Asian Journal of Distance Education

Design considerations for MOOCs with mathematics education context: Let's listen to the voice of learners

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Abstract: Massive open online courses (MOOCs) can be designed with different pedagogical approaches and course components as in face-to-face courses. In this context, the development of some standards and field-specific design principles related to MOOCs is seen as a critical step for the creation of quality online courses. The aim of this study is to examine the MOOC experiences of the learners in mathematics education and proposing reflections about design principles of MOOCs for mathematics education. In this respect, the MOOC experiences of 30 teacher candidates enrolled in MOOCs (with mathematic education context) were analyzed, and the general course structure, pedagogical orientations, and mathematical connection elements used in these MOOCs were examined. The data obtained from the participants revealed a comprehensive course evaluation structure including 7 categories and 85 codes under 3 themes and mathematical connection findings consisting of 3 categories and 3 subcategories. The research findings uncovered that teacher candidates had course experiences that differed according to national/international MOOC evaluation criteria in terms of audiovisual elements, video/course durations, interaction-feedback features, teaching methods, measurement/evaluation, and mathematical connection dimensions. Course evaluation codes/propositions and mathematical connection findings that emerge as a result of this research can be considered as a resource that can be used in the design of MOOCs to be planned in mathematics education.

Keywords: MOOCs for mathematics education, MOOCs for teacher education, mathematical connection, online mathematics education, preservice mathematics teachers

Highlights

What is already known about this topic:

- Developing domain-specific design principles related to MOOCs is critical to improving learner outcomes
- The question of how to design a MOOC for a practice-based field such as mathematics education has not yet been answered in the literature

What this paper contributes:

- The data obtained from the participants revealed a comprehensive field specific MOOC evaluation structure
- In mathematics education MOOCs, the "connections with real life" strategy is the most intensely observed mathematical connection strategy
- 4–5-minute videos were insufficient in learning the course subject, whereas videos lasting more than 20 minutes could reduce the attention of the learner

Implications for theory, practice, and/or policy:

- MOOC designs can be customized in mathematics-related courses differently from traditional evaluation criteria.
- Opening a separate parenthesis in MOOC designs to the subject of mathematical connection strategies may become an essential design element in the future

Published by Asian Society for Open and Distance Education (ASODE), Japan
ISSN 1347-9008 http://www.asianjde.com/

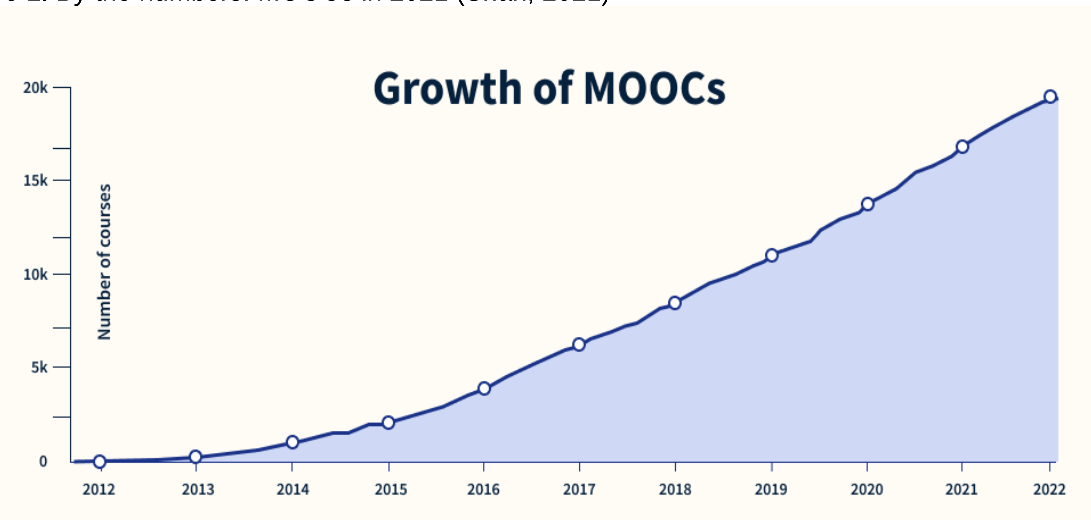
Introduction

In recent years, more and more online courses have started to be offered to learners, especially in higher education, with online courses being incorporated into the teaching curricula of universities in many countries (Gonda et al., 2020). Today, many universities from different parts of the world offer significant opportunities/incentives for their enrolled students to take online courses along with face-to-face (F2F) courses during their teaching process (Hamann et al., 2021; Wang et al., 2021). While there are different reasons underlying this incentive, these reasons can be fundamentally related to technology (Bozkurt et al., 2015) and changing learner characteristics (Engelbrecht et al., 2020).

Especially "the OpenCourseWare movement" that came to the agenda with the year 2002 and the massive open online courses (MOOCs) that are a product of this movement have created an axis shift in higher education. MOOCs have enjoyed marked popularity in higher education and have formed a major trend throughout the entire educational world. MOOCs, which peaked all over the world with the year 2012, paved the way for the rethinking of the traditional higher education structure built on F2F education. Today, MOOCs have become a "mainstreaming learning model" especially in higher education (Bozkurt, 2021). It is now an accepted fact that skill-based learning processes are more valid in real life than diploma-based formal teaching. In addition, changing learner demands, the flexibility brought by technology, and the economic structures of universities are also making online courses increasingly accepted in higher education.

MOOCs offer learners a flexible learning opportunity and differ from other formal online courses in several aspects (Bozkurt, 2021). MOOCs are open online courses, usually 4-8 weeks long, with a mass audience, free or affordable. These courses are offered by different higher education institutions through various MOOC provider platforms or by the platforms created by universities. After its advent, the number of MOOCs that make hype with the year 2012 is increasing year by year. As of 2021, approximately 19400 online courses have been introduced by 950 universities worldwide (excluding China) (Shah, 2021).

Figure 1. By the numbers: MOOCs in 2021 (Shah, 2021)



According to their general pedagogical structure, MOOCs can be classified into three basic categories (Aldon et al., 2019):

> "*xMOOCs (e.g., Coursera or Udacity) are designed on a pedagogical model dominated by drill and grill teaching methods, "using video presentations, quizzes, and tests" (Yuan & Powell, 2013, p. 7); cMOOCs or connectivist MOOCs, for example, Connectivism and Connective Knowledge, are based on the theory of learning with informally developed networks" and are a*

> *participatory pedagogical model and quasi-MOOCs, for example, Khan Academy that provide online open educational resources aimed at supporting learning-specific tasks and do not offer social interaction of cMOOCs or a structured xMOOC course structure* (Siemens, 2013, p. 8)."

MOOCs can be designed with different components, durations or pedagogical approaches, as in F2F courses. However, the development of some standard or domain-specific design principles related to these courses is also critical to improving learner outcomes (Drake et al., 2015). In addition, the evaluation of online courses in terms of different learning components is regarded as an essential step in the creation of quality online courses (Baldwin & Ching, 2019). In the literature, there are different studies (Baldwin & Ching, 2019; Clark & Mayer, 2016; Drake et al., 2015; Guàrdia et al., 2013; Jaggars & Xu, 2016; Ralston-Berg, 2011; Yousef et al., 2014) and evaluation tools (Quality Matters Higher Education Rubric, 2018; Canvas Course Evaluation Checklist, 2019; Blackboard Exemplary Course Program Rubric, 2017) that offer propositions related to online course design. It is noticeable that there are limited studies on MOOC designs in the relevant literature (Drake et al., 2017; Wang et al., 2021). It should not be forgotten that the pedagogical design of a MOOC is the most crucial factor affecting the quality of the course, and the quality of the course is the most essential factor affecting the usefulness of the course, the participation in the course, the participant engagement, and the attendance to the course (Yang et al. 2017). One of the notable interpretations in the literature on MOOC designs is the inclusion of more complex studies such as "learner and instructor interviews, and actual MOOC session observations" in addition to surveys or other descriptive studies (Zhu et al., 2018). Apart from this, it is known that MOOC designs continue with the design elements of the first periods (Bozkurt, 2021).

