Teaching Materials Developed Using QR Code Technology in Science Classes

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Abstract

The present study aims to investigate the opinions of prospective science teachers about the use of QR codes in the teaching materials that they prepared in the "Instructional Technologies and Material Development" course. The study group consists of 38 (32 female, 6 male) 3rd-year prospective science teachers who attended the "Instructional Technologies and Material Development" course in the fall semester of the 2018-2019 academic year, and who chose to use QR codes academic year, and who chose to use QR codes in the teaching materials. In this case study, the data were collected through semi-structured interviews. The data were analyzed by the content analysis method. The study revealed the perspectives of prospective science teachers on the use of QR codes in the teaching materials they prepared, in the learning process, its advantages, disadvantages, and effects of QR codes on the materials prepared.

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INTRODUCTION

In today's world, there have been great developments in the field of informatics. Information technology provides communication between people and ensures that information is transmitted without any restrictions. The introduction of the Internet, wireless internet networks, and mobile devices into social life has accelerated the progress in technology. Digital cameras, smartphones, tablets and other mobile devices have become influential actors in the changing global world (Taskesenlioglu, 2010: 14).

In the informatics world, the use of QR codes increased in parallel with the development of smartphones. QR codes now appear in many areas of life (Virtual 2017). QR codes were first developed in 1994 by a Japanese company as a symbol that can be easily read through the scanner for tracking of production processesin the automotive industry. The most widely used and highest capacity QR codes are 2D barcodes, which can store information both horizontally and vertically. Therefore, they have more capacity than linear barcodes that encode information horizontally (Akin, 2014). The use of QR codes is also quite simple. QR codes can be scanned through barcode scanner applications on smartphones. The user only needs to hold the camera on the QR code. In this way, the desired information is obtained (Insights, 2011).

QR codes have become widespread in all areas, especially with the use of mobile technology tools. Furthermore, there is a growing interest in the use of QR codes in the education and learning process (Ramsden and Jordan, 2009). Cataloglu and Ateskan (2014) stated that QR codes could be used in educational activities in two ways. First, QR codes help the student reach online applications, and second, after QR codes are scanned, the student may have the desired information without any need for the Internet connection.

The use of QR codes increases efficiency in learning environments because they prevent students from wasting time on search engines and being exposed to irrelevant information. With the QR codes on printed materials, educators can enable students to access more resources related to the subject. This both prevents paper wastage and helps students access more resources. QR codes support mobile education and enrich the learning process (Aktas and Cayci, 2013).

Considering the last five years when mobile devices have spread more rapidly in everyday life, we can see that the resources that replace printed materials (e.g. e-books), and the use of printed learning resources in conjunction with online information, have begun to stand out. In other words, it is unlikely that the printed resources will be completely replaced by electronic resources (it is unlikely that the printed books will disappear in the near future and only e-books will be available). In this regard, not the replacement of printed materials by online information resources but the combined use of them has the potential to enhance the learning potential of students (Ozdemir, 2010).

QR codes can be used for different purposes in the science education. For example, videos of experiments and periodic table podcasts (describing the elements) embedded in QR codes can be used as an alternative to traditional periodic tables in science education (Bonifacio, 2012). Similarly, QR codes may draw student's interest concerning topics that they have difficulty in understanding and have misconceptions about (Yilmaz and Canbazoglu Bilici, 2017). Furthermore, students can enrich their lab reports with QR codes and present them as posters (Canbazoglu Bilici, Tekin and Karahan, 2016).

The importance of the study

Although QR codes have a vast use potential in education, studies on the use of QR codes in science education in Turkey have only recently begun (Karahan and Canbazoglu Bilici, 2017; Yilmaz and Canbazoglu Bilici, 2017; Canbazoglu Bilici, Tekin and Karahan, 2016). However, there is a clear need for further studies on the use of QR codes in education. The tablets distributed within the scope of the 'Movement of Enhancing Opportunities and Improving Technology' (FATIH project) enabled

teachers and students access to mobile devices and diversified the educational process through mobile applications such as QR codes. Karahan and Canbazoglu Bilici (2017) aimed to examine the opinions of science teachers about the use of QR codes in their classes. In addition to exploring the positive and negative opinions of teachers with various levels of professional experience, they aimed to investigate the participant teachers' recommendations about the use of these technologies in science classes. On the other hand, the present study aimed to highlight the opinions of 3 rd-year prospective science teachers about the use of QR codes in the science education. In this context, the problem statement of the present study is as follows:

