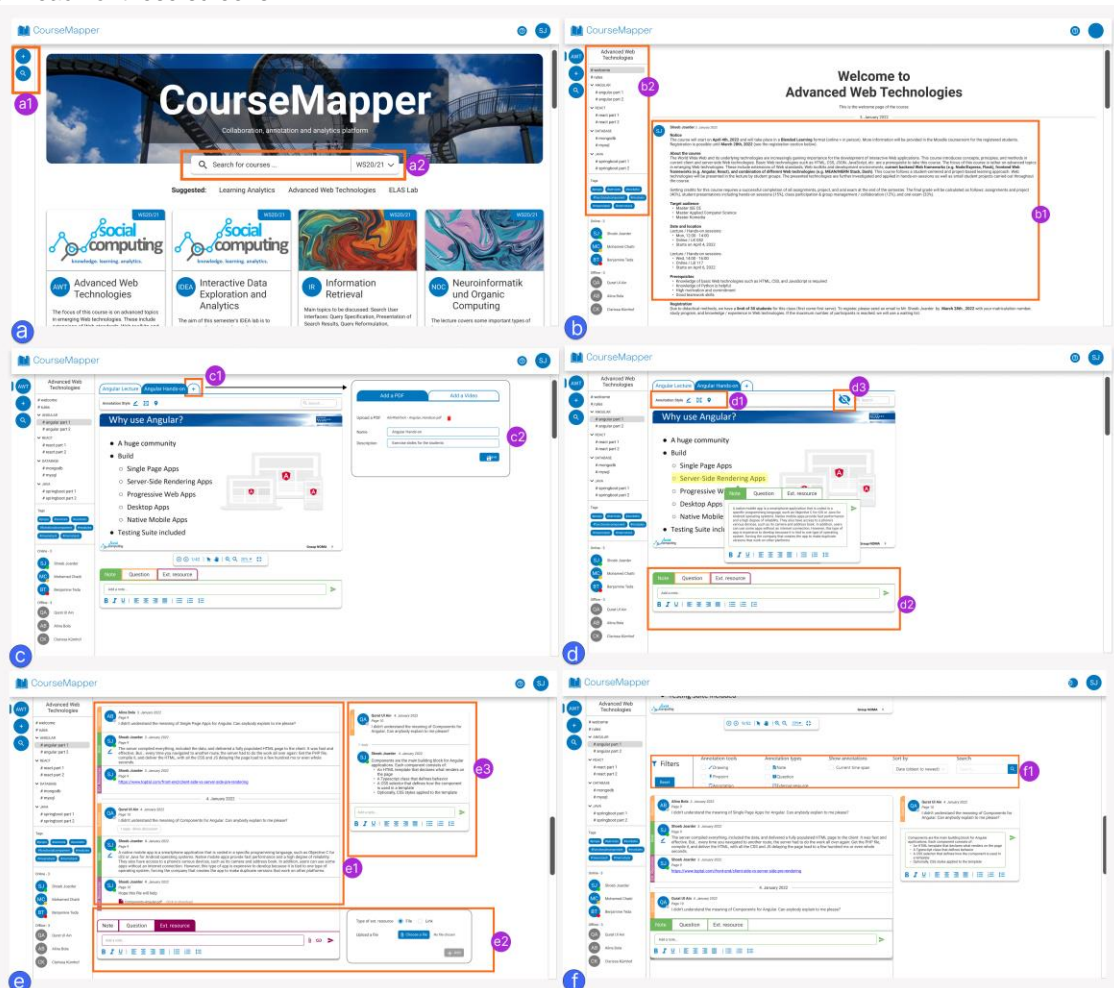


Figure 4: Screens of the final prototype a) course overview, b) and c) course details, d) annotation screen, e) discussion panel, f) filters and search

Course management screen (Figure 4 a,b,c): This screen supports all the activities related to course management and organization. It helps the user view and search existing courses and create new ones.

Course overview: This is the landing page of CourseMapper after login. This UI has a list of available courses shown as cards, with a search bar to search for courses (Figure 4-a2). To create a new course, a plus (+) button is at the top left corner of the UI (Figure 4-a1). Clicking on any course card will take the user to the course details UI.

Course details: This UI shows the course description (Figure 4-b1). A course can have multiple topics and each topic has one or more learning channels, as shown in the left navigation bar. The hashtags defined by users in the different learning channels in the course are shown under the topics list (Figure 4-b2). Multiple Pdf

or video learning materials can be added to a learning channel by clicking on the add (+) button (Figure 4-c1). This opens a popup where the user can add a Pdf or a video learning material (Figure 4-c2).

Annotation screen (Figure 4d): At the top of a Pdf or a video learning resource, the user can choose between three different annotation tools (i.e., highlight, draw, pinpoint) to mark specific parts of the learning resource and then add a note, question, or external resource, that we refer to as annotation types (Figure 4-d1). Users can also add annotations to a specific page of Pdf and for a specified time span on a video learning resource. These added annotations will then appear in the discussion panel underneath the learning material, categorized with different colors based on the annotation type (i.e., note, question, external resource) (Figure 4-d2). Furthermore, there is an option to directly view the annotations on the learning material using the show/hide button (Figure 4-d3) (**DG1**).

Discussion Screen (Figure 4 e,f): This is the screen where all interaction and collaboration activities between course participants (students and teachers) are shown.

Discussion Panel: The annotations added to the learning materials will appear under it in the discussion panel (Figure 4-e1). This panel also allows the user to add general notes, questions, or share related external learning resources under the learning material without using any annotation tool (Figure 4-d2,e2). Users can also mention someone directly using @, add related hashtags, and comment on an existing annotation. This will open a thread panel where users can add replies and likes/dislikes to other users' comments (Figure 4-e3). These actions would increase user interaction with each other as well as with the teacher, thus improving the whole learning process and environment (**DG2, DG3, DG4, DG6**).