One of the hotly debated topics of discussion in online learning is, how a pedagogical process should be established for the efficiency of online courses in practice-based fields such as mathematics education (Smith & Ferguson, 2004; Smith et al., 2008). In the teaching of mathematics, the focus is not only on the teaching of knowledge, but also on the development of skills. In the mathematics education literature and in the curriculum of many countries, there is often an emphasis on the development of various mathematical skills (NCTM, 2010; MONE, 2018). In this direction, it seems inevitable to rethink how online mathematics teaching can improve skills along with theory. In this sense, MOOCs also have important opportunities for the field of mathematics education. Borba et al. (2016) explain this situation as follows:

> "*The potential of MOOCs to disrupt the institutional and hierarchical nature of traditional education, offering students opportunities to access courses without prerequisites, without fees (unless they require a record of course completion), and the potential of MOOCs to affect access to and the quality of mathematics education is not well understood. (p. 606)*" (Borba et al., 2016)

One of the aforementioned math education skills is "mathematical connection." Mathematical connection is a mathematical process skill. This process skill enables the understanding of mathematical thoughts and the relationships between them (Van de Walle et al., 2012), thus enabling more successful learning of mathematics (Hard et al., 2022). Mathematical connection skill is critical in terms of learning new concepts (Mousley, 2004), establishing a link between formal mathematics learned in school and everyday life (NCTM, 2000). The Turkish Ministry of National Education has also recommended that teaching environments should be prepared for the interrelation/connection of different forms of representation (MONE, 2013: VI). In addition, different visual structures and representations used in the courses were found to have a significant positive effect on the mathematical connection skills of the learners (Kenedi et al., 2019). At this point, it should be noted that there are clues in the literature that the different materials and flexibility provided by online education have more positive effects on the mathematical connection skills of learners than F2F learning (Hard et al., 2022). In the light of all these, it can be thought that planning to support mathematical connection skills in the structuring of MOOCs related to mathematics education can have an effect on the efficiency of these courses.

Various studies show that there are different classifications of mathematical connection skill. However, in these studies, it is seen that connecting mathematics within itself, connecting it with different disciplines and connecting it with daily life is commonly at the forefront (Özgen, 2013). This study examined mathematical connection skill elements in MOOCs within the scope of the different types of connection titles such as connections with mathematics in itself, which was widely used by Özgen (2013, 2016) (connections between concepts and procedures, connections between different representations, connections between different mathematics subject areas), connections with real life and connections with other disciplines.

Based on the aforementioned arguments, the main purpose of this research was to examine the experiences of mathematics education teacher candidates regarding MOOCs. This examination was carried out through two main foci. The first of these was to examine the course structure and general pedagogical systems of 3 different MOOCs experienced by the teacher candidates, and the second was to follow the strategies related to the mathematical connection elements in the courses with the context of mathematics education. In this respect, the research sought answers to the research questions listed below:

1. What are the opinions of teacher candidates about the structural features of the course videos (visual features, durations of videos-course, audio elements) used in MOOCs with mathematics education context?
2. What are the opinions of teacher candidates on the interaction-feedback features in MOOCs?
3. What are the opinions of teacher candidates on pedagogical approaches (assessment/evaluation, motivational strategies and elements, teaching methods and techniques) in MOOCs?
4. What are the mathematical connection elements (connections with mathematics in itself, connections with real life, connections with other disciplines) that are included in MOOCs for mathematics teaching?

Methodology

Research Design

The research was designed as a qualitative single holistic case study. Qualitative case studies are carried out to examine a limited system or event in detail and in depth (Glesne, 2016, Stake, 2005). Although the researcher can determine the focus of the examination, which can be specified as a limited system, the individual holistic case analysis used in this study is suitable for cases where the system components/limits cannot be understood sufficiently and clearly (Yin, 2009). This methodological choice aims to examine complex systems (such as MOOCs examined in the study), "interactions within the system" (Sezgin, 2018) through techniques such as observation, interview, or document analysis (Glesne, 2016). Case study findings obtained through experiencing the condition provide researchers with the opportunity to notice the deficiencies associated with the system being studied and improve on the existing one.

Study Group and Data Collecting Tools

The participant group of the study consisted of 30 secondary school mathematics teacher candidates. All of the participants were candidates who had online course experience but had not previously registered for a MOOC. A semi-structured interview form created with the help of field experts and online learning experts was used as a data collection tool.

Research Process

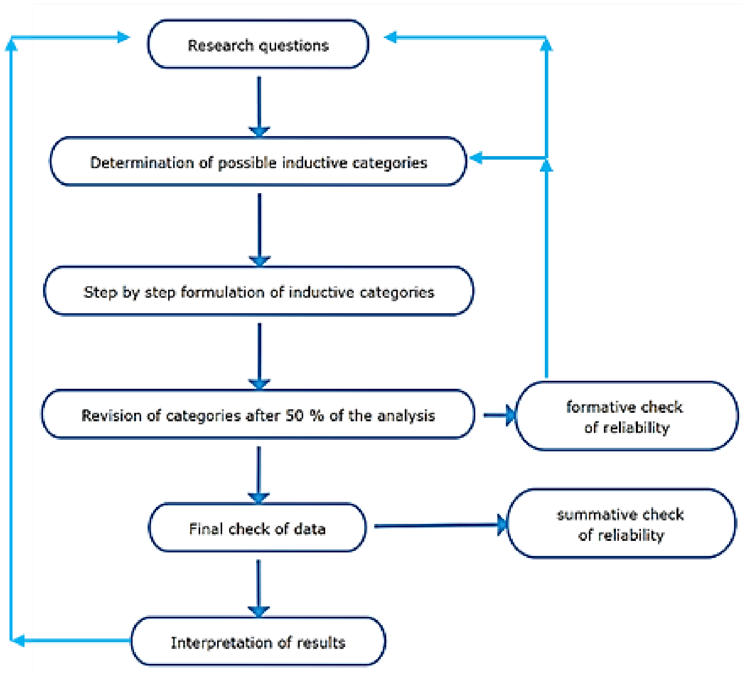
Following the start of the Covid-19 pandemic process, teacher candidates continued their formal education through online learning for 3 semesters. In the research process, teacher candidates were asked to take 3 MOOCs of their choice from various online platforms and to examine these courses in the context of the research framework created with the help of researchers, field experts, and online learning experts. The MOOC experience and completion process of the teacher candidates lasted about 2 months. The stages of the general MOOC experience process of teacher candidates are listed below.

1. Teacher candidates discussed about the online learning platforms they used during the pandemic. After the discussion, they were asked to come to the next meeting by researching MOOC platforms.
2. Teacher candidates came to the F2F class by researching different MOOC providers and discussed about these platforms/courses in these platforms.
3. For the following F2F meeting, teacher candidates were asked to choose various MOOCs and to register to them if they liked them.
4. Teacher candidates registered for 3 different courses from different platforms. In the following process, they were asked to examine the structural features of the courses and the mathematical connection strategies used.
5. In the following weeks (with the completion of the online course processes), interviews were conducted with teacher candidates about MOOCs.

Analysis of the Data

Within the scope of the research, qualitative content analysis was performed on the data collected from the participants. Qualitative content analysis aims to create specific categories from the data/answers collected on research questions selected by the researcher. The creation of categories is based on the identification of codes and patterns within texts (Patton, 2015).

Figure 2. Analysis process (adapted from Mayring 2000)



Thematic analysis approach was also used together with content analysis depending on the research questions. The analyses were carried out through MAXQDA qualitative analysis software. As a result of the content analysis of the first three research questions, 7 categories (sub-themes) emerged under 3 themes. The fourth research question, the analysis of mathematical connection elements, was examined regarding connections with mathematics in itself, connections with real life, connections with other disciplines by considering the theoretical framework of mathematical connection skills in the literature. In the analysis maps created in this study through the MAXQDA software, the concepts were shown in different sizes based on the code density. The basic analysis process of the research was carried out with an inductive process.

Validity and Reliability

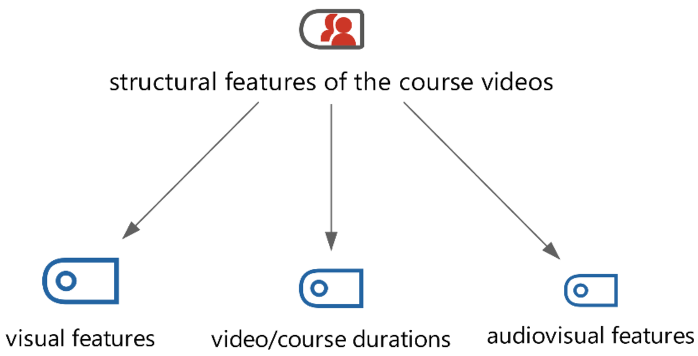
The data obtained from the participants were independently examined by 2 field experts and an online learning expert and themes/categories were created. Then, all the data is once again read independently by 2 field experts, and coded under the relevant themes. Interrater reliability was calculated to demonstrate the reliability of the research with the relevant process. The final version of the code schema and themes was agreed upon. The reliability coefficient between coders was determined as $\kappa = 0.890$ in the study. In addition, in order to ensure the credibility of the research, various quotations about the transcrypted views of the teacher candidates were presented in the results section.

