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Implementing an online course in the MOOC environment with a focus on science and mathematics education

Julia Kazakova[1], Elena Shastina[2], Ilzira Gibadulina[3]
[1]Department of English Philology and Cross-Cultural Communications, Kazan Federal University, Yelabuga, Russia
[2]Department of German Philology, Kazan Federal University, Yelabuga, Russia
[3]Department of Biology and Chemistry, Kazan Federal University, Yelabuga, Russia

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ABSTRACT

The study focused on the development and evaluation of an online course in the massive open online courses (MOOC) environment, specifically targeting science and mathematics education. The goal was to utilize pedagogical design principles, particularly those derived from the analysis, design, development, implementation, and evaluation (ADDIE) model, to create an effective learning experience for students in different years of study. The online course was hosted on the edX platform, which is a popular platform for MOOCs. The assessment of the online course covered various criteria: interface, interaction, and design. The criteria of interface, interaction, and design received high marks from students of the two groups. The study found that the participants were highly engaged during the training, which is a positive outcome. The analysis of interest in online learning among first- and fourth-year students shows that first-year students had an average level of interest in online learning of 4.50 with a standard deviation of 0.32. Fourth-year students had an average level of interest of 4.45 with a slightly larger standard deviation of 0.41. Student engagement is an important factor in effective learning, as it reflects their active involvement and motivation in the learning process.

Corresponding Author:

Julia Kazakova
Department of English Philology and Cross-Cultural Communications, Kazan Federal University
Kazanskaya Str., 89, Yelabuga 423600, Russia
Email: kazakova696@gmail.com

1. INTRODUCTION

Initially, massive open online courses (MOOCs) provided open access to all participants; this was their core concept [1]. Although the advantages of these benefits are extensively expounded, an increasing volume of criticism has emerged, primarily centered around the aspects of providing feedback and assessing students [2]. MOOCs have indeed gained significant attention as a learning approach in higher education, leveraging new technologies to make education more accessible. One of the key advantages of MOOCs is their availability through the internet, allowing learners to access a wide range of courses conveniently. The fact that most MOOCs are offered for free further enhances their accessibility and removes financial barriers that may limit participation. To enroll in a MOOC, learners typically only need access to the internet and an email address to register for the course [3]. Platforms such as Udacity, edX, and Coursera have gained significant popularity as leading providers of MOOCs. One of the primary reasons why MOOCs have become a popular choice among students is the low cost associated with these courses. Unlike traditional educational programs, MOOCs often offer free registration and participation, allowing learners to access high-quality educational content without the financial burden of tuition fees [4].

Numerous studies have indeed focused on the challenges students face in learning science and mathematics disciplines. One study highlighted the persistent issue of students' low ability to solve problems effectively, specifically in terms of translating and interpreting abstract concepts into tangible forms such as language, tables, graphs, and mathematical symbols accompanied by numerical representations. This finding suggests that students encounter difficulties when it comes to applying their mathematical skills to practical problem-solving scenarios [5]. Managing students' learning environments involves shifting the focus from traditional teaching styles to understanding and addressing students' learning behaviors. Recognizing the importance of this shift, instructors are encouraged to adopt new methods and approaches that foster active engagement and promote higher-level thinking skills among students. MOOCs have emerged as a promising tool in this regard. Aparicio *et al.* [6] highlights the potential of MOOCs in promoting higher-level thinking skills among students. The problems with MOOCs are high dropout rates (approximately 95%), difficulty in conducting student assessments, and the provision of feedback by an instructor [7]. The study of the quality of educational service delivery in MOOCs requires proper attention. When developing and implementing MOOCs, certain criteria need to be taken into account. Effective MOOCs are characterized by quality learning analytics and an independent evaluation procedure for participants [8].

