

Original article

The Effects of Educational Use of the QR Code: A Study about Experiences and Perceptions

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Abstract

Courses on the use of current applications such as instructional technologies offer appropriate opportunities for future teachers to have the right experiences. One of these technological applications is QR codes, which allow content enrichment without harming the instructors in terms of time and cost. The aim of this study is to reveal the experiences of pre-service mathematics teachers on the process of producing QR code supported material. Within the scope of the study, 55 pre-service teachers implemented book chapter enrichment within the scope of instructional technologies course. At the end of the application, the opinion determination form was evaluated and subjected to content analysis. As a result of the analysis of the qualitative data, codes and themes related to the contribution of the materials containing QR codes to education, the problems that may be experienced during the production and use of the materials and suggestions were revealed. According to the results, pre-service teachers think that materials containing QR code can contribute to students motivationally and cognitively, can help practitioners to gain TPACK components and to ensure cooperation. In line with the results, it can be said that there is a need for design and development research on QR code supported materials.

Keywords: QR Code, Tpack, Learning by Design, Math Education

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INTRODUCTION

In a classroom environment where current technologies are used effectively, everything does not happen by itself. The protagonist of a teaching process involving digital technologies is teachers who know how to organize themselves, and who spend time and serious effort to create important tasks by thinking ahead of time what tools and resources will be needed (Goodyear, 2018). Many factors can be effective in teachers' having these organizational skills. However, as one of the external factors, the importance of pedagogical and content knowledge courses taken during the teacher education process in terms of facilitating the organization cannot be denied. Therefore, teacher candidates should be helped to gain experience in the use of instructional technologies in their education, since engaging with technology-supported instructional material design processes has been reported to enhance both professional awareness and technology integration competencies (Karakuş & Şeyihoğlu, 2022).

It is seen that teacher candidates' use of current practices in education by blending technological knowledge with pedagogical knowledge is necessary for them to grow up as teachers with the required qualifications. Therefore, it would not be right to wait for them to graduate in order to see them as a part of the teaching process. It may be possible for teachers to blend theory and practice of the teaching process intensively during university years in terms of pre-professional development. Considering that the university has such a strong impact on the professional development of teacher candidates, raising design awareness in them provides opportunities for comprehensive and sustainable change. When teachers, who are the main responsibilities of teaching, are placed in the target, it can be ensured that they are adopted as agents of innovation and change. (Goodyear, 2015).

The commonly used teaching material in traditional classrooms is books. Textbooks are important as they are resources that help to teach in accordance with the annual plan. In this study, it is aimed to enrich the textbooks by producing QR code supported teaching materials in the instructional technologies course of university students studying at the faculty of education. In order to achieve this aim, a design-based approach was adopted and pre-service teachers were provided to produce educational content interactively in groups.

Learning By Design

Koehler and Mishra (2005) emphasize that technology teaching, which will be given by strengthening the connections between technology, content and pedagogical knowledge, is important in order to go beyond the traditional skills teaching suggested by traditional approaches. In this context, the researchers introduced the Learning by Design approach, which is an approach that teachers will encounter with these three basic skills. With the Learning by Design approach, teachers develop a special material design for a specific instructional goal, instead of gaining general knowledge of technology and dealing with general learning goals while designing. In this approach, after teachers come together in small groups, they focus on producing solutions using technology for certain

pedagogical problems and cooperate (Mishra & Koehler, 2003). Therefore, the concept of learning by design can be considered as a process that includes collaborative material production or collaborative instructional technology design.

What teachers should know about technology is more of an issue than how they should learn it. In other words, it would be appropriate to adopt an understanding that aims to comprehend the relationship between educational technologies, their users and their applications, rather than having knowledge about certain software and hardware (Koehler & Mishra, 2005). Courses such as educational technology and instructional technology offered in faculties of education may be a perfect fit for adopting the learning by design approach. In various studies, the blending of content knowledge, technology knowledge and pedagogical knowledge in the education of teachers has been achieved in different ways with this approach. One of these studies is the doctoral thesis conducted by Lu (2014). The researcher carried out design and application studies in the learning environment he created with the approach of learning by design in a technology integration course for preservice teachers, The results of the study revealed that the learning environment based on the Lbd theory can be effective for the development of teachers' TPACK. In addition, it has been observed that pre-service teachers have positive perceptions about the teaching process using technology with Lbd.