Findings

Findings on the structural features of the course videos used in MOOCs with mathematics education context

After the content analysis, the experiences/opinions of the research participants regarding the structural features of the course videos used in the MOOCs they completed were grouped under 3 categories. These are the video visual features, audiovisual features, and the video/course durations.

Figure 3. Structural features of the course videos used in online courses.



Although it is noticed that the participant opinions about the video structure are concentrated in the visual flow and elements of the videos, it can be claimed that the codes for the course-video duration and the audio features of the videos show a balanced distribution. The code categories that emerged under the video visual feature's theme are presented in Table 1 below.

Table 1. Codes-Propositions for video visual features

Codes- Propositions for video visual features	Frequency within the code group
Seeing the instructor's face-eye contact	26,36
Proper use of tone of voice, gestures, and body language	11,63
Supporting narration with engaging visual materials	10,85
The composition of the background (being remarkable, not distracting)	10,85
Writing and teaching with colored pencils	8,53
Using different types of visuals (animation, cartoon use, etc.)	7,75
Use of context-related visuals	7,75

Clear image to see every detail, image quality can be adjusted	5,43
Setting the font size appropriately for viewers	3,10
The instructor's personal appearance (dressing, smiling, etc.)	3,10
Proper distribution of the screen in the video, no distracting visual components in the overall video, simplicity	3,10
Change of camera angle in problem solutions and similar expressions	0,78
When the video is paused, there is no different text, advertisement etc. in the image reflected on the screen	0,78

Table 1, which contains the codes for the video visual elements, shows that code blocks such as the personal appearance and movements of the video narrator, the background of the video and the distribution of the elements in the video on the screen, and the visual materials contained in the videos stand out. In addition to these, it is noteworthy that variables such as fonts, font colors, and video quality are among the codes under the theme.

Table 2. Codes-Propositions for audiovisual features

Codes-Propositions for audiovisual features	**Frequency within the code group**
Different tones of narration/emphasis in different subject sections - Using a non-vivid tone of voice	36,58
Instructor's/Narrator's voice color	15,85
Sound quality-microphone quality (no background noises)	12,20
Use of fluent, understandable and simple language/narration	9,76
A friendly and reassuring tone of voice	6,10
Speaking speed of the instructor	4,88
No mechanical robotic voice-use of real human voice	3,66
Proper pronunciation-Diction	3,66
Keeping the volume constant in video transitions-preventing level differences	2,44
Using sample sound effects related to the topic described	2,44
Using the start and end sound effects of the subject	2,44

The most obvious code emphasized by the participants regarding the audios in the course videos is that the course instructor's narration (using dynamic and different tones of voice). Accordingly, participants were disturbed by their unaccented monotonous narrator voices. In addition to intonation, the narrator's having an intriguing voice color, diction, the sense of confidence and intimacy that his voice reflects are the codes that depend on the narrator's characteristics. The smooth transmission of the video narration to the audience also emerged as an element that requires environmental and hardware control. The data obtained indicate that artificial sounds created by computers along with the narrator may also be an important variable for online courses. In addition to the demand for the use of live human voices in the video-lessons and the discomfort felt from mechanical sounds, the sound effects and sample sounds used in various situations in the videos are also among the variables that can affect the course engagements of the participants.

Table 3. Codes-Propositions for video/course durations

Codes-Propositions for video/course durations	**Frequency within the code group**
4–5-minute videos are insufficient in terms of attention-focus in mathematics education	45,45
20-30-40-minute videos are too much in terms of attention-focus in mathematics education	18,18
In the first week of the course, the total number of course duration-videos specified on the course main page; too much is daunting/too little lowers motivation	24,24
The total course hours/video duration of 4 weeks is too short to learn the subject	9,09
Short-form videos are appropriate in a reinforcing context, long-running videos are appropriate in an instructive context	3,03

The course video durations of the courses attended by the participants during the research process were recorded by the researcher. Accordingly, the video duration of the courses completed by the participants was quite different from each other. In the research, specific opinions of mathematics education teacher candidates regarding video/lesson durations were revealed. Accordingly, it was stated that short videos of 4-5 minutes in online mathematics education courses were insufficient in the context of learning the course subject, whereas the videos lasting more than 20 minutes, could reduce the attention of the learner. In this regard, the participants evaluated that the short lecture videos were reinforcing and the long lecture videos were instructive. Apart from this, the large number of videos listed on the main page of the course during the first-class week (and therefore the total duration) indicates that there may be an interface planning that can lead learners to develop negative ideas about the lesson.

Findings on interaction-feedback characteristics in MOOCs

In another research question of the study, the opinions of the participants about the interaction and feedback elements in the online courses were analyzed. The codes determined after the analysis can be shown in Table 4.

Table 4. Codes-Propositions for interaction-feedback features

Codes-Propositions for interaction-feedback features	Frequency within the code group
Providing a discussion forum-providing student-student interaction	28,57
Providing an environment where the student and instructor can interact about the course	19,05
Providing quick feedback	14,29
Automatic feedback after written question and answer in video	9,52
Peer assignment feedback	9,52
Providing a course evaluation area for students	9,52
Providing under-video discussion area	4,76
Finding a personal promo video placement space	4,76

The table illustrates that the existence of discussion forums where the participants -especially learners with learners- can interact, as well as the presence of an interaction mechanism where the learner and the instructor can interact one-on-one are positive features. Actions such as providing quick feedback to learners, either automatically or individually, and giving feedback to assigned assignments are also critical features that learners value about the course. In addition, interaction design elements such as the provision of special discussion areas for the whole course or the video content and the personal introductory video areas that can trigger social interaction are also features that are noted by the learners.

Findings on pedagogical approaches in MOOCs

After the content analysis, the experiences/opinions of the research participants regarding the pedagogical approaches used in the MOOCs they completed were collected under 3 categories. These are teaching methods/techniques, assessment/evaluation, and motivational strategies/elements.

Figure 4. Pedagogical approaches in MOOCs

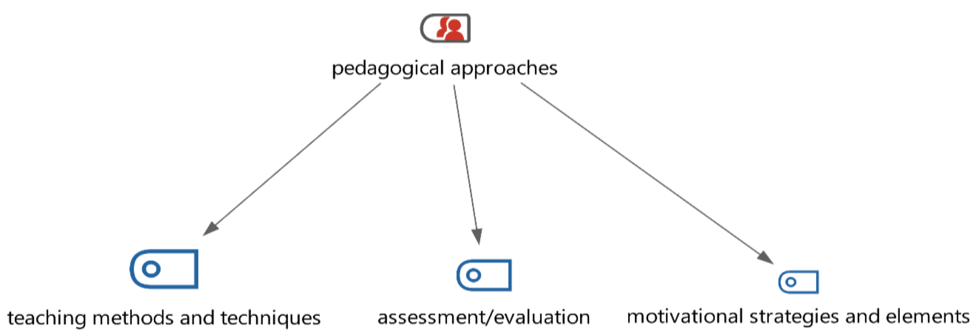


Table 5. Codes-Propositions of teaching methods and techniques

Codes-Propositions of teaching methods and techniques	Frequency within the code group
Using analogy/metaphor	23,01
Using question-and-answer-brainstorming as if there were one-on-one interaction	22,12
Direct instruction technique- the use of a conversational narration	17,70
Problem solving	14,16
Transferring experience on the subject (individual memories-learning adventures, etc.)	4,42
Narration using body language	4,42
Progress of the instructor by writing what he/she will tell on the board -(not using preset presentations)	3,54
Intensive use of visuals and narration through visuals (providing visual permanence)	3,54
Interview with experts at the end of class or during class reinforcing the subject	2,65
Teaching by recalling/recognition of previous knowledge	2,65
Demonstrating and having it done – encouraging students to experiment in their own physical environment	1,77

Participants' opinions on the teaching methods and techniques used in MOOCs formed 11 different codes. The codes under the theme include hints that asynchronous interaction can be enriched by using various techniques in MOOCs. In the context of mathematics education, making analogies to real-world situations related to the topic at hand and comparing them to previously known examples, i.e., benefiting from analogies, is a frequent strategy. In addition, problem solving (inductive or deductive), visualization of the mathematical contents described (or narration with different visuals) and the narrator's progress by writing instead of ready-made operations may be considered crucial.