2. LITERATURE REVIEW

Numerous researchers have explored the subject of MOOC development; however, a definitive technological and pedagogical definition for designing a high-quality course environment remains elusive [9]. There are two main approaches in online courses: the connectivist one is based on the principles of innovative technologies in pedagogy within the framework of a social learning regimen with a well-developed internet network and database. In turn, the institution-centric (xMOOC) focus is on the organization of the learning process with social contacts, video lectures, and automated assessment [10]. This classification is fixed in a binary system. This system offers a rather primitive shorthand for describing the origins of MOOCs and pedagogy. The connectivist approach was originally introduced at the beginning of the use of courses available to the masses. Its purpose is to examine the principles of "connectivism" and provide an interpretation of the learning process in environments characterized by extensive networks [11]. The first connectivist MOOCs (cMOOCs) were designed to stimulate unifying processes, forming and exchanging information among groups that were divided and trained online. Courses like cMOOCs are structured in such a way as to be able to provide central control, and also, to develop the capacity of participants to contribute to digital technologies. Probably, the "mass character" of these areas is more related to the possibility of quantitative connections, the organization of the content, and the activity of students in these programs than to the number of participants [12].

The term xMOOC is a modern course classification framework offered on platforms such as edX and Coursera [13]. The main advantage of using this approach is that it is scalable, and can meet the educational needs of many people. For example, one MOOC had 226,652 students [14]. This possibility is important for large MOOCs, whose main purpose is to provide global access to education. The cMOOC/xMOOC binary concept provides a useful framework for understanding the different development trajectories and philosophies behind two distinct types of MOOCs: cMOOCs and extended MOOCs (xMOOCs). The new literature is increasingly moving away from a simplified version of categorization and is moving towards a discussion of the practical use of online courses and empowerment for learners [15], [16]. Oversimplified categorization of MOOCs can lead to distortions and limitations in understanding their dynamics and potential. MOOCs are complex and multifaceted learning environments that can vary in terms of pedagogical approaches, learner interactions, and the role of instructors. Watson *et al.* [17] highlight the potential drawbacks of oversimplification in categorizing MOOCs. Rieber [18] points out the need for more research to explore the institutional factors, opportunities, and challenges associated with MOOC implementation.

In MOOCs, the role traditionally attributed to a teacher is largely assumed by a set of automated procedures encompassing diverse automatically evaluated assessments and message detection algorithms. The notion of minimal participation in MOOCs refers to the limited opportunities for active engagement and interaction within the learning environment [19]. This perspective is supported by cMOOC theorists, who emphasize the importance of learner autonomy, self-directed learning, and networked connections in MOOCs [20]. They argue that the pedagogy of MOOCs is not solely encapsulated in the platform itself but rather emerges from the connections and interactions among learners, resources, and networks [20]. The Coursera website presents detailed descriptions of the pedagogical foundations, often without presenting the differences between course design and platform design. For example, Coursera's design often uses a variety of interactive exercises [21]. Certain studies have raised critiques regarding the notion of minimal teacher participation, arguing that the social presence of an instructor holds significance in attaining favorable learning outcomes attributable to the intricacies of students' cognitive engagement [22].

The role of a teacher in MOOCs has received relatively little attention in comparison to the extensive focus on learner perspectives and experiences [23], [24]. This challenge arises due to the diversity of participants in each specific MOOC, who are actively involved in various activities. Thus, the present practice must include nuance, strategy, and dynamics [25]. For educators of different institutions, and scholars, this is a problem, as they are used to apply "ending" as a boundary of stability for the success of educational offerings. It is misleading and inaccurate to rely solely on formal completion rates as a measure of the quality of MOOCs or the experience of test takers. These rates are typically below 10% and do not provide a comprehensive picture of engagement and learning outcomes.

In free courses, the selection barrier for participants is low, so a sufficient number of people enroll and do not complete the course. For fee-paying institutions, this practice is quite unusual. Because the behaviors and intentions of course participants are very different from one another, new measures of success and quality of learning need to be applied [26], [27]. Discussion forums in MOOCs serve as an indicator to assess the level of engagement and success within the courses. However, the use of forums can significantly vary depending on the specific context of each MOOC. Such factors as course topic, instructor facilitation, participant demographics, and cultural differences can influence the level of activity and effectiveness of forums as a learning tool. Therefore, it is necessary to consider the specific context and characteristics of each MOOC when interpreting the significance of participation in discussion forums as an indicator of engagement and success. When MOOCs are supplementary materials for traditional classroom courses, students may interact less frequently or completely refrain from participating in these discussion forums. This could be attributed to the fact that their participation in the MOOC is not a requirement for their enrollment in the face-to-face course. Davis *et al.* [28] highlights this phenomenon and suggests that the availability of MOOCs as optional resources in face-to-face courses may impact students' motivation and engagement in utilizing the forums.