Another study on the contribution of Lbd to teachers was conducted by Yelland, Cope, and Kalantzis (2008). In this study, the experiences of 30 teachers about the learning environments they prepared with the Lbd approach were revealed. Teachers working in two different schools designed environments where students were active participants and had problem-solving experiences. According to the results, the participants stated that it was satisfactory that they used new ways in their planning and thinking processes and they were inclined to continue incorporating technology into their teaching with this discipline.

In his doctoral thesis, Timmons (2018) investigated the relationship between Lbd, tpack and technology integration. The results of the study, in which 109 mathematics teachers participated, showed that Tpack partially mediated technology integration. However, according to the results of the study, it has been observed that intense technological knowledge has a saturation effect on technology integration.

Lbd is an approach used in the learning of both students and teachers as it enables them to be active participants in the learning process (Du Plessis & Webb, 2011). In this study, the Lbd approach has been adopted as a theoretical framework for pre-service mathematics teachers to gain experience of enriching the textbook, which is a traditional teaching tool, with instructional technologies.

Use of QR code in education

The QR code system, which we are accustomed to seeing in market checkouts, was first developed in 1994 based on the logic of scanning and reading two-dimensional barcode images, and is a system

that is used to display different types of content such as text, message, sound, video, contact information. The use of the QR code system by people became possible with the widespread use of smart phones. Users with smartphones can access the code information stored in any way on the internet by scanning the existing codes.

Internet technologies and the development of mobile devices affect the trends in education and the way technology is used. Both the increase in the technological opportunities in the classroom and the increase in the technological opportunities of the students have resulted in the need for new and different educational applications. At this point, QR code technology emerges as a technology that can be used in different ways in the classroom. QR code technology can be used to direct students to educational resources available online via mobile devices through printable educational materials (Acartürk, 2012). QR codes placed on printed materials such as books, posters and brochures can be used for different teaching processes such as registering students, giving place to survey applications, preparing worksheets, and performing the measurement and evaluation process (Çataloğlu & Ateşkan, 2014). In addition to this, QR codes can be placed in the presentation in class presentations. In this way, students can access the presentation from their mobile devices via QR codes. In addition, electronic resources, images, audio files and written resources in the presentation can be accessed via QR codes (Aktaş & Çaycı, 2013).

Studies have revealed that the textbook, supported by data matrix applications, contributes to self-learning level (Güleç, 2019), vocabulary acquisition development (Yunus et al., 2020), conceptual understanding and system thinking skills (Ormancı, 2018). The fact that classrooms are supported by technology around the world, and the widespread use of smart boards can facilitate the combination of QR code technology both inside and outside the classroom.

Considering that interaction with mobile devices has become increasingly widespread, QR code supported printed materials may offer new opportunities for enriching learning environments across different age levels. However, when the literature is examined, it is seen that studies focusing on QR code supported enrichment practices in mathematics education are still limited. Moreover, existing research has largely concentrated on the effectiveness of such materials rather than on providing authentic material development experiences for pre-service teachers. In this context, there is a need to better understand how engaging in QR code supported material design processes contributes to the professional development of future teachers and how they perceive the potential benefits and challenges of using these materials. Therefore, the aim of this study is to examine the perceptions of pre-service mathematics teachers regarding both the development and implementation processes of QR code supported materials.

The study seeks to answer the following research questions:

1. What are the perceptions of pre-service mathematics teachers regarding the contributions of QR code supported material development?
2. What problems do pre-service teachers experience during the development and use of QR code supported materials?
3. What suggestions do pre-service teachers offer for the more effective use of QR code supported materials?

To address the research questions of the study, a qualitative research design was employed in order to examine the perceptions of pre-service mathematics teachers about the development processes of QR code supported materials.

METHOD

Research Design

This study employed a qualitative research design to explore the perceptions of pre-service mathematics teachers regarding the development and implementation of QR code supported instructional materials. The implementation process was structured around an experiential material design activity in which participants enriched textbook content using QR codes. In this way, the study aimed to obtain in-depth insights into participants' views on the contributions, challenges, and suggestions related to QR code supported material development.