Table 6. Codes-Propositions for assessment and evaluation elements

Codes-Propositions for assessment and evaluation elements	Frequency within the code group
Using quiz after each course topic section (week, module) – (with time limit)	25,64
Using quiz, homework, open-ended questions, mini question-answer after each video	16,67
Use of exams as a condition for qualifying to the next section	10,26
Using quiz or question asking activity during class	6,41
Using post-quiz feedback, explanation and threading links	6,41
Immediate reflection of the answers on the screen at the end of the test	5,13
Using simple in-video quiz or assignment with an explanation of how to do it in the next video)-asking and explaining inferential questions	5,13
Using simple activities-assignment (with no feedback)	5,13
Using single-answer open-ended, multiple choice or true-false questions	5,13
Using open-ended question and answer (written)	3,85
Providing hints in quizzes and ensuring that a solution is reached	2,56
Change of questions and options in repeated exams	1,28

Examining the opinions of participants on the topic of measurement and evaluation revealed that simple measurement applications were more prevalent in MOOCs than evaluation. These practices are usually carried out through quizzes, simple homework-activities or open-ended questions. The point that draws attention and needs to be investigated later seems to be the timing of the measurement activity performed. This timing can be after the end of the lesson, after the course sections, after the videos in the sections, or in the video (stop and ask questions). Apart from these, conditional passing applications between course sections can be used as a basic evaluation element, and the competence of the participants to pass to the next course section can be questioned. Providing quick feedback on the measurement, thus directing the learners to the topics they are missing, is also one of the actions regarded positively by the participants.

Table 7. Codes-Propositions for motivational methods and strategies

Codes-Propositions for motivational methods and strategies	Frequency within the code group

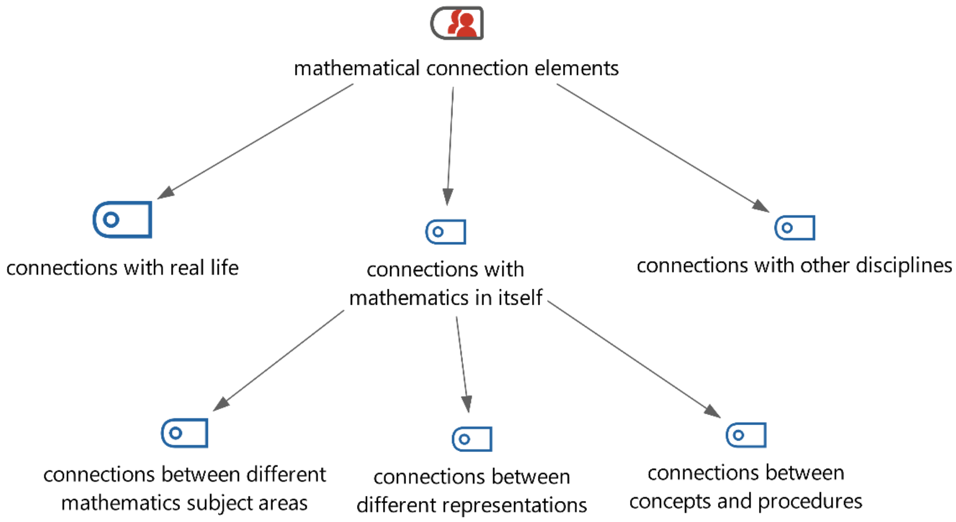
The instructor's physical appearance (having a beautiful face), body language, tone of voice is very motivating	12,70
At the beginning of the course, giving remarkable information about the course, explaining the purpose of the course in detail	11,11
Providing a one-to-one narrative feeling-Creating a conversational atmosphere	11,11
Using gamification elements (points system, energy system, progress bar, etc.)	7,94
Affirmation at the beginning or end of class (for example, "I am focused on success with my heart and logic", etc. course introduction activities)	6,35
Interrupting the narrative and asking questions about the topic—for example, "What do you think?", "It's your turn!", "Is it right or wrong?" Student-activating narration (video stops and answers are received)	6,35
Using joke-cartoons on the subject	6,35
Simulating and giving examples	3,17
Using play activities (in-class - extracurricular)	3,17
Using "are we ready" or "take a deep breath and let's get started" at the beginning of each video	3,17
Automatic instant verbal or emoji feedback on question solutions	3,17
Question-and-answer activities at the end of the video	3,17
Continuously moving camera focus	3,17
Attention-grabbing use of images/objects in the background	1,59
Instructor talking about his/her own learning journey	1,59
Inclusion of common mistakes and their causes, and empathy	1,59
Easy navigation on the course page	1,59
Using practical applications that can be used immediately	1,59
Starting a presentation with a standout title that seems subject-independent	1,59
Visual integration of the instructor into the subject visuals explained	1,59
Motivational quotes during the video	1,59
Starting the course with an intriguing question	1,59
Presenting interviews with well-known/renowned experts in the field	1,59
Using a clapping effect in the final video	1,59
End of class talks, giving encouraging advice	1,59

When it comes to the category of motivational methods and strategies, it was determined that there are quite a variety of motivational actions and strategies that attract the attention of the participants. It was observed that the codes under the theme also show commonality with some codes related to teaching methods and techniques or video structure. This can be taken for granted when the course design is viewed from a holistic perspective. As in the theme of assessment and evaluation, it is noticeable that there are motivational triggers that can be realized at different moments of the course under this theme. However, it is noteworthy that for MOOC participants, the physical appearance of the instructor and the features that stood out in some other themes such as body language and tone of voice may be prominent MOOC design elements for the motivation of the learners. In addition, it was observed that strategies such as giving remarkable course information at the beginning of the course, explaining the purpose of the course, and creating a conversation atmosphere that evokes the one-to-one interaction situation in the course process attract the attention of the participants more intensively. However, it should be remembered that all the actions and strategies that appear under this theme, as with other themes, may have critical importance separately. Since the qualitative analysis in the study was carried out with a holistic approach, the codes under the theme can be clustered within themselves. For example, the icebreaker and hook strategies used at the beginning of or during the course, the use of game and gamification elements, focusing, positive belief, and attitude development activities are the main clusters under this theme.

Findings on mathematical connection elements included in MOOCs with a mathematical context

The views of teacher candidates about the mathematical connection elements contained in the MOOCs were analyzed under 3 categories and 3 sub-categories.

Figure 5. Mathematical connection elements included in MOOCs.



The intensity and type of mathematical connections vary according to the subject of the course. In the MOOCs examined, it was remarkable that "connections with real life" was used more intensively than other types of mathematical connection types.

Connections with real life

Teacher candidates found that the strategy of connections with real life is used in many MOOCs. Although examples of real-life situations differ according to the subject and the course designer, the most common mathematical connection element is "connections with real life". It was seen that real life contexts were used in various problem situations in the courses. For example, in relation to the subject of integers, connections were made with receivables and payables; or an example of parked cars was given to illustrate parallel lines. Also, sentences established in daily life were connected with the subject of logic and expressed with logic symbols. Regarding the subject of probability, the "Monty hall" situation, which includes a probability problem that is also the subject of competition programs in different countries, was given as an example.

> *"There are 3 doors, and behind each door is a prize. But two of the prizes are small, worthless awards. When the contestant chooses one of the 3 doors, one of the doors he did not choose opens. Let's say one of the worthless rewards is at the door. One of the closed doors has a grand prize and the other a worthless reward. The presenter asks: Do you want to change your choice? If he changes his choice or if he continues with his first choice, will he be more likely to win?"*

Although connections with real life is the most emerging code group, some of the MOOCs chosen were criticized for not having enough connections with real life. The statement of the teacher candidate is as follows:

> "*I can say that the connections with real life was almost non-existent. From everyday life, it could simply show the decimal numbers on the receipt or bill." (P27)*

Connections with mathematics in itself

This theme is discussed in 3 subcategories as connections between different mathematics subject areas, connections between different representations, connections between concepts and procedures.