Most MOOC platforms produce large amounts of data that denote complex models of participation in MOOCs. It is imperative to conduct a comprehensive exploration, analysis, and discourse on these models while also considering their visualization [29]. the field of learning analytics is still relatively new, and its full potential and impact on teaching and learning are still being explored. Learning analytics involves the collection, analysis, and interpretation of learner data to gain insights into learning processes and outcomes. It aims to inform instructional decisions, improve educational practices, and enhance the learning experience. These ideas are relevant in completely different learning contexts. Learning analytics is promising for MOOC research and development because critical questions need to be asked [30].

The main purpose of this research is to develop and implement an online course in the MOOC environment. In particular, the course should focus on natural science and mathematics education for first- and fourth-year students. Thus, the research objectives of the study were: i) develop and implement an online course in natural sciences and mathematics education; ii) evaluate the use of the online course by conducting surveys among first- and fourth-year students; and iii) assess the activity level in studying the online module by students of two different academic years.

3. METHOD

3.1. Study participants

For the study, a total of 60 students from Kazan Federal University were selected as participants. Half of the students (30 people) studied in the first year; another 30 studied in the fourth. The participants had an average age of 21 years, indicating that they were in the early stages of their higher education journey. The online course developed as part of the study was conducted over a period of six months.

3.2. Research instruments

The utilization of the analysis, design, development, implementation, and evaluation (ADDIE) model in research demonstrates a systematic approach to instructional design and development. The ADDIE model is widely recognized as a systematic instructional design system that facilitates a structured process for creating an effective learning experience. In this study, the ADDIE model was utilized as a framework, comprising five distinct phases: analysis, design, development, implementation, and evaluation.

During the analysis phase of the study, the necessary data was collected to understand the context, goals, and objectives of the project. This information helps to shape the subsequent design phase. The design phase encompassed several essential steps that determined the groundwork for developing module content. These steps include the initial setup, checklist creation, defining deliverables (such as course objectives and learning outcomes), storyboarding, determining content layout, and designing the module's appearance.

During the development phase of the study, the module content was created and prepared for implementation. Thus, a total of seven videos were uploaded to the open learning platform, and each of the

videos corresponded to a specific chapter of the module and course. The videos were designed to present the content in an engaging and visually appealing manner. In terms of visual design, different color schemes and bright backgrounds were used to make the fonts and animations stand out. This choice of design elements helps to capture the learners' attention and maintain their interest throughout the videos. The animated videos for each chapter were kept relatively short, around 5 minutes in duration. This duration is often considered effective for online learning as it allows for concise and focused content delivery, keeping the learners' attention and preventing information overload. To enhance the learning experience, the videos were accompanied by sound. The audio component adds an auditory dimension to the visual presentation, making the content more dynamic and engaging. The development stage was followed by the innovative module that implied placing the content on the edX platform as an online course. This platform provided a suitable environment for delivering the course content and facilitating student participation.

During the implementation stage, the materials and resources created in the previous phases were made accessible to the intended group of students. This allowed the developers to test the functionality, validity, and reliability of the materials within the online course. To evaluate the effectiveness and user experience of online courses, the study used a questionnaire filled out by 60 students. These students have already completed the online course. The questionnaire covered five categories: interface, interaction, design, benefit, and value of information. Each category aimed to gather feedback and insights from the students regarding their experience with the course. A Likert-type scale was utilized in the questionnaire, which is a commonly used survey rating scale. It allows respondents to indicate their level of agreement or disagreement with a series of statements or criteria related to the different aspects of the course. By using this scale, the developers could gather quantitative data and measure the students' perceptions and satisfaction with the various elements of the online course.