1. What are the opinions of the prospective science teachers on the use of QR codes in science education?

METHOD

Research Design

This study was conducted according to the principles of the case study, which is one of the patterns of qualitative research methodology. A case study includes an in-depth analysis of one or more events, setting, program, social group, community, or a restricted system. The case refers to a holistic system. A teacher, a student or a newly implemented program can be the case. The case study is defined as the investigation of the actual context of a current case (Stake, 1995: 2; Yin, 2003: 13). In this study, which aims to determine the opinions of the prospective science teachers about the QR codes used in the materials they prepared, the case study approach was used for descriptive purposes, and a holistic single case design was used.

Study Group

The study group consists of 38 (32 female, 6 male) 3rd-year prospective science teachers who attended the "Instructional Technologies and Material Development" course in the fall semester of the 2018-2019 academic year, and who chose to use QR codes in the teaching materials. Semi-structured interviews were conducted in 16 groups. This is because the prospective teachers had prepared their teaching materials in groups of two, three, or four; so they were interviewed in groups.

Research Process and Data Collection Tool

The study was carried out within the scope of "Instructional Technologies and Material Development" course of 3rd-year of Science Teaching Department. During the course, the instructor provided information about QR codes and how to make QR codes and provided the students with the option to use QR codes when preparing teaching materials. The students were completely free to choose whether to use QR codes in their materials. The prospective teachers had no previous knowledge of QR codes and had not encountered any sample teaching materials containing QR codes. They only made sample QR codes during their course with the instructor. The prospective teachers then developed their materials in groups, and 38 prospective teachers (16 materials-16 groups) preferred to use QR codes. The QR codes were put on display in the teaching materials exhibition held at the end of the semester for other prospective teachers, faculty members, and secondary school students from various secondary schools, and their science teachers. This exhibition enabled the prospective teachers to observe the opinions of other prospective teachers, secondary school students from various secondary schools, and science teachers working in these schools on the use of QR codes in teaching materials. Following the exhibition, the researcher conducted semi-structured interviews in groups with the prospective teachers who chose to use QR codes in their teaching materials.

Once the interview questions were prepared, an interview was conducted with three prospective teachers who were not included in the study to test the comprehensibility of the interview

questions. Then, the questions were edited according to the opinions of a faculty member with expertise in the field.

Data analysis

For the analysis of the data, content analysis, one of the qualitative data analysis techniques, was used. The content analysis includes an in-depth analysis of the data, and in this way, themes and dimensions that are not previously pronounced are revealed. The content analysis aims to bring together similar data within the framework of certain concepts and themes and to organize and interpret them in a way that the reader can understand. Therefore, the inductive approach is followed when conducting the content analysis. By inductive analysis, it is aimed to reveal the underlying concepts of data through coding and the relationships between these concepts. The resulting codes (subcodes) and the relationships between these codes (categories) function as the foundation stones used to explain the phenomenon or theory underlying the data (Yildirim & Simsek, 2011).

The data obtained from the interviews with the groups were written in word files under the titles of 'interview 1', 'interview 2', 'interview 3', 'interview 4', 'interview 5', 'interview 6' etc. Subsequently, sub-codes were created based on the data of each prospective teacher and categories were formed based on the sub-codes. Then, the data were analyzed by content analysis. The data were compared with the data of the second researcher in terms of consistency. The second researcher analyzed the interview data of a randomly selected group. Reliability was calculated based on the analysis of the findings of the same group, and the reliability coefficient was found to be 89.25%. In the calculation of the inter-rater reliability, the formula; $P= [Na/Na+Nd] \times 100$ (Miles and Huberman, 1994: 69) was used. Then, in order to conduct an agreement analysis between the evaluations of the two researchers, they came together and the agreement on different codings was reached through discussion. Besides, during the data collection process, the case study report was read to the prospective teachers, and their opinions were taken.

FINDINGS

The Findings from the Interviews with the Prospective Teachers

Semi-structured interviews were conducted to investigate the opinions of prospective science teachers about the use of QR codes in the teaching materials that they prepared in the "Instructional Technologies and Material Development" course. Based on the findings of the interviews, categories and sub-codes were formed. These categories and sub-codes are presented in Table 1.