Connections between different mathematics subject areas. Teacher candidates came across examples of connections between required subjects in many MOOCs. For example, teacher candidates (who followed a MOOC that addressed probability) stated that the subject was successfully connected with sets, ratio, fractions, decimals, and percentages. In another course on the subject of fractions, it was mentioned that the subject's ratio-proportion and the issues related to operations in fractions were related to hcf-lcm issues. A MOOC on algebraic modeling is associated with geometry topics such as height and volume. In another MOOC, teacher candidates who followed the topic of decimal numbers stated that decimal numbers were related to the concepts of fractions and percentages. In the same course, it was stated that cyclic decimal numbers were explained in relation to algebra and equation issues. However, the teacher candidate made some criticisms by thinking that this would not be appropriate in terms of the subject ranking in the Ministry of National Education program. The statement of the teacher candidate is as follows:

> *"He used equality and equation when converting the cyclic decimal number into a fraction. According to the program in Turkey, equality and equation are the subject of the 7th grade. Okay, we introduce the cyclic decimal number in 6th grade and show how to convert the cyclic number to a fraction in the 7th grade, but algebra is again after the learning field of numbers and operations. A 7th grade middle school student in Turkey cannot make sense of the video of writing a cyclical decimal number in fraction format from Khan Academy" (P5)*

Connections between different representations. Teacher candidates (although the MOOC followed differed according to the subject of mathematics covered) stated that many different types of representation were used in relation to each other. For example, it was stated that tables and graphics were used in the "data" subject and that they were related appropriately. It was also stated that table representation was mostly used in a course involving problem solving, and in a course related to logical reasoning, propositions were shown with tables. Again, a teacher candidate noted that different representations were used for a probability course as follows.

> *"In the probability course I enrolled in, connections were made between representations. Representation by list, representation by table, representation by graph, verbal representation, representation by set model were used. (P28)"*

In another MOOC on numbers, the relationships of number sets were expressed on both the Venn diagram and the number line. In another course on fractions, it was stated that fractions were explained with semi-concrete models, for example, with the image of pizza, as well as the field model and the length model. Teacher candidates also expressed their views on the mathematical connection elements that they expected to be included in their reports but were not included in the MOOCs. For example, a teacher candidate expressed the expectation of connections with different representations in relation to a course on the subject of integer as follows:

> *"Instructor never explained why the sign changed when multiplying negative numbers and positive numbers in whole numbers, nor did he express it with any representation. He could use number stamps, he could use the number line model, he could use patterns. He didn't do any of it. (P1)"*

Connections between concepts and procedures. Participants noted that in most MOOCs, a conceptual expression is at the forefront, while processes and concepts are also related. In addition, it was observed that there were only a small number of courses that explained mathematical operations and procedures. For example, not only definitions of concepts such as experiment on probability and sample space were given, but also what these concepts were in the context of the question was explained. A MOOC with divisibility rules describes how to arrive at these rules, rather than giving them directly. In some courses, it was stated that instead of giving a uniform solution to a problem, different solutions to the problem were included. The observation of a teacher candidate for a MOOC involving operations in decimal numbers is given below:

> *"He explained that just as the sum of the ones digit and the ones digit are normally taken, here the tenth digit and the tenth, the one percent digit and the one percent are summed up, and he writes one below the other to easily distinguish the groups of digits and to add the ones directly on the same digit. In the decimal notation, which is memorized, numbers are written so that the commas are sublined one below the other, then added or subtracted conceptually explained the operational knowledge. (P5)"*

Connections with other disciplines

Participants encountered elements of connections with other disciplines in MOOCs less frequently than other types of mathematical connections. As can be seen in the examples, the course of integers was explained in relation to meteorology. In the algebra course, the conversion of Celsius and Fahrenheit units was used by connecting with science. A probability MOOC was connected with sports and included a probability question asked by a famous athlete. The participants who enrolled in this course stated that asking questions directly from the field by famous athletes was very effective in terms of both connecting with different disciplines and motivation. Examples of games of chance, sports, stock market and chemistry were also given in different probability courses. Participants generally stated that they found the mathematical associations with different disciplines insufficient.

Discussion

The aim of this study was to examine the MOOC experiences of the learners in the field of mathematics education and proposing reflections about design principles of MOOCs for mathematics education. In this respect, the MOOC experiences of 30 teacher candidates enrolled in MOOCs (with mathematic education context) were analyzed, and the course structure, pedagogical orientations and mathematical connection elements used in these MOOCs were examined. The data obtained from the participants revealed a comprehensive course evaluation structure including 7 categories and 85 codes under 3 themes and mathematical connection findings consisting of 3 categories and 3 subcategories. Before proceeding to the interpretation of the findings, it should be noted that each of the codes obtained from this study is actually a design proposal for MOOCs to be given in both a theoretical and practical field such as mathematics education. Therefore, the study findings can answer questions such as what can be considered when designing a MOOC in the field from the perspective of the participants studying in mathematics education, and how the mathematical connection elements can be integrated into the course. The issue of how online courses can be offered to learners in the most efficient way is one of the questions that are still sought to be answered, especially in a field like mathematics education.

Online learning refers to a complex process that requires a rigorous design process and detailed planning "aimed at creating an efficient learning ecosystem" (Bozkurt & Sharma, 2020). As mentioned earlier, there are a variety of evaluation studies and tools in the literature that offer design recommendations for online courses. The evaluation tools obtained as a result of these studies are generally used in the form of checklists or rubrics (Baldwin & Ching, 2019). The main code list obtained in this study presents 85 codes consisting of 3 themes and 7 categories, as well as evaluations under the theme of mathematical connection. However, there are few studies containing detailed propositions on MOOCs in the relevant literature (Drake et al., 2017; Wang et al., 2021).

The first theme is the structural features of the course videos used in MOOCs in which a total of 30 codes/propositions for video visual elements (13), audio elements (11) and video-lesson duration (5) were combined. Video visualizations are one of the most important elements of online courses and therefore MOOCs (Ou et al., 2019). The bond with learners is provided primarily through videos. However, more research is needed on instructional video design, which is supportive of learning (De

Koning et al., 2018; Hansch et al., 2015). Yousef and others (2014) analyzed effective MOOC environments according to learner and teacher opinions, and they determined 74 criteria under the categories of instructional design, assessment, user interface, video content, social tools and learning analytics. 14 of these criteria are related to the visual and audio elements of the lecture videos and the duration of the video. Unlike the ones in the current study, the criteria of Yousef and others (2014) had more general expressions. For example, the sound elements should be clear, the visual details should be appropriate to the level of the participants etc. There were no design recommendations/propositions in titles such as the personal appearance and movements of the video narrator, the background of the video and the distribution of the elements in the video on the screen, and the visual materials contained in the videos. The Canvas Course Evaluation Checklist (Baldwin & Ching, 2019) lists visual elements with the provision of color contrast and the use of fonts and titles. In the studies of Abeer and Miri (2014), where they evaluated MOOCs according to their learning views, presenting multimedia features, pictures, animations and simulations as part of the learning materials were considered important. Fiorella and Mayer (2018) have argued that breaking instructional videos into small pieces and making video narratives from different perspectives (first person-third person) improves learning outcomes, and that seeing the instructive face on the screen has no effect on learning outcomes. Clark & Mayer (2016) states that the use of different types of visuals is an important strategy of the multimedia principle. In this current study, especially striking codes/propositions such as background layout, interesting and various in-class visuals emerged, as well as seeing the teacher's face, personal appearance (dressing and smiling, etc.) were determined as desired situations by the participants. Videos with talking heads of professors are also known to be more engaging (Guo et al., 2014).

There is no detailed list of recommendations in the relevant literature on the use of audio elements in MOOCs. However, apart from the visual elements in videos, the use of audio elements is also an issue that needs to be elaborated on in video design. Of the studies that evaluated MOOCs in detail, only Yousef et al. (2014) referred to the use of sound elements in general terms ("sound should be clear"). The audio element is usually an element that can be evaluated holistically with the video design. This study provides detailed suggestions on how audio elements can be used in a MOOC video content.

In the study, video or total video durations in MOOCs were examined according to the opinions of the learners. Different studies have suggested that short-form videos in online classes and MOOCs are more engaging (0-3 min) and impressive, ideally less than 6 minutes (Guo et al., 2014). In this research, online mathematics field courses were examined and according to the participants, it was stated that 4–5-minute videos were insufficient in learning the course subject, whereas videos lasting more than 20 minutes could reduce the attention of the learner. In this research, it was concluded that the participants did not prefer the short form videos in courses such as mathematics education, but the videos could be created between 5-20 minutes. In addition, there are opinions that it may be appropriate to have a total course duration of more than 4 weeks in mathematics education MOOCs.