3.3. Statistical analysis

To ensure the reliability of the questionnaire used in the study, the researchers calculated the Pearson correlation coefficient. The obtained value of 0.83 indicates a high level of correlation among the questionnaire items, suggesting that the questionnaire is consistent and reliable for measuring the intended constructs. The use of a statistical package for the social sciences (SPSS) version 25.0 for data analysis adds to the rigor and objectivity of the study.

It is important to acknowledge the limitations of the study. The relatively short duration of the study may have restricted the depth and breadth of the findings, potentially limiting the understanding of the long-term impact of the online course. Additionally, the low sample size might affect the generalizability of the results to a larger population. Imperfections in the ADDIE model, which served as the basis for course development, could have influenced the effectiveness of the online course. The researchers might consider addressing these imperfections in future iterations of the course.

4. RESULTS

The evaluation of the online course involved the assessment of five categories: interface usability, interactivity, design, usefulness, and information importance. These categories aimed to provide a comprehensive understanding of the online course's effectiveness and user satisfaction. The specific evaluation criteria and corresponding results are presented in Table 1 to Table 3: interface (Table 1), interaction (Table 2), and design (Table 3).

In general, the participants positively assessed the course interface, which received high scores for all features. Students especially appreciated the functionality of the options button, rating it as the highest with a score of 4.35 (from first-year students) and 4.38 points (from fourth-year students). This indicates that the option button was well-received and considered useful by the students. The positive feedback regarding the course interface suggests that it was user-friendly, intuitive, and provided a satisfying user experience. The high ratings reflect the successful design and implementation of the interface, meeting the expectations and needs of the students.

Table 1. Evaluating interface usability

No.	Item	1st-year students (n=30) Mean	4th-year students (n=30) Mean
1	The content of the short notes and videos is easy to understand	4.20	4.18
2	Easier access to the module with the navigation menu	4.21	4.20
3	The options in the navigation menu are clear	4.24	4.26
4	Option button is functional	4.35	4.38
5	This application is easy to manage and access	4.33	4.31
	Total	4.26	4.26

Table 2. Evaluating interactivity

No.	Item	1st-year students (n=30) Mean	4th-year students (n=30) Mean
1	The app element is very interactive in terms of videos and notes	4.39	4.37
2	The online module created is interesting for you	4.18	4.15
3	The amount of multimedia in each topic is sufficient	4.34	4.32
4	Everyone can interact with each other on this module page, such as sharing information and their point of view	4.44	4.40
5	A student can get an immediate result of a test paper or lesson	4.25	4.27
	Total	4.32	4.30

Students of the two groups evaluated the online course as highly interactive, indicating its effective engagement in their learning process. This suggests that the course incorporated interactive elements, such as various color schemes and vibrant backgrounds to enhance font and animation visibility, as well as animated video clips that contributed to student participation and involvement. The elevated rating in this category reflects the positive perception among students regarding the course's interactivity and its ability to sustain their engagement in the learning process.

Furthermore, the students expressed a high level of interest in the online module, rating it with a score of 4.18 and 4.15. This indicates that the course content and activities captured their attention and sparked their curiosity. The positive evaluations of interactivity and interest indicate that the online course successfully employed interactive elements and engaging content, contributing to a positive learning experience for the students.

Table 3. Design evaluation

No.	Item	1st-year students (n=30) Mean	4th-year students (n=30) Mean
1	The font size is easy to read	4.46	4.31
2	The image quality is clear	4.15	4.21
3	Sound quality is clear and audible	4.31	4.39
4	Each video can be conveniently accessed and viewed	4.02	4.00
5	Video animation is attractive	4.30	4.15
	Total	4.25	4.21

The course design plays a crucial role in creating a visually appealing and user-friendly learning environment. According to the feedback from the first-year students, they were particularly attracted to the size of the font used in the online course, which received a high rating – 4.46. This suggests that the font size was appropriately chosen and contributed to easy readability, enhancing the overall learning experience for the students. For fourth-year students, the sound quality was important: they rated it with 4.39 points. However, there were some issues reported regarding access to videos, resulting in a lower score for this aspect from both groups of students (4.02 and 4.00, respectively). Difficulties in accessing videos can hinder the student's ability to fully engage with the multimedia content and may have caused some frustration or inconvenience.