Participants

The participants of the study are 55 second year mathematics teaching department students studying at a state university in Turkey. 12 of the participants are male, 43 of them are female.

QR code supported book section project

An informative lesson was given to the participants about what the QR code is, its purposes of use, and its use in education. Then, they were involved in a process that included the following steps so that the participants could practice.

1. Determination of working groups (groups of 5-6 people)
2. Book review and book chapter selection
3. Creating a draft showing the QR code placement and content on the book
4. Learning the necessary applications for structuring the content
5. Creation of content
6. Pdf splitting and pdf editing studies for placing QR codes in pdf files

In the first step of the study; working groups were determined. At this stage, 11 groups were formed. Working groups consist of 5 people each. The participants took part in the groups that they thought created a good dynamic based on their previous working experiences, in line with their own choices.

In the second step; pre-service teachers digitally examined the textbook, which was planned to be enriched with QR code by the researcher, and determined the section they wanted to enrich. The specified textbook is a textbook that has been decided to be used by the Ministry of National Education for 5th grade students. 6 of the groups chose the topic of Fractions and Operations with Fractions in the second unit of the book, 4 of them chose the topic of Area Measurement, Geometric Objects in the sixth unit of the book, and 1 selected the topic Natural Numbers, Operations with Natural Numbers in the first unit of the book, and started to QR code supported the material production process.

In the third step of the study; the groups stated what kind of digital content support was needed at which locations on the pdf files of the departments they determined and sent them to the lecturer of the course. After examining the comments, the instructor provided feedback to each group separately. Then the students made necessary corrections on the comments. In addition, the instructor asked each group to indicate how many QR codes will be on a text document, on which pages, for which activities they will be prepared, and how the content source will be obtained.

The fourth step involved students creating the content. The instructor stated that all groups should create at least 15 QR codes in their studies, and at least 3 of these 15 QR codes should be an animation created with Powtoon. Finally, each group was asked to prepare unit evaluation questions in the Kahoot environment. The groups were able to direct their QR code links to resources such as ready-made websites and video links. In addition, by opening a Youtube channel for the sound, video and animations that the students created as a group, they were provided to direct the QR code links to these channels. At this stage, Unitag, which offers unlimited reading options, and QR code generator, which provides link support for all kinds of file types such as pictures, audio, video, were preferred as a QR code generation tool. The most important reason why these websites are preferred is that they are free. At this stage, the participants were given the necessary assistance and information about editing the pdf by the instructor. Three screenshots from the instructional animation video prepared by a group with Powtoon are combined and given in Figure 1.



Figure 1. A section of participant animation work screenshots

In the fifth step, the contents were created. Participants were informed about developing the content in accordance with the readiness levels of the target audience and learning outcomes. During the preparation of the contents, the researcher carried out regular inspections and controls.

In the sixth step, the participants placed the QR codes they linked in the appropriate places in the book and checked whether the links were working. At this stage, the participants took advantage of the smallpdf.com website, which is a free pdf editing environment, and made arrangements to include only the chapter pages they chose. Therefore, this process was completed without experiencing relatively difficult processes such as installing paid and licensed software and without causing loss of time. At the end of this process, the researcher made the necessary controls.

Data collection

The data of the research were collected with the opinion determination form distributed to the participants at the end of the application. There are five questions in the opinion determination form. Participants answered the open-ended questions in this semi-structured form in a way that they expressed their own opinions regardless of the group they joined. The questions aim to reveal the opinions of the participants about the QR code development application in the instructional technologies course. Therefore, necessary time was given for the participants to reflect on all their experiences, opinions and suggestions, which may be positive or negative.

Data analysis

The data obtained from the opinion forms were analyzed using content analysis. In this process, similar responses were grouped under common codes and themes in order to identify meaningful patterns in participants' experiences. An inductive approach was followed during the analysis. First, the researcher read all responses several times to gain a holistic understanding of the data. Then, initial codes were generated and related codes were brought together under broader themes. After the coding process was completed, the data were organized and presented in accordance with the emerging themes and supported with direct quotations from participants.

RESULTS and DISCUSSION

In this section, the themes and codes that emerged with the analysis of the opinion determination form are given in tables. The opinions of the pre-service teachers about the contribution of the production of QR code supported material and problems-suggestions were tabulated, respectively, and explained with direct quotations.