The second research problem examined the opinions of teacher candidates regarding the interaction-feedback characteristics in MOOCs. The majority of studies in the literature indicate that interaction, feedback, and collaboration are critical variables for online courses (Jaggars & Xu, 2016). Common assessment criteria in various online course evaluation studies include student feedback on the learning process, community building, presentation of instructor contact information, activities to ensure student-student interaction (discussion, project, etc.) and student-instructor interaction, and activities to encourage student-content interaction (engaging content, must-do content, etc.) (Baldwin, & Ching, 2019; Baldwin et al., 2018). In addition to interaction and collaboration between course stakeholders, social networking, interest groups, peer support (Guàrdia et., 2013), peer instruction (Hew, 2016), discussion forums (Coetzee et al., 2014), e-mail messages, and chat components (Abeer & Miri, 2014) are frequently referred to components in online courses and MOOCs that are thought to affect student success (Kellogg et al., 2014). In this study, findings supporting the relevant literature were reached. However, unlike the literature, participants considered the sub-video topic discussion areas and the personal introduction video upload areas as positive interactional components. These are simple but effective components that can support social interaction and peer learning, and moreover, engage individuals in lessons.

In the third research question, the opinions of teacher candidates on pedagogical approaches (measurement and evaluation, motivational strategies and elements, teaching methods and techniques) in MOOCs were analyzed. The relevant literature indicates that different measurement and evaluation methods can be used for MOOCs. These methods can be examined in 3 groups; quizzes (weekly, video-back, mid-term exams, final exams, and homework), peer-graded assignments (open-ended questions, final projects), and discussion forums, (graded according to the average of votes, posts, views) (Abeer & Miri, 2014). In Baldwin et al. (2018) study, 12 different online course evaluation tools were examined and it was determined that rubrics stand out as a common measurement tool in all assessment tools. However, in a similar study, it was revealed that self-evaluation is regarded as a common measurement approach in MOOCs (Baldwin & Ching, 2019). Peer feedback (Guàrdia et al., 2013, Yousef et al., 2014), determination of transparent grading criteria (Jaggars & Xu, 2016), use of low stakes (formative) and high stakes (summative) measurement activities (Johnson, 2019) are also frequently referred to measurement and evaluation principles. In the studies of Yousef et al. (2014), 14 different assessment and evaluation strategies were identified. Apart from some basic principles (providing diversity of question types, quiz-test submission, deadline for measurement, giving feedback in each measurement, etc.), codes/propositions such as putting quizzes after each task, providing tips in quizzes, providing quick feedback /correct answers of each quiz, suggestion of new questions by learners, and development of peer assessment module stood out as findings that support the findings of this study. As mentioned before, the findings of the current study, when evaluated together, indicate that simple measurement practices are included in MOOCs rather than evaluation, and that the timing of the measurement activity performed is crucial in the basic course design plan.

Online learning has a different pedagogy than face-to-face learning. Active learning and collaborative activities that participants can interact with are essential in ideal online learning (Baldwin & Ching, 2019). Again, there are various activities that stand out in different MOOC evaluation studies and are recommended to be performed since instructional design is the most important factor in MOOCs and is a sine qua non process for the quality of the course (Oh et al., 2020). In different course evaluation studies, some basic design principles have come to the forefront. Some of these include clearly stating course objectives, ensuring collaboration between participants, including mentoring activities, including activities that support self-regulation, giving understandable examples independent of culture (Yousef et al., 2014), providing problem-based activities (Hew, 2016), using instructor humor correctly (Baker & Taylor, 2012), and providing helpful and supportive course materials (Hew, 2016).

In addition, it is common for MOOCs to prefer plain narration using only PowerPoint presentations (Abeer & Miri, 2014). In general, when different national and international evaluation tools are examined, it is noticeable that detailed propositions are not presented regarding the teaching methods and techniques for the MOOCs. However, the findings obtained in this study offer clues that the course experience can be enriched by using various narration techniques in MOOCs. These tips may be seen as especially important for course contexts that also have an applied aspect, such as mathematics education. Holistic examination of the codes/propositions show that pedagogical actions are generally focused on enriching the narration and that the inclusion of problem-based activities in the course process is seen as positive. Continuing the subject by activating the previous information, capturing the mood of conversation, creating a discussion environment with expert interviews, demonstration, intensive visual use, and similarly the use of body language and transfer of experience or learning adventures are some of the educational suggestions that stand out in this study.

Motivational methods and strategies are a category that can be evaluated within the instructional design, but in this current study, participants drew a lot of attention to the use of these strategies. As a result of the analysis, this has led to the gathering of codes under a separate theme. Although this issue is considered quite important in the literature (Park & Yun, 2018), it has not been considered as a separate category in evaluation studies. This situation can be considered normal when motivational methods and strategies are accepted as part of the pedagogical design. Nevertheless, the 25 codes/propositions obtained in this study can be considered to be important MOOC design elements in areas such as mathematics education when the voice of the learners is heard.

The relevant literature states that mathematical connection skills are tried to be developed with various online methods (Rohendi, 2012; Ariyani et all, 2020). However, there have been no studies with reviews or recommendations for the design of a MOOC. The mathematical connection findings of the current study revealed that the use of different mathematical connection strategies in the courses varied according to the course planning. There are no studies in the relevant literature that can be compared with these study findings. However, holistic analysis of the findings of the current study shows that "connections with real life" was the most mentioned one among the mathematical connection strategies in MOOCs. The intensity of the connection codes encountered after this, is respectively, "connections between different mathematics subject areas", "connections between different representations", and "connections between concepts and procedures ", which are among the sub-dimensions of "connections with mathematics in itself". The least used connection strategy was "connections with other disciplines" and teacher candidates emphasized that the courses were inadequate in this regard. However, the participants noted that, contrary to this finding, it was highly motivating for the course to have a good connection strategy with other disciplines.

Various studies that have examined mathematical association skills found out that the participants' related connection skills were not at the desired level (Özgen, 2013; Yavuz Mumcu 2018; Rahmi et. all, 2020). Considering sub-dimensions of mathematical connection (although the dimensions in which better mathematical connection is done result differently in different researches), it is seen that, in general, the dimension of connecting mathematics in itself is not at the desired level, and the dimension of connecting it with different disciplines and daily life remains at low levels (Baki et all, 2009; Ozgen, 2013; Yavuz Mumcu 2018). Yavuz Mumcu (2018) stated that this difference may be related to the formal difference of the application/data collection processes of the researches. In relation to the MOOCs examined in this research, it was noticed that different mathematical connection elements were at the forefront in different courses. Therefore, in the development of mathematical association skills, it is thought that the development of these skills can be contributed to by a MOOC design in which the sub-elements of the connection skills are well planned.

It is thought that mathematical connections can be realized more intensively and easily, especially since MOOCs make it easier to integrate different technologies into the courses in a more practical way. These courses, which are carried out in the digital environment, have some potentials such as easy use of different virtual manipulations, easy inclusion of different visual models, and rapid creation of graphics on various topics. However, there have been criticisms that some courses do not use sufficient amounts and varieties of representations. This is related to the planning of the MOOC content and therefore to the instructional design. Based on all these points, it can be claimed that for a more qualified online mathematics course, the contents should be planned by considering which skills can be developed in what way as well as the information required to teach the mathematics subject addressed in the courses.

Conclusion and Suggestions

This qualitative research comes with interesting questions for online learning and mathematical education: How can MOOCs be redesigned for math education? Is mathematical connection used in MOOCs with mathematics education context, or how can it be used? The research results provide some clues that MOOC designs can be customized in mathematics-related courses differently from traditional evaluation criteria. While searching for these clues, the voices of mathematics education teacher candidates were listened to. The use of MOOCs in the field of teacher training has not yet become fully widespread, especially in mathematics education. From this point of view, it seems crucial to select teacher candidates as research participants and to obtain different perspectives.