Table 4 demonstrates the interest in online learning among students in two different years of study. The data show that first-year students had an average interest in online learning of 4.50 with a standard deviation of 0.32. The average interest of fourth-year students was 4.45 with a slightly larger standard deviation of 0.41. A value of $p<0.05$ indicates that differences in interest between first- and fourth-year students are statistically significant at a significance level of 0.05. Thus, the results suggest a slight difference in interest in online learning among first- and fourth-year students. Statistical differences between groups of students were also confirmed.

Table 4. The interest in online learning of students (first and fourth year of study)

Year of study	The interest in online learning	
	M	SD
1st year students (30 people)	4.50	0.32
4th year students (30 people)	4.45	0.41

Note: $p<0.05$

The lower rating for the video-related item could potentially be attributed to issues with the internet connection at the university, as mentioned in the study. Unstable and limited internet connectivity could have impacted students' ability to access and view the videos effectively, leading to lower satisfaction in this

aspect. The findings highlight the importance of addressing technical challenges, such as internet connectivity, to enhance the overall learning experience of students in online courses. By improving the stability and accessibility of resources, such as videos, universities can better support students' engagement and comprehension of course materials.

5. DISCUSSION

The study by Hamid *et al.* [31] focused on investigating student perceptions of an electronic content module developed using the ADDIE manual development model for a MOOC. The researchers administered a questionnaire to 129 students to gather their feedback on the module's content, usability, design, and effectiveness. The findings of Hamid *et al.* [31] align with the results of the present study, as both studies reported high mean scores in the assessed dimensions. This indicates that students in both studies perceived the module positively across various aspects. The similarity in results suggests that the design and development approaches employed, such as utilizing the ADDIE model, were effective in creating online course modules that resonated well with students. The authors propose to use this module of digital content in the form of a MOOC as an informative online resource for all individuals involved in education. It applies to natural sciences and mathematics within higher education institutions [32].

An evaluation of open online courses by English scientists in collaboration with the health iQ scientific programs was carried out [33]. The article analyzes and studies the results of students' behavior during the organizational learning process using open online courses. According to the studied findings, the courses successfully attracted their intended audience, and students perceived their use and methods of engagement to be effective. These findings align with the results of the present study. The study participants gave their evaluation of the MOOC training: for them, it was useful, with further potential for use in their work. Before and after using MOOCs, networking, as an education technology, needs to be improved and developed in the future to modernize learning processes. The findings of this evaluation align with the existing evidence that MOOCs have the potential to enhance skills-based learning and knowledge acquisition. The positive outcomes observed in the study suggest that participants in the MOOC demonstrated improvements in their learning outcomes and acquired new skills.

The study by Rehfeldt *et al.* [34] identified various factors that influence student engagement in MOOCs. Understanding these factors is crucial for designing and implementing effective MOOCs that promote student engagement and learning outcomes. Some of the key factors identified in the study are as: these are access to videos, opportunities for self-assessment, and contact and communication between students. Knowledge can be applied with the right organization and all the necessary resources for the educational process. For ongoing professional development, MOOCs must consider work-related barriers. The authors of this study did not identify such factors; however, they fully concur with the conclusions drawn in this research, as effective support and communication among students are essential for organizing a comfortable and productive learning environment.

The iMOOC model developed at the Portuguese University of Distance Education is an interesting hybrid approach that combines elements from existing MOOCs with additional features to better integrate into the institutional pedagogical culture. The integration of platforms like Moodle and Elgg suggests a comprehensive approach to course delivery and learner engagement. The fact that more than a thousand people registered for the pilot course indicates a significant level of interest and participation. While it is encouraging that the technology solution was successful, it is important to note that the completion rate of 3.3% (with 50% of registered participants) suggests that a relatively small percentage of participants completed the course.

A study conducted by Lee *et al.* [35] evaluated the reliability of digital content and digital score control in MOOCs. The training course was developed on the OpenLearning platform following the ADDIE model of designing instructions. In their study, Li [25] collected data on students' perceptions of the course using a questionnaire. The overall mean scores for perceptions, elements of instructional design, acceptance, and barriers to use were reported as 3.87, 3.91, 3.83, and 2.80, respectively. The mean scores present an assessment of the degree of concurrence or contentment among students concerning various facets of the course. Comparing the results of Lee *et al.* [35] with the present study, it is mentioned that the mean scores obtained in both studies were not significantly different. This suggests that there is consistency in the perceptions of students across the two studies, indicating similarities in the effectiveness of the online course and the instructional design elements.