Opinions of pre-service teachers about the contributions of QR code supported material production

As a result of the content analysis, the frequency values of the codes that emerged regarding the opinions of the pre-service teachers about the contributions of QR code supported material production are given in Table 1.

Table 1. Distribution of pre-service teachers' views on the contribution of QR code material production in Instructional Technologies course

Contributions to the students	F	Contributions to the pre-service teachers	f	Other	F
Motivational Contributions	29	Providing professional information	14	Being economical	2
Being remarkable	7	Reducing the workload	13	No storage required	6
Being fun	7	Providing technology information	10		
Making the lesson love	2	Supporting collaboration	2		
Providing active participation	2				
Increasing interest	12				
Cognitive Contributions	37				
Providing permanent learning	8				
Facilitating learning	24				
Providing technology information	3				
Supporting individual learning	2				
Increasing course success	1				

When the data obtained from the teacher candidates are analyzed, it is seen that the codes are formed under three themes: the contributions of the QR code supported materials to the students, the contributions to the teacher candidates and other contributions. According to Table 1, pre-service teachers think that QR code supported materials will contribute to students motivationally and cognitively. When the frequency distribution is examined, it is seen that cognitive contributions (f=37) are more than motivational contributions (f=29). Cognitive contributions according to the sub-codes obtained from the opinions of the participants; facilitating learning (f=24), providing permanent learning (f=8), providing technology knowledge (f=3), supporting individual learning (f=2) and increasing course success (f=1).

The facilitating learning code refers to the convenience of students in accessing content and course resources, and the facilitation of the learning process. A few examples reflecting the views of the participants regarding this code are as follows:

“It provides a quick and effective solution for questions and activities that students have difficulty in understanding.”

“Especially for abstract topics in mathematics, this application is perfect. After learning the abstract subjects, the students can make concrete reenactments with the materials given in the QR codes.”

“Associating technological resources with lessons may be more beneficial for students we will teach in the future. It makes an abstract lesson more concrete and understandable for students.”

The code of providing permanent learning means that students are in a more efficient learning process thanks to these materials and that these materials help them to place what they have learned in long-term memory. Some of the opinions of the participants regarding this code are as follows:

“It makes teaching permanent. It increases their interest in the lesson. It is an efficient application.”

“It is a useful way to reinforce the topics and help students understand better. If we consider the geometry part as an example, thanks to the QR codes added next to the activities, students can access 3D content and animations and understand such geometric shapes or concepts more effectively.”

“I think it is very colorful and beautiful. It supports permanent learning in terms of keeping students in mind. It makes the lesson more efficient.”

“Thanks to the QR code, the information becomes more memorable.”

The code of providing technology information refers to the students being technology literate. A participant's opinion referring to this code is as follows:

“It enables students to easily use web 2.0 tools interactively and to access audio-visual materials with any tool connected to the internet. It also makes it possible for children to become involved with technology at an early age.”

The code of supporting individual learning refers to the support of the materials produced for students to perform learning activities that are expected to be performed individually, such as homework and quizzes. One participant opinion referring to this code is as follows:

“In this case, the QR code application is very functional. Because the content to be transferred to the students is presented to the students in an easy way. In addition, accessing the content thanks to this QR code also supports individuality. For example, a student can easily access an application that needs to be done individually.”

The code of increasing course success states that QR code supported materials can be effective on the general learning performance of students. The view of the participant who put forward this view is as follows:

“I think it can be used in other lessons as well. In fact, it would be good for students to have such a practice in all courses. Since students like to learn more with fun things, students' success can be increased by making this application in all lessons.”

Motivational contributions according to the sub-codes obtained from the opinions of the participants; increasing interest (f=11), being remarkable (f=7), being fun (f=7), making the lesson love (f=2) and providing active participation (f=2). The code of increasing interest means that students can maintain their interest in the lesson for a longer period of time with QR code supported materials. Some of the participant opinions referring to this code are as follows:

“Using QR codes in mathematics education can increase students' interest in the lesson. We can help learning numbers by defining games and animations on QR codes. At the same time, we can present how geometric shapes are formed and activities to create geometric shapes for them. Since we cannot do all of these through the book, QR code should be used in mathematics teaching.”

“I think it is very necessary. The use of different tools will keep students' interest high.”