Table 1. Categories and Sub-codes obtained from the Interviews with Prospective Science Teachers

Categories	Sub-codes
Opinions about the use of QR codes in science education	Attracting attention- arousing interest
	Fun
	Integration of science with technology
	Integration of science with life
	Enables permanent learning
	Supports learning
The use of QR codes in learning process	Game-based learning
	Laboratory
	Assessment of classes
	Assignments
	Classroom boards
	School corridors
Advantages	Short preparation time
	Easy preparation

	Portability
	Updateable
	Time-saving
	Prevents paper wastage
	Direct access to targeted information
Disadvantages	Internet connection problem
	Requires tablets or smart phones
	QR code preparation in paid applications
Effects on the materials prepared	Simplifies
	Enables individual learning

The findings obtained from the interviews with the prospective teachers were presented under five main categories.

Category 1: Opinions about the use of QR codes in the science education

Attracting attention- arousing interest

On the use of QR codes in science education, the prospective teachers interviewed usually stated that they think that this technology will arouse interest in students. The majority of the prospective teachers (32 people) stated that students regarded the cryptography contained in the QR codes something mysterious, which aroused interest in them. For example, one participant stated their opinions on the use of QR codes in the teaching materials as follows: *"For example, some of my friends designed a game about the reproduction in animals. The game contained QR codes, and there were moments of birth hidden in them. For example, a whale giving birth, a turtle covering its eggs after leaving them... Even we were quite* curious about the codes, and *when we came to the parts containing the codes in the game, we watched these videos with pleasure. I think it attracts the attention of children too. Children are very open to technology. When computers or phones are involved, children are more interested. We heard the secondary school students say 'wow' at the exhibition many times when they scanned the QR codes"* (P.T.7). (P.T.- Prospective teacher). Another pre-service teacher stated opinions in this direction as follows: *"There was a material about bone types and joint. With a bingo play constituted by QR codes. The students selected and read a QR code from the bag and when they performed the matching on the material then the bulb lighted and when the bulb lighted they used to stick a QR code on bingo cards. It was very interesting for them and they wondered what was in QR codes. In my opinion, QR codes are incredibly interesting and as far as I could see in the exhibition, they aroused a great interest on the part of the students"* (P.T.4).

1.1. Fun

Another aspect that the prospective teachers addressed in the interviews is that the use of QR codes in science education will be fun for students. One of the prospective teachers expressed their opinions on this subject as follows: *"We have designed a game about physical and chemical changes. Rather, we have adapted this subject into a popular game. On the game platform, there are sample images on the right for physical changes and on the left side for chemical changes. These visuals consist of examples that children often have difficulty understanding. For example, the formation of a rainbow, bees making honey... In this game, the children had much fun. There were students who wanted to play the same game three times. We were happy that they had fun playing. They used QR codes when they had difficulty in the games."* (P.T.11). Another pre-service teacher stated opinions in this direction as follows: *"The games designed by using QR codes entertained them a lot. It was really good to see them enjoying" (P.T.4)"*

1.1. Integration of science with technology

Another aspect that the prospective teachers addressed related to the use of QR codes in the teaching materials used in science education is that this technology integrates science course with

technology. One of the prospective teachers expressed their opinions on this as follows:*"We combine science and technology. Before I used QR codes, I didn't think I could integrate the technology with science. QR codes function as a bridge that combines the model with reality. For example fetal development stages model... In the model, we showed fetal development stages using felt. One of the sperm was magnetized. The magnetized sperm was fertilizing the egg. The QR code in the model enabled the students to watch a video showing the fetal development in the womb. I think QR codes integrated science and technology. The name of the course "Science and Technology" literally happened"(P.T.20).* Another pre-service teacher stated opinions in this direction as follows: *"For example, there is an activity book which was prepared by my friends. There are examples of mutation, modification and adaptation. For example, in a page of the book, they modelled the environment-dependent colour change of a chameleon. There was a QR code next to it. When this QR code was read, a 20-second video showing the colour change of a chameleon was started. The use of QR codes in this material can combine science and technology" (P.T.12).*