The study conducted by Kamarudin *et al.* [36] focused on the development of an e-assessment module for MOOCs and the assessment of perceptions among 129 undergraduate science and math students. The ADDIE model was utilized for the design and development of the e-assessment module. The mean value of students' perception of the e-assessment module was 3.44, the standard deviation was 0.58. These results

were slightly lower than the results of this experiment. The authors concluded that the course can allow students to conduct online self-assessments, and improve self-organization and time management skills.

The study by Lee *et al.* [37] focused on the development of an online course using the ADDIE model as the learning design model. The researchers also examined students' perceptions of the course. In contrast to the current study, Lee *et al.* [37] determined a course validity index and assessed the e-content and e-assessment modules. According to the results of Lee *et al.* [37], both the e-content and e-assessment modules received a validity index of 1.00, indicating high validity. This finding is consistent with the results of other studies [32], [35], [36]. These studies also reported high validity indices for their respective modules within the MOOC context.

6. CONCLUSION

Within the study, the authors created an online course and put it into practice. Students were actively involved in the pilot phase of the course, where they had the opportunity to participate in and evaluate the module. The evaluation questionnaire was analyzed using SPSS version 21, and the results indicated a high percentage of positive feedback across all five criteria. This suggests that students strongly agreed that the online module contributed to their understanding of the discipline. In general, the participants positively assessed the course interface, which received high scores for all features. Students especially appreciated the functionality of the options button, rating it as the highest with a score of 4.35 (from first-year students) and 4.38 points (from fourth-year students). According to the feedback from the first-year students, they were particularly attracted to the size font used in the online course. This parameter received a high rating – 4.46. This indicates that students found the course content easily readable and accessible. The design of the module allowed students to watch animated videos at their convenience and free of charge. Additionally, they were able to download sample problems and solutions that were provided for each chapter. The authors also evaluated the interest in online learning among students of two study years. Thus, first-year students had an average level of interest in online learning of 4.50 with a standard deviation of 0.32. The average level of interest of fourth-year students was 4.45 with a slightly larger standard deviation of 0.41. Student engagement is an important factor in effective learning, as it reflects their active participation and motivation in the learning process.

The online module developed in this study holds the potential for assisting teachers in their instructional practices. By utilizing the online module, teachers can reduce their reliance on theoretical teaching and instead prioritize interactive learning and exercises within the classroom setting. This approach can enhance student engagement and promote active learning. To expand our understanding, future research could focus on exploring the attitudes and perceptions of teachers towards online courses in the MOOC environment. Understanding how teachers perceive and utilize such resources can provide valuable insights for improving instructional practices and incorporating online modules effectively.

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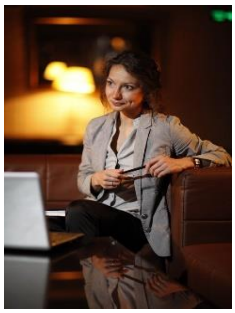
BIOGRAPHIES OF AUTHORS



Julia Kazakova holds Ph.D. degree. She is an Assistant Professor of the Department of English Philology and Cross Cultural Communications of Kazan Federal University in Yelabuga, Russia. Research interests: MOOC; science and math education; self-study. She can be contacted at email: kazakova696@gmail.com.

Elena Shastina holds Ph.D. degree. She is a Professor of the Department of German Philology of Kazan Federal University in Yelabuga, Russia. Research interests: MOOC; science and math education; self-study. She can be contacted at email: shastina@rambler.ru.

Ilzira Gibadulina holds Candidate of Biological Sciences degree. She is an Associate Professor of the Department of Biology and Chemistry, Kazan Federal University, Kazan, Russia. Research interests: MOOC; science and math education; self-study. She can be contacted at email: abdullina_ilzira@mail.ru.