According to the framework of Biglan's (1973) hard domains and soft domains, mathematics education is located somewhere in between. This is because although mathematics education seems to be under social sciences-educational sciences, it can also include pure mathematics subjects. Accordingly, the content, instructional and measurement differences between different disciplines, described by Neumann et al. (2002) in their Biglan (1973) taxonomy, should be regarded as normal to appear in MOOCs. In this context, it is also natural that there are differences in mathematics education, which can be considered as an intermediate discipline (especially when online pedagogy is considered). The results of this research reflect a pedagogical perspective that includes a mixture of both "teaching and learning activities being focused and instructive" and "teaching and learning activities largely constructive and interpretative" (Neumann et al., 2002) approaches in parallel with the characteristics of hard and pure domains.

In addition, it is obvious that not all of the 85 design propositions obtained in the study can be used in a single MOOC. In this context, it can be assumed that the more of the obtained design propositions (specific to the relevant themes) are used, the more it can affect the efficiency of the course. Of course, MOOC designs are highly influenced by domain-specific practices and contents, but it can also be considered that design proposals shaped by learner opinions can make a significant contribution to MOOC designs in line with the suggestion of Zhu and others (2018).

An important part of the pedagogical design of MOOC is the design of course videos. However, there is no one-size-fits-all method of making a learning video (Hansch et al., 2015). One of the significant findings of this research is that it presents various findings regarding video designs in MOOCs with a mathematics education context. MOOC pedagogical designs can be redesigned to meet changing learning needs by being shaped according to participant and expert opinions as a field dependent approach. In this sense, it can be thought that this study, which evaluates the voices of the participants, can support MOOC design decisions. It should be noted that MOOC design and planning is a critical development process that can affect course quality, and quality can affect learner engagement, understanding, and retention (Drake et al., 2017; Yang et al. 2017).

In MOOCs with a mathematics education context, mathematical connection is a design component that can improve understanding in the course, and thus be important on the learning outcomes of the course. However, the results of this research provide data that while mathematical connections can be used extensively in MOOCs, it is not used properly. Although it is not traced in the literature, it can be assessed that this deficiency may be a significant variable in the design of MOOCs with a mathematical context. Therefore, opening a separate parenthesis in MOOC designs to the subject of mathematical connection strategies may become an essential design action for these courses in the future.

One of the important limitations of this study is that only participatory opinions were used when obtaining the design codes/propositions. As mentioned earlier, there are different national/international tools to evaluate the designs of MOOCs. While some of these tools have been created by experts, some of them listen to the voice of the learners. Therefore, in future studies, especially in field-dependent MOOCs, the joint work of learners, instructors and online experts, as well as various empirical researches specific to the field, will pave the way for the development of effective, efficient and widespread MOOCs.

References

Abeer, W., & Miri, B. (2014). Students' preferences and views about learning in a MOOC. *Procedia-Social and Behavioral Sciences*, *152*, 318-323. https://doi.org/10.1016/j.sbspro.2014.09.203

Aldon, G., Arzarello, F., Panero, M., Robutti, O., Taranto, E., & Trgalová, J. (2019). MOOCs for mathematics teacher education to foster professional development: design principles and assessment. In *Technology in Mathematics Teaching* (pp. 223-246). Springer, Cham. https://doi.org/10.1007/978-3-030-19741-4_10

Ariyani, W., Suyitno, H., & Junaedi, I. (2020). Mathematical connection ability and students' independence in Missouri Mathematics Project E-Learning. *Unnes Journal of Mathematics Education Research, 9*(2), 185–189.

Baker, C. & Taylor, S. L. (2012). The importance of teaching presence in an online course. *Online student engagement tools and strategies*. Faculty Focus Special Report (pp. 6–8). Magna Publication.

Baldwin, S. & Ching, Y.-H. (2019). Online Course Design: A Review of the Canvas Course Evaluation Checklist. *International Review of Research in Open and Distributed Learning*, *20*(3). https://doi.org/10.19173/irrodl.v20i3.4283

Baldwin, S., Ching, Y. H., & Hsu, Y. C. (2018). Online course design in higher education: A review of national and statewide evaluation instruments. *TechTrends*, *62*(3), 46-57. https://doi.org/10.1007/s11528-017-0215-z

Baki, A., Çatlıoğlu, H., Coştu, S., & Birgin, O. (2009). Conceptions of high school students about mathematical connections to the real-life. *Procedia-Social and Behavioral Sciences*, *1*(1), 1402-1407. https://doi.org/10.1016/j.sbspro.2009.01.247

Biglan, A. (1973). The characteristics of subject matter in different academic areas. *Journal of applied Psychology*, *57*(3), 195-203. https://doi.org/10.1037/h0034701

Blackboard. (2017). Blackboard exemplary course program rubric. https://community.blackboard.com/docs/DOC-3505-blackboard-exemplary-course-programrubric

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Sánchez-Aguilar, M. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM Mathematics Education, 48*, 589–610. https://doi.org/10.1007/s11858-016-0798-4

Bozkurt, A. (2021). Surfing on Three Waves of MOOCs: An Examination and Snapshot of Research in Massive Open Online Courses. *Open Praxis, 13*(3), pp. 296–311. https://doi.org/10.5944/openpraxis.13.3.132

Bozkurt, A., Akgun-Ozbek, E., Yilmazel, S., Erdogdu, E., Ucar, H., Guler, E., ... & Aydin, C. H. (2015). Trends in distance education research: A content analysis of journals 2009-2013. *International Review of Research in Open and Distributed Learning*, *16*(1), 330-363. https://doi.org/10.19173/irrodl.v16i1.1953

Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to CoronaVirus pandemic. *Asian journal of distance education*, *15*(1), i-vi. https://doi.org/10.5281/zenodo.3778083

Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. John Wiley & Sons.

Coetzee, D., Fox, A., Hearst, M. A. & Hartmann, B. (2014). Should your MOOC forum use a reputation system. In *Proc. CSCW 2014* (pp. 1176–1187). New York: ACM Press. https://doi.org/10.1145/2531602.2531657

Drake, J. R., O'Hara, M., Seeman, E. (2015). Five principles for MOOC design: With a case study. *Journal of Information Technology Education: Innovations in Practice, 14,* 125-143. http://www.jite.org/documents/Vol14/JITEv14IIPp125-143Drake0888.pdf

De Koning, B. B., Hoogerheide, V., & Boucheix, J. M. (2018). Developments and trends in learning with instructional video. *Computers in Human Behavior, 89*, 395–398. https://doi.org/10.1016/j.chb.2018.08.055

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020). Transformation of the mathematics classroom with the internet. *Zdm*, *52*(5), 825-841. https://doi.org/10.1007/s11858-020-01176-4

Fiorella, L., & Mayer, R. E. (2018). What works and what doesn't work with instructional video. *Computers in Human Behavior*, *89*, 465–470. https://doi.org/10.1016/j.chb.2018.07.015

Glesne, C. (2016). *Becoming qualitative researchers: An introduction*. Pearson. One Lake Street, Upper Saddle River, New Jersey 07458.

Gonda, D., Ďuriš, V., Pavlovičová, G., & Tirpáková, A. (2020). Analysis of factors influencing students' access to mathematics education in the form of MOOC. *Mathematics*, *8*(8), 1229. https://doi.org/10.3390/math8081229

Guàrdia, L., Maina, M., & Sangrà, A. (2013). MOOC design principles: A pedagogical approach from the learner's perspective. *Elearning papers*, (33). https://openaccess.uoc.edu/webapps/o2/bitstream/10609/41681/1/In-depth_33_4%282%29.pdf

Guo, P.J., Kim, J., & Rubin, R. (2014). "How video production affects student engagement: an empirical study of MOOC videos," Proceedings of the first ACM conference on Learning @ scale conference, 2014. [Online]. http://dl.acm.org/ft_gateway.cfm?id=2566239&ftid=1434762&dwn=1&CFID=323292369&CFTOKEN=64850224

Hamann, K., Glazier, R. A., Wilson, B. M., & Pollock, P. H. (2021). Online teaching, student success, and retention in political science courses. *European Political Science*, *20*(3), 427-439. https://doi.org/10.1057/s41304-020-00282-x

Hansch, A., Hillers, L., McConachie, K., Newman, Ch., Schildhauer, T. & Schmidt, P. (2015). Video and online learning: Critical reflections from the field. Alexander von Humboldt Institute for Internet & Society. Discussion Paper Series, 13. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2577882

Hard, H., Wahyudi, W., Suyitno, H., Kartono, K., & Sukestiyarno, Y. L. (2022). The mathematic connection ability of pre-service teacher during online learning according to their learning style. *JOTSE*, *12*(1), 230-243. https://doi.org/10.3926/jotse.1198

Hew, K. F. (2016). Promoting engagement in online courses: What strategies can we learn from three highly rated MOOCS. *British Journal of Educational Technology*, *47*(2), 320-341. https://doi.org/10.1111/bjet.12235

Hodges, C., Lowenthal, P. & Grant, M. (2016). Teacher Professional Development in the Digital Age: Design Considerations for MOOCs for Teachers. In G. Chamblee & L. Langub (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2075-2081). Savannah, GA, United States: Association for the Advancement of Computing in Education (AACE). Retrieved July 1, 2022 from https://www.learntechlib.org/primary/p/171978/.