1.2. Integration of the science with life

Another aspect that the prospective teachers addressed related to the use of QR codes in the teaching materials used in science education is that this technology integrates science course with life. One of the prospective teachers expressed their opinions on this as follows: *"For example, we have designed a material on mitosis and meiosis. When the student matches the shapes correctly with the stages, the bulb will be on. Otherwise, it will not. We used a QR code to enable the students to see actual mitosis and meiosis under a microscope. It was a video showing cell division. That video aroused great interest in the children. Even the science teachers at the exhibition were interested. The videos lasted 25-30 seconds. Some of the prospective teachers were amazed at that video, saying they did not know such videos of mitosis and meiosis existed or that they saw such videos for the first time. Even I was so impressed by the video showing cell division under a microscope when I was preparing the material. After all, you see what is going on in your cells. Thanks to QR codes, science gets integrated with life"(P.T.27).* Another pre-service teacher stated opinions in this direction as follows: *"Except for a few materials prepared with QR codes, the science course reflected what is happening in our life. We could not see this only in materials where questions were written in QR codes because when we read them, there were questions in them. However, apart from them, all the materials showed that the science course actually exists in the real life, through QR codes" (P.T.15).*

1.3. Permanent learning:

Another aspect that the prospective teachers addressed related to the use of QR codes in the teaching materials used in science education is that this technology enables permanent learning in students. One of the prospective teachers expressed their opinions on this as follows: *"For example, we have designed an activity book. There were examples of mutation, modification, and adaptation. On one page of the book, we modelled chameleons' ability to change colors. Next to it was a QR code. When this QR code was scanned, a 20-second video showing a chameleon changing its color was played. This video attracted a lot of interest in the children. On each page of the activity book, we put QR codes next to models made of felts. This definitely increased memorability. The students watched the video very carefully. Some of them were so amazed that they downloaded QR code scanner application on their phones. They were happy to watch the video on their own phones. It certainly increases the permanency of learning." (P.T.2).* Another pre-service teachers stated opinions in this direction as follows: *"These materials present students with visuals. That is, when something is told we tend to forget it easily, but if something is shown to us, we do not forget it easily. When this visual is combined with a QR code, then the learning becomes more permanent (P.T.16)"*

1.4. Supports learning

Another aspect that the prospective teachers addressed related to the use of QR codes in the teaching materials used in science education is that this technology supports learning. One of the prospective teachers expressed their opinions on this as follows: "*For example, we have designed two teaching materials about organelles. QR codes contained songs, poems and visuals about organelles. We put QR codes for students with different intelligence area. For example, a child with musical intelligence can learn organelles by song, or a child with verbal intelligence can learn organelles with poetry. The model contained images of organelles. These visuals were for students with visual intelligence. QR codes facilitated students' learning. We then prepared a game on the same material. We did all this to support learning.*" (P.T.15) Another pre-service teacher stated opinions in this direction as follows: "*In some of the games, like physical and chemical change game, the student plays the game but when he/she gets stuck then he/she looks at the samples of physical and chemical changes presented through the QR codes then he/she can answer the questions more easily. That is, the student can set his/her own path of learning. If these QR codes were not there, then the students would go on without answering. But, it did not happen so. With just one click, they were able to get help from QR codes*" (P.T.2).

Category 2. The use of QR codes in the learning process

One of the aspects that the prospective teachers addressed related to the use of QR codes in the teaching materials used in science education is that QR codes can often be used in different areas in science classes.

2.1. Game-based learning

Prospective teachers stated that QR codes could be used frequently in game-based learning in science education. One of the prospective teachers expressed their opinions on this as follows:"*I will definitely use this technology when I am a teacher. Especially in game-based learning... The game will not include evaluation questions, but students will learn the topic while playing the game. Like the periodic street game. Some of the friends modelled the elements using felts. From this model, the students picked non-metals from the non-metals pouch. They had QR codes on them. The QR codes contained videos showing the use of the non-metals in daily life. Students try to find out where the elements are on the periodic street by scanning the QR codes. They learn by playing games*" (P.T.19). Another pre-service teacher stated opinions in this direction as follows: "*Play is a part of child nature. No matter how old they are, children enjoy playing. I will absolutely use it in plays when I become a teacher*" (P.T.13).