“We can include audio files, videos, animations that we cannot include in books while developing QR codes. This increases students' interest in that lesson.”

The code of being remarkable means that the application is different and attractive in a way that will arouse curiosity in the students. A few participant opinions regarding this code are as follows:

“Content transfer and access can be easily provided in limited areas using a QR code. Also, QR code arouses curiosity in people. That's why it's remarkable. It provides benefits in many areas. For example, we can now easily scan documents or make payments. In order to access these conveniences and more, the QR code development application is beneficial for us.”

“I think it should be used more. It attracts attention and attracts students' attention. Working in the digital environment, even for a short time, excites the new generation more.”

“With the QR code, the student can find the lesson more interesting. He wonders what he will encounter by reading the QR code after each topic.”

The code of being fun means that students learn and have fun while examining QR codes. The participant opinion being referring to this code is as follows:

“Mathematics is a very enjoyable lesson when it can be taught in a concrete way. QR code has a very important place for this.”

“Students will like an online book with fun animations, videos and sounds for a difficult lesson like math.”

“Instead of just reading, he can put games to improve that subject. When they read the QR code, they can play that game. So the lesson will be more fun.”

The code of making the lesson love states that QR codes can be effective in liking a course that is more difficult because it requires numerical operations such as mathematics. The student opinion referring to this code is as follows:

“Since students generally like to watch animations, they learn the subject better and in a way that is compatible with daily life, thanks to the animations with stories after the subjects.”

The code of providing active participation indicates that a more positive and willing to learn student community can be formed when it comes to the atmosphere in the classroom. Here is a participant view that references this code:

“The QR code development application also helps students in their teaching life. Thanks to the QR code, more active learning can be realized in the course.”

The pre-service teachers expressed contribution of the production of QR code supported material to themselves under the codes of providing professional knowledge (f=14), reducing the workload (f=13), providing technology knowledge (f=10) and supporting cooperation (f=2).

The code of providing professional information states that contributes of the QR code development process to preservice teachers in using different teaching methods and techniques effectively. Gaining professional knowledge and skills is one of the main aims of education faculties. Therefore, the participants think that the experience they have in this course contributes to the professional knowledge and skills that a teacher should have, who can serve in line with the main objectives of national education. Some of the participant opinions regarding this code are as follows:

“It enables to plan ahead of time how to spend time for the activity given in the classroom. In this way, time and teaching become more efficient.”

“I find it positive for our professional life. It adapts us to technology. Rather than being a traditional, straight-up teacher; It makes us more equipped teachers by delivering the applications we make, such as video design and digital stories to the students via QR code.”

“We have mastered the subjects we have chosen, and we have seen how the MEB deals with the subjects in the textbooks. In addition, thanks to the QR codes we made, we learned how to use many web 2.0 tools effectively.”

“In the instructional technologies course, the QR code development application has contributed a lot to us in terms of education and training in order to adapt to the next generations, and I will try to use and develop these skills.”

“Our age is the age of technology and educational materials are developing. For this reason, educators should have knowledge of applications and materials compatible with technology. This application prepares us as teacher candidates for technology and new generation education.”

The code of reducing the workload means that technology (QR codes) helps teacher candidates to provide effective teaching without wasting time in the preparation process for the lesson. Some of the participant opinions referring to this code are as follows:

“QR code is a technology that is frequently used today and makes our work easier. I think that learning how to create QR code in this course will benefit me in the future.”

“It is a good application in terms of being easily convertible. It is also very good that we can translate any document we want. Good application in terms of usability in education.”

“It provides us the opportunity to use technology more efficiently and quickly in our future teaching lives.”

“It makes our work easier in all lessons and in daily life. Long articles, videos, links, photos are presented to us with a single code.”

The code of providing technology information states that the production of QR code supported material helps teacher candidates to have information about current technologies. A direct excerpt from a few participant opinions that referenced this code is as follows:

“It changed my perspective on technology. It developed to prepare me for the future. It increased my interest in technology. Improved my computer skills.”

“We have added new things to ourselves in terms of technology. Learning how to do it gave experience.”

“While I was developing QR code, my technology dominance increased a little more. In other words, making animations, making videos, creating QR codes, pawtoon application helped me to be more informed.”