Filters and Search: Three main filtering options can be used: by annotation tool (i.e., highlight, draw, pinpoint), by annotation type (i.e., note, question, external resource), or by Pdf page/time span on video. Users can also use the "Sort by" to sort the existing annotations. Further, a "Search" function allows users to search by username, hashtag, or a specific word in an annotation (Figure 4-f1) (**DG5**).

4 FINAL EVALUATION

We implemented the final prototype of the learning channels in CourseMapper using the MongoDB, ExpressJS, Angular, and NodeJS (MEAN) stack. Finally, we explored the usage and users' attitudes towards the learning channels concept by conducting a quantitative and qualitative user study to evaluate the degree to which the defined design goals are achieved.

4.1 Study Design

The evaluation was performed based on the Technology Acceptance Model (TAM), which consists of two subfactors: the perceived usefulness (PU) and the perceived ease of use (PEOU) [31]. A user testing protocol was designed consisting of some tasks that the users were asked to perform using the system, namely signup and login, creating a course and adding a new topic, learning channel, and Pdf/video lecture materials, adding different types of annotations, adding hashtags and comments to the annotations, replying to comments, liking and disliking comments or replies, and using filters and search features in the discussion panel. The evaluation process was as follows: First, the participants were briefly introduced to the concept of learning channels in CourseMapper (CM). Then, they were asked to perform the above-mentioned tasks. Finally, they were asked to fill out a questionnaire, containing (1) demographics and general information related to user experience with

MOOCs, social media, collaboration, and annotation platforms, and (2) questions to evaluate the implemented solution to achieve our design goals based on TAM.

4.2 Analysis and Results

Ten participants participated in the study, aged between 18 and 44 years (five bachelors, four masters, one Ph.D. student). All participants completed all the assigned tasks. The questionnaire responses can be summarized as follows. All participants had prior experience with MOOCs and social media platforms but had no experience with online collaborative annotations in the past. Referring to means of collaboration, often they used to study together in groups. The feedback was divided into four main dimensions: PU, PEOU, satisfaction, and willingness to use the system. In terms of PU, 80% of participants strongly agreed the annotation types (i.e., note, question, external resource) and annotation tools (i.e., highlight, drawing, pinpoint) were useful (Figure 5a) (DG1). 70% of participants strongly agreed that the discussion section was useful for expressing individual thoughts (DG2) and 80% of participants strongly agreed that CM's annotation service is useful for sharing knowledge (DG4). Furthermore, 70% of participants strongly agreed that filtering annotations by annotation type, tool, date, and users, is useful for getting a better overview of annotations (DG5). Regarding PEOU, 60% of the participants strongly agreed and 30% agreed that the UI of CM was easy to use. 60% of the participants found it easy to use in terms of annotation services (DG1), and to help them perform day-to-day learning activities (Figure 5b). In terms of user satisfaction, 60% of the participants strongly agreed and 20% agreed that CM satisfied knowledge sharing (DG4) and 70% of the participants strongly agreed that it supports active learning (Figure 5c) (DG6). Moreover, 60% of the participants strongly agreed and 40% agreed that CM satisfies interaction with learning materials and teachers (DG1, DG3), and collaboration between peers (DG2). In terms of willingness to use it in the future, 70% of the participants strongly agreed that they would like to use CM and its annotation services in the future (Figure 5d). In summary, the evaluation results showed a high user acceptance of the interaction and collaboration possibilities offered through the introduction of learning channels in a MOOC environment.

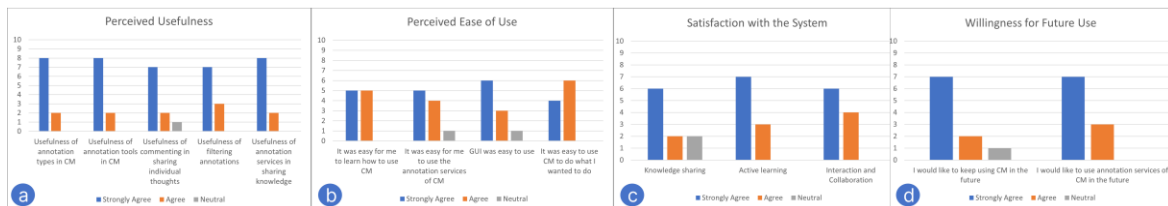


Figure 5: Results of the final evaluation of CourseMapper based on TAM

5 CONCLUSION AND FUTURE WORK

In this paper, we explored how to leverage learning channels to support interaction and collaboration in MOOC environments. We introduced the concept of learning channels as collaborative spaces in a MOOC platform where learners can collaboratively annotate learning materials, discuss them with other course participants, and share related learning resources. Following a human-centered design approach (HCD), three design iterations were conducted from an initial user interview to the final design of learning channels in the MOOC platform CourseMapper. Finally, a small user study was conducted using the technology acceptance model

(TAM) to gauge the users' perception of learning channels in a MOOC platform. The evaluation results showed that the overall user experience with the platform is positive and that learning channels have the potential to support effective interaction and collaboration in a MOOC environment. However, due to the small sample size of the study, the results should be interpreted with caution and cannot be generalized. A larger sample would probably have yielded more significant and reliable results. In future work, we will conduct a large qualitative and quantitative user study to validate the effectiveness of learning channels in CourseMapper. Furthermore, we plan to extend CourseMapper with a notification module to enhance users' awareness of learning activities in the platform as well as a learning analytics module to support monitoring, reflection, feedback, and recommendation.

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