2.2. Laboratory

Another aspect that the prospective teachers addressed related to the use of QR codes in science education is that this technology can be frequently used in laboratories. One of the prospective teachers expressed their opinions on this as follows: "*We can use this technology in laboratories as well. I think this technology will function as a second teacher. Last year, for example, we used to ask our teacher in the laboratory if the screening was correct or incorrect. We didn't know what to see, so we didn't know if the screening we had found was correct. The teacher could have put QR-coded instructions. We could have checked if the screenings were correct. Similarly, we work in groups of two in the physics laboratory. From time to time, the teacher sometimes has difficulty in answering to*

us all. Too many groups... So, teachers can support their classes with QR codes in group work. Moreover, students can progress in the laboratory at their own learning pace. The fact that QR codes progress step by step is quite useful" (P.T.31). Another pre-service teacher stated opinions in this direction as follows: *"They can be used in a laboratory. For example, the teacher prepares scenarios. There are scenarios in QR codes. Then students read the QR codes in groups and then attempt to solve the problems in the scenarios. Each group can read the QR codes separately and then try to solve the problems in different ways and then present their findings to each other" (P.T.23).*

2.3. Assessment of the classes

Another aspect that the prospective teachers addressed related to the use of QR codes in science education is that this technology can be frequently used in the assessment of classes. One of the prospective teachers expressed their opinions on this as follows: *"Our material was for the assessment of classes. We have designed a bingo game. First, a student draws a card. QR codes contained questions. Then the student scans the QR code, sees the questions and answers them on the model. If, for example, the answer to the question is 'long bone', when the student places the pencil on the place on the model with the 'long bone' words, the bulb is on. Otherwise, it is not on. If the bulb is on, the student puts his/her card on the bingo card. When all the cards are completed, the student shouts "Bingo". Thus, students assess themselves and the class of that day, or teachers assess whether the lesson is learned or not" (P.T.13).* Another pre-service teacher stated opinions in this direction as follows*: "It can be absolutely understood whether the student has achieved the objective, when used for evaluative purposes. In the case of the organelles material, the teacher explains the organelles from the three-dimensional model. Then, there are questions in the QR codes about the organelles presented in the form "Let's guess who I am". If the student knows it, then this organelle is stuck onto its place. If he/she does not know, he/she cannot stick. In this way, we can understand whether he/she has learned the subject or not. Has the objective been accomplished or not?" (P.T.33).*

2.4. Assignments

Another aspect that the prospective teachers addressed related to the use of QR codes in science education is that this technology can be used in assignments. One of the prospective teachers expressed their opinions on this as follows: *"This technology can also be used in assignments. Teachers often assign tests as homework. But children are fed up with solving tests. So, teachers can assign QR-coded assignments. Students don't know what their homework is or how to do their homework until they go home and start doing it. I think QR codes should contain original questions. Students can also submit their assignments with QR code. Or students can send their QR coded assignments to their teachers via e-mail" (P.T.18).* Another pre-service teacher stated opinions in this direction as follows: *"The teacher can assign experiments that last long as homework. For example, plant germination experiment can be given as homework and students can be asked to germinate the beans at home. After students have completed the germination experiment, they can add QR codes on the plant. When they read the QR code in the class, an animation from YouTube can start showing how a plant germinates. In this way, this would be very good. I will want my prospective students to prepare their homework with QR codes" (P.T.1).*

2.5. Classroom boards

Another aspect that the prospective teachers addressed related to the use of QR codes in science education is that this technology can be used on classroom boards. One of the prospective teachers expressed their opinions on this as follows: *"If I were a teacher, I would use this technology frequently on classroom boards. Every week, I would put different QR codes on classroom boards. If the topic of that week is, for example, constellation, I would put constellations in QR codes. Or, I would put the life story of the man who invented the first telescope. Moreover, I would ask my students to do research on the topic and put related QR codes on classroom boards." (P.T.23). Another pre-service teacher stated opinions in this direction as follows: "They can be placed on classroom boards.*

They can be placed by either the teacher or students. Something can be put in relation to the unit having been studied. Even project works can be placed on classroom boards at the end of the term with QR codes" (P.T.34).