“It allows us to improve ourselves. It allows us to look at technology in a positive way. It allows us to make peace with the computer. In this way, we learn how to make QR codes. We learn where the QR codes come from.”

The code of supporting cooperation means that the application, which is carried out by the participants as a group work, supports the interaction between each other. The participant referring to this code expressed an opinion as “The activities we did taught group work.”

Teacher candidates explained other contributions of the QR code supported material production process under the codes that is no storage required (f=6) and that is being economical (f=2).

The code of no storage required means that both students and teacher candidates do not need an external space on different technological devices such as phones, tablets, and PCs that they use while teaching with QR code supported materials. The participant opinions regarding this code are as follows:

“Thanks to the QR code, we can upload a lot of information to a very small area. Since there is unlimited knowledge in mathematics, QR code is very useful in this branch of science.”

“Thanks to the QR code, unlimited information and content can be transferred in limited areas. Ease of use, small footprint and unlimited content are the good sides of QR code technology.”

“For the math lesson, we can put different videos, hands-on games, photos, pictures, sounds in a small area instead of placing them directly on the area.”

Being economical means that the applications used in the code QR code development process are free and therefore can be used easily only with internet access. A participant's view on this code is as follows: *“As technology develops, it is inevitable to use it more. Since every individual now has smart phones, QR code is not a difficult system to reach. It can be put into any lesson and books. It is more fun and it is very economical to reach the book with only a QR code.”*

Opinions of prospective teachers about the problems of QR code supported material production

With the content analysis of the interview form, which is a data collection tool, codes were created regarding the problems experienced in the process of developing QR-code supported material, the problems that may be experienced during the use of the materials by the students, and the suggestions of the teacher candidates. The frequency values of the participants' ideas and suggestions about the problems they encountered during the development of QR codes, and the problems that may arise regarding the use of QR codes are given in Table 2.

Table 2. Distribution of pre-service teachers' opinions and suggestions about the problems related to the production and use of QR-coded material

Problems during the development of QR code supported materials	F	Problems with the use of QR code supported materials	f	Suggestion	f
Technical incompetence	1	Inadequate financial resources	9	It should be disseminated	31
Economic incompetence	1	Distraction	2	IT course should be intensified	10
Time and effort	1	Making laziness	1	Should be used offline	2
		Not to be used offline	1	Should be used when needed	2
		Making exposure to the screen	1	Should getting feedback from students	1
		QR codes out	1		
		Not developing the right content	1		

According to Table 2, the participants stated that they had problems in terms of technical (f=1), economic (f=1), and time and labor (f=1) during the QR code supported material production process. It is seen that the participants expressed their opinions about the problems that may be experienced in the process of using the QR code supported material rather than the process of producing QR code supported material. The participants' views are inadequate financial resources (f=9), distraction (f=2), making them lazy (f=1), not to be used offline (f=1), exposing them to the screen (f=1), QR codes not working (f= 1) and not developing the right content (f=1).

Pre-service teachers were free to use the computer laboratory with a capacity of 40 computers in the university during the material production process. Therefore, it was possible to use the laboratory with group friends in extracurricular times, depending on the availability of the laboratory. However, in some weeks when the classes were held, internet access was not possible due to the studies on the internet cables in the campus. The technical problems experienced by pre-service teachers during material production were expressed by one participant as follows: *“If computers had worked in the previous process, we would not have time constraints. So it is a little difficult to reach the computer. We also do group homework. One computer in the group is not enough.”*

QR code generation applications on the web are usually paid, but offer limited scanning for free. However, the lecturer of the course mentioned a QR code creation environment that is completely free and has unlimited scanning opportunity to the pre-service teachers and asked them to use this environment in the material production process. A participant's view on the economic problems experienced by pre-service teachers during material production is as follows: *“It is paid and to create a limited number of QR codes.”*

A participant's view on the problems that pre-service teachers experience during material production is as follows: *“It took both time and effort to think and do each activity one by one.”*

Pre-service teachers mentioned some problems that may be experienced in the process of using QR code supported materials in the opinion determination form. In this category, the code of insufficient financial resources means that not all students will be able to afford the internet access and technical equipment necessary to use these materials. In addition, it has been mentioned that some schools may not have the necessary technical facilities. One participant's opinion regarding this code is as follows: *“The biggest negative aspect of the QR code development application is that it is limited in use in the classroom environment, since not everyone has the opportunity to have tools such as phones and tablets.”*