Jaggars, S. S., & Xu, D. (2016). How do online course design features influence student performance?. *Computers & Education*, *95*, 270-284. https://doi.org/10.1016/j.compedu.2016.01.014

Johnson, D. (2019). Course Evaluation Checklist v2.0. https://community.canvaslms.com/t5/Canvas-Instructional-Designer/Course-Evaluation-Checklist-v2-0/ba-p/280349

Kellogg, S., Booth, S., & Oliver, K. (2014). A social network perspective on peer supported learning in MOOCs for educators. *The International Review of Research in Open and Distributed Learning, 15*(5), 263–289. https://doi.org/10.19173/irrodl.v15i5.1852

Kenedi, A. K., Helsa, Y., Ariani, Y., Zainil, M., & Hendri, S. (2019). Mathematical Connection of Elementary School Students to Solve Mathematical Problems. *Journal on Mathematics Education*, *10*(1), 69-80. https://doi.org/10.22342/jme.10.1.5416.69-80

Mayring, P. (2000) 'Qualitative Content Analysis'. *Forum Qualitative Sozialforschung, 1*(2), pp. 1–10. doi:10.1007/978-3-658-21308-4_42

MoNE (2018). Mathematics education programs for primary and middle school grades 1-8. Turkish Head Council of Education and Morality, Ankara.

Mousley, J. (2004). An aspect of mathematical understanding: the notion of "connected knowing". In *PME 2004: Proceedings of the 28th conference of the International Group for the Psychology of Mathematics Education* (pp. 377-384). Bergen University College. https://files.eric.ed.gov/fulltext/ED489595.pdf

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and Standards for School Mathematics*. Reston, Va.: NCTM.

Neumann, R., Parry, S., & Becher, T. (2002). Teaching and learning in their disciplinary contexts: A conceptual analysis. *Studies in higher education*, *27*(4), 405-417. https://doi.org/10.1080/0307507022000011525

Oh, E. G., Chang, Y., & Park, S. W. (2020). Design review of MOOCs: Application of e-learning design principles. *Journal of Computing in Higher Education*, *32*(3), 455-475. https://doi.org/10.1007/s12528-019-09243-w

Ou, C., Joyner, D.A., & Goel, A.K. (2019). Designing and developing video lessons for online learning: A seven-principle model. *Online Learning, 23*(2), 82-104. http://dx.doi.org/10.24059/olj.v23i2.1449

Özgen, K. (2013). Mathematical connection skill in the context of problem solving: the case of pre-servıce teachers. *Education Sciences*, *8*(3), 323-345. http://dx.doi.org/10.12739/NWSA.2013.8.3.1C0590

Özgen, K. (2016). A theoretical study on the mathematical connection. In W. Wu, M. T. Hebebci, & O. T. Öztürk (Eds.), *International Conference on Research in Education and Science* (pp. 220–230). Bodrum: ICRES Publishing.

Park, S., & Yun, H. (2018). The influence of motivational regulation strategies on online students' behavioral, emotional, and cognitive engagement. *American Journal of Distance Education*, *32*(1), 43-56. https://doi.org/10.1080/08923647.2018.1412738

Patton, M. Q. (2015). *Qualitative research and evaluation methods.* (4th Ed.). Thousand Oaks: Sage Publications, Inc.

Rahmi, M., Usman, & Subianto, M. (2020). First-grade junior high school students' mathematical connection ability. *Journal of Physics: Conference Series, 1460*(1). https://doi.org/10.1088/1742-6596/1460/1/012003

Rohendi, D. (2012). Developing e-learning based on animation content for improving mathematical connection abilities in high school students. *International Journal of Computer Science Issues (IJCSI), 9*(4), 1.

Quality Matters. (2018). Specific review standards from the QM higher education rubric, sixth edition. https://www.qualitymatters.org/sites/default/files/PDFs/StandardsfromtheQMHigherEducationRubric.pdf

Ralston-Berg, P. (2011). What makes a quality online course? Paper presented at the 3rd Annual Quality Matters Conference, Baltimore, MD.

Sezgin, S. (2018). Analysing adaptive gamification design principles for online courses [Unpublished doctoral thesis]. Anadolu University.

Shah, D. (2021). By The Numbers: MOOCs in 2021. https://www.classcentral.com/report/mooc-stats-2021/

Siemens, G. (2013). Peer review of a framework for MOOCs. Momentum.edthemes.org. *Introduction to the MOOCJam*. http://momentum.edthemes.org/about-mooc-jam/

Smith, G. G., & Ferguson, D. (2004). Diagrams and math notation in e-learning: growing pains of a new generation. *International Journal of Mathematical Education in Science and Technology*, *35*(5), 681-695. https://doi.org/10.1080/0020739042000232583

Smith, G. G., Heindel, A. J., & Torres-Ayala, A. T. (2008). E-learning commodity or community: Disciplinary differences between online courses. *The Internet and Higher Education, 11*(3-4), 152-159. https://doi.org/10.1016/j.iheduc.2008.06.008

Stake, R. E. (2005). *Qualitative case studies. In Y. S. Lincoln & N. K. Denzin (Eds.), The handbook of qualitative research (3rd ed., pp. 443-466).* Thousand Oaks, CA: Sage

Taranto, E. (2018). *MOOC's Zone theory: Creating a MOOC environment for professional learning in mathematics teaching education*. Doctoral thesis. Turin University.

Wang, X., Lee, Y., Lin, L., Mi, Y., & Yang, T. (2021). Analyzing instructional design quality and students' reviews of 18 courses out of the Class Central Top 20 MOOCs through systematic and sentiment analyses. *The Internet and Higher Education*, *50*, 100810. https://doi.org/10.1016/j.iheduc.2021.100810

Yang, M., Shao, Z., Liu, Q., & Liu, C. (2017). Understanding the quality factors that influence the continuance intention of students toward participation in MOOCs. *Educational Technology Research and Development*, *65*(5), 1195-1214. https://doi.org/10.1007/s11423-017-9513-6

Yavuz Mumcu, H. (2018). Matematiksel ilişkilendirme becerisinin kuramsal boyutta incelenmesi: Türev kavramı örneği. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *9*(2), 211-248 . https://doi.org/10.16949/turkbilmat.379891

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: SAGE Publications. https://doi.org/10.33524/cjar.v14i1.73

Yousef, A. M. F., Chatti, M. A., Schroeder, U., & Wosnitza, M. (2014, July). What drives a successful MOOC? An empirical examination of criteria to assure design quality of MOOCs. In *2014 IEEE 14th International Conference on Advanced Learning Technologies* (pp. 44-48). IEEE. https://doi.org/10.1109/ICALT.2014.23

Yuan, L., & Powell, S. (2013). MOOCs and disruptive innovation: Implications for higher education. *eLearning Papers, In-depth*, *33*(2), 1-7.

Zhu, M., Sari, A., & Lee, M. M. (2018). A systematic review of research methods and topics of the empirical MOOC literature (2014–2016). *The Internet and Higher Education*, *37*, 31-39.

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Katibe Gizem Yığ: Conceptualization, Formal Analysis, Methodology, Resources, Writing – original draft, Writing – review & editing

Acknowledgements

Not applicable.

Funding

Not applicable.

Ethics Statement

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants for being included in the study. Ethical approval for the study was obtained from the ethics committee of Burdur Mehmet Akif Ersoy University.

Conflict of Interest

The authors do not declare any conflict of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Suggested citation:
Yığ, K. G. (2022). Design considerations for MOOCs with mathematics education context: Let's listen to the voice of learners. *Asian Journal of Distance Education, 17*(2), 66-88.
https://doi.org/10.5281/zenodo.7013343