2.6. School corridors

Another aspect that the prospective teachers addressed related to the use of QR codes in science education is that this technology can be used in school corridors. One of the prospective teachers expressed their opinions on this as follows*: "I would design my material in a way that my students can use it in school corridors during breaks. I think school corridors can also be used for learning. I designed a big carpet and the twister game on that carpet. It is a game which students can play with their hands and feet. I created questions about acids and bases. On the carpet, I would put QR codes related to the properties of acids and bases and about which substances are acid or which are bases. Even the students who do not know anything about this subject can play the game in the corridor. Students first scan QR codes. Then they play the game" (P.T.23).* Another pre-service teacher stated his/her opinions as follows: *"As you know there is a Tubitak science fair organized at schools. For example, projects developed by students can be video-recorded and these videos can be placed into QR codes and then they can be displayed in the corridors of schools. In this way, all the projects having been conducted can be archived in QR codes hung on the corridors of schools. I will do it like this, when I become a teacher" (P.T.4).*

Category 3. Advantages

The prospective teachers listed the advantages of QR codes as short preparation time, easy preparation, portability, updateable, time-saving, preventing paper wastage and providing direct access to targeted information. One of the prospective teachers expressed their opinions on this as follows*: "I think its advantages include that it can be prepared easily in a short time and that it is portable. Also, the contents of QR codes can be updateable. The fact that we can change the contents makes QR codes updateable. It is quite a useful feature. By changing QR codes, we can even diversify children's learning on the same material. I think QR codes enhance the efficiency of teaching materials (P.T.35)".* Another prospective teacher stated their opinions as follows: *"I think this technology reduced wasted time and saved paper. Especially in games… The prospective teachers in the Department of Social Studies Teaching did not use QR codes at the exhibition as they did not know how to use QR codes. So, they printed a word file containing 120 questions and cut each of the questions. We, on the other hand, had written our questions in QR codes. We printed the QR codes and put them in a bingo pouch. When they saw that, they said 'We wish we had known how to use QR codes as it took a lot of time and paper to prepare the question sheets (P.T.14)."* Another prospective teacher stated their opinions as follows: *"The children may not want to read a piece of paper, but they find it very interesting to scan that paper by their phones. Next generation is the technology generation. So we have to keep up with them. Because children are not playing in the streets any more. They have tablets and everything virtual. QR codes can be a bridge to reach them; thus we can provide them with whatever information we want (P.T.9)".*

Category 4. Disadvantages

The prospective teachers listed the disadvantages of QR codes as Internet connection problems, requiring tablets or smartphones, and QR code preparation in paid applications. One of the prospective teachers stated their opinions as follows: *"If teachers and students do not have tablets or smartphones... if, for example, in a village school, there is no internet connection, how will they use this technology? I think it is a disadvantage that this technology requires tablets and internet connection (P.T.16)."* Another prospective teacher stated their opinions on this as follows: "Children may not always have the opportunity to scan QR codes as not all of the schools have tablets. Also, tablets may pose cost-related problems in education. I think there are no other disadvantages. The new generation is more open to innovations than us. They learn technology very quickly (P.T.4)."

Similarly, another prospective teacher stated their opinions as follows: "*The page where I made QR codes had a trial period. It was over some time later. So, all I did was in vain. We need to pay attention to this. There are free applications. It's better to use them (P.T.8).*"

Category 5. Effects of the use of QR codes on the teaching materials prepared

The prospective teachers stressed only two effects of QR codes on the materials prepared. Firstly they simplify the teaching materials, and secondly, they enable individual learning. One of the prospective teachers who highlighted the simplification feature of QR codes stated their opinions as follows: *"The materials prepared are simpler in this way. The hidden information in the material makes the materials simpler (P.T.1)"*. Also, one of the prospective teachers stated that QR codes enable individual learning: *"In some of the games, students first get information from QR codes, then, when they have difficulty in understanding something, they look at the examples in QR codes and continue. I think it supports individual learning. Or, QR codes on the organelle models contained songs and poetry about organelles. I think in this way, students have the opportunity to learn a subject individually whenever they want (P.T.24)"*.

DISCUSSION

The present study investigated the opinions of prospective science teachers about the use of QR codes in the teaching materials that they prepared in the "Instructional Technologies and Material Development" course.

The study revealed the opinions of prospective science teachers about the use of QR codes in science education, about its use in the learning process, its advantages and disadvantages, and its effects on the teaching materials. The majority of the prospective teachers stated that QR codes in the teaching materials aroused interest in students. They also stated that the use of QR code in games entertained the students. Yilmaz and Canbazoglu Bilici (2017) stated that the games designed with QR codes aroused interest in children and entertained them. Furthermore, some of the prospective teachers stated that QR codes in paper-based materials integrated science with both technology and life. OR codes can be embedded on educational materials such as notebooks, books and papers used in the traditional education process and can be scanned by mobile communication technologies used in the learning process (Aktas and Cayci, 2013). Thus, QR codes can direct students to the online environment from printed materials via mobile devices (Chen, Teng, Lee and Kinshuk, 2011). In this respect, QR codes form a bridge between teachers or students and information. Students can access the content on the mobile web pages directly and quickly. Thus, as prospective teachers indicated, science and technology are integrated. Some prospective teachers stated that QR code embedded materials provide permanent learning while others thought that they support the learning process. Akin (2014) examined the effect of QR code application on permanent learning to support students' learning in the context of mobile learning, regardless of time and place. Although there was no significant difference between the groups, permanent learning averages were found to be higher in QR-supported learning environments. Yilmaz and Canbazoglu Bilici (2017) also concluded their study that QR code embedded games, models etc. can contribute to the efficiency of classes where smart boards and mobile devices are used.

The prospective science teachers stated that QR codes could be used in game-based learning, laboratories, assessment of the class, assignments, classroom boards, and school corridors. Yilmaz and Bilici (2017) designed QR code embedded four games for the learning outcomes targeted in the "Solar System and Beyond; Space Puzzle" unit at the 7th grade and aimed to contribute to the literature on the use of this technology in science education. In this context, QR codes form a bridge between teachers or students and information. Similarly, in their study with prospective science teachers, Canbazoglu Bilici, Tekin and Karahan (2016) asked the participants to prepare experiment reports in the form of posters enriched with QR codes. Prospective teachers embedded videos and photos of the experiments and YouTube links of videos in QR codes on the posters. The participants stated that the

videos that they made or the photos that they took for the contents of QR codes helped them better understand the subject. Karahan and Canbazoglu Bilici (2017) stated that QR codes containing informative videos and texts about scientists can be embedded in QR codes, which can be placed on classroom boards chronologically, and that questions and answers can be embedded in QR codes in the assessment and evaluation phase of the teaching process.

The prospective teachers listed the advantages of QR codes as short preparation time, easy preparation, portability, updateable, time-saving, preventing paper wastage and providing direct access to targeted information. According to Law and So (2010), one of the reasons why QR codes are used in education is ease of use. Making and scanning QR codes are easy for both students and teachers. This enhances the use of QR codes in education. Akin (2014) listed the opportunities provided by QR codes as access to information, time-saving, rapid access to information, access to desired information without being connected to the Internet and facilitating access to online resources. Aktas and Cayci (2013) listed the advantages of QR codes as time-saving, preventing exposure to irrelevant information, access to more resources on the subject, and preventing paper wastage. According to Law and So (2010), Aktas, (2012) and Hau et al. (2013), with QR codes, it is possible to access information quickly and directly. According to Polat (2014), QR codes are becoming more and more popular due to their practical usage and low cost.

The prospective teachers listed the disadvantages of QR codes as Internet connection problems, requiring tablets or smartphones, and QR code preparation in paid applications. Akin (2014) also stated that the disadvantages of QR codes could be grouped under three headings as problems arising from devices, problems related to deformation of QR codes and user-related problems. Besides, with regards to the effects of QR codes on the teaching materials prepared, the prospective teachers stated that QR codes simplify teaching materials and enable individual learning. Leone and Leo (2011) stated that with the flexibility and personalization that QR codes introduce to the learning process, mobile devices might be more widely used in education.

According to Cataloglu and Ateskan (2014) and Akin (2014), the use of mobile technologies in the classroom environment will be of interest to today's student profile and can be considered as a step that will meet their expectations. Moreover, QR codes serve as a bridge for access to information and enable students to reach the information they need without being exposed to irrelevant information. Therefore, teachers can direct students to the resources they want by QR codes. Observations and reflections from tutors and students are positive, suggesting that QR codes have the potential to be used in the teaching and learning process (Saprudin, Goolamally, Abdol Latif, 2014).

Recommendations

QR codes can support the learning process in science education. Similarly, the use of QR codes in games may arouse interest in students. Therefore, as the participants of this study indicated, QR codes