The distraction code states that directing students to an environment containing audio-visual stimuli other than the book can be distracting. A participant's view on this is as follows: *“The inclusion of tools such as phones and tablets in the training shows that there is a distraction factor.”*

The code of making laziness indicates that the materials presented to the students can stifle their desire for research and inquiry. The view of the participant defending this view is as follows: *“Actually, the use of QR code makes mathematics easier, but on the other hand, it simplifies our research-inquiry, accessing information. This accustoms students to comfort.”*

The code not to be used offline includes the view that it is a problem that students cannot access the materials without internet access. The participant's opinion referring to this view is as follows: *“My negative opinion is that the content of QR codes is not opened offline while we can reach it with internet connection.”*

Making exposure to the screen code indicates that students who will benefit from QR code supported materials may also have increased screen exposure time. The words of the participant referring to this view are as follows: *“It leaves students in front of the screen more.”*

The code that QR codes out refers to the problem that the codes are not scanned and that the scanned codes do not serve their purpose. The participant opinion referring to this code is as follows: *“In some cases, incomplete scanning and some difficulties encountered in the creation process are the negative parts of this technology.”*

The code of not developing the right content means that it is not always possible to direct the media to the appropriate and instructive potential media. The view of the participant referring to this code is as follows: *“If QR codes suitable for the event or application are not set, everything will turn upside down. It would be waste of time.”*

The participants made some suggestions in the light of the problems encountered and to be encountered. In the suggestion category, it should be disseminated (f=31), IT course should be intensified (f=7), technological opportunities should be increased (f=2), it should be used offline (f=2), it should be used when needed (f=1) and students' feedback should be received (f= 1) codes have been revealed.

The code it should be disseminated includes the views on the production of QR code supported materials in other courses, and the active use of QR code supported materials for different activities such as question solving and homework. When these views are examined, it is seen that the pre-service teachers especially stated that the use of QR code supported materials in science lessons should be included. Some of the participant opinions referring to this code are as follows:

“I think that QR codes make it possible to share information easily and practically with everyone, so its use in more areas and in different ways should be increased. For example, in science education, experiment videos and simulations can be shared with students. It can also be used in sharing the solution of questions as in mathematics.”

“QR code can be used in other courses as well. For example, it is not possible to do all the experiments given in the science lesson in the classroom. We can use QR code for this. But it does not need to be used too much in a Turkish lesson.”

“I think it will be especially useful in science lessons. Animations and videos that will be presented to students in physics, chemistry and biology lessons can make the information they learn more permanent.”

“I think this practice should be applied in all other courses as well.”

“The application can also be made in textbooks. Students may be asked to read that QR code as homework. And he can be asked questions about the videos he has learned and watched. QR code development application can also be used in other courses. As in the math class, students can take part in the textbooks and watch the video. Homework can be done.”

The code that IT course should be intensified includes the opinions of the pre-service teachers that this course should be given importance, that the necessary technological opportunities should be provided for this course, and that what they learned in this application process should be continued in a more detailed and improved manner. Here are a few of the participant comments that refer to this code:

“QR code reading and creation applications can be created. Thus, students do not have to struggle to find it from different places.”

“A different application may be preferred while generating the QR code. By adding QR codes to the beginning parts of the book, students can be informed about what gains the course will provide.”

“In this age where technology is intertwined, more technological opportunities should be offered to us teacher candidates.”

“It was a very good application. I think this application we have made is complete. More emphasis should be placed on this course in the future.”

“Classroom or group activities should be increased in order to students to be interactive.”

The code should be used offline includes the views that scanned materials can also work offline. A direct quote from the opinion of a participant defending this situation is as follows: *“A free application, not just web-based, that anyone can access and download to their smartphones can be offered to users.”*

The code should be used when needed states that too many QR codes can be boring for students, and that face-to-face interaction can be reduced if the teaching is carried out only on the material. A participant's view on this is as follows: *“There should be a QR code in every lesson and it should be*

used in every activity on every subject, but we should not interaction with the student and educate through QR code. Students and teachers should apply to the QR code whenever they need it.”

The code of should getting feedback from students means that the opinions of the students of the target audience should be taken about the use of the developed materials. The participant's view on this code is as follows: *“I think we would have shown the QR codes we created with such effort to the 5th grade students and received their feedback. On the other hand, in the application and narrative part, everything was as it should be.”*

Discussion

In this study, the views of pre-service mathematics teachers about their experiences of enriching the textbook with QR codes were examined. According to the results of the research, pre-service teachers think that the QR code supported textbook will contribute positively to the motivation of the students. This finding is supported by the research results of Karahan and Bilici (2017). Pre-service teachers think that the application will also be beneficial for students cognitively. This result is similar to the opinions of teachers about the z-book sample developed by Ormancı (2018) as a doctoral thesis.

Pre-service teachers think that the production of QR code supported material improves their professional knowledge and skills as it contributes to them both in terms of pedagogical and content knowledge. In addition, they stated that once they prepare the QR code supported materials, they can use them for a long time thanks to the up-to-date technology, thus reducing their workload. In addition, they stated that they have technological knowledge as they need to use technology actively for reasons such as animation preparation and video shooting during the content creation phase. At this point, it can be thought that the production of QR code supported material contributed to the TPACK development of teacher candidates.

Many competent researchers in the field underline the importance of one-on-one experience in technology integration. High-level use of technology may not make sense on its own. According to An and Reigeluth (2011) teachers should develop their technology skills by creating student-centered activities. Therefore, up-to-date technologies that are easy to use and interesting for students can be used effectively by designing different learning experiences.

Pre-service teachers think that the materials they produce cannot be used effectively for students who do not have equal financial conditions. Although opportunities are being increased in education, this may cause inequality in education. This is Ertmer et al. (1999) considered it as one of the external factors affecting technology integration. It is also possible to see that technological opportunities are increasing day by day, considering that such external factors may be in question despite all the years that have passed. There are studies in the literature that address similar problems with the use of QR codes in teaching (Ali et al. 2017; Durak et al. 2016).

Finally, pre-service teachers made some suggestions based on the problems they saw. Based on the suggestions of the pre-service teachers, it is possible to make suggestions for future studies on this subject. One of them is for the use of QR code supported materials in courses other than mathematics, such as science. Especially in cases where laboratory conditions are not sufficient, performing QR code supported simulation applications can help to realize more effective teaching.

In addition, pre-service teachers have repeatedly stated that it is important to use QR code supported content to support question solutions and evaluation process. Therefore, there is a need for structured environments with emphasis on activities that will enable students to interact with the content. Linking the evaluation tools created with educational game techniques to QR codes in the evaluation process can ensure active participation of the students.

Conclusion

This study examined the views of pre-service mathematics teachers on the process of enriching textbooks with QR code supported materials. The findings revealed that the material production process contributed positively to both student-related outcomes such as motivation and cognitive engagement and to the professional development of pre-service teachers. However, certain external barriers, particularly inequalities in access to technological resources, were also identified. Overall, the results suggest that QR code supported materials have the potential to enrich learning environments when they are designed with pedagogical considerations and equitable access in mind.

This study constitutes the preliminary stage of a research that will continue in the future. The QR code supported books enriched by the pre-service teachers will be examined by field experts and instructional technology experts and subjected to pre-application after development studies are carried out. Therefore, a further design and development research is needed. Then, asking the opinions of teachers and students as users may be another suggestion.

Additional Declaration

Author Contributions

The author contributed to all stages of the research process, including the development of the research idea, data collection, data analysis, interpretation of the findings, and writing and proofreading of the manuscript.

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Responsible Artificial Intelligence Statement

In this study, artificial intelligence tools ChatGpt and Deeply were used in language editing stage. The artificial intelligence tool was used to correct language errors, to check the data analysis made by

the author, and to provide the colophon information of current related resources in the literature review. We declare that we, as the authors, take full responsibility for the problems that may arise from the content produced by artificial intelligence.

Conflicts of Interest

The author declares that there are no conflicts of interest related to the publication of this study.

Ethics Approval

In all processes of this study, the principles of Pen Academic Publishing Research Ethics Policy were followed.

The study received ethical approval from the Ethics Committee of Süleyman Demirel University on October 31, 2023 (Approval No: 141/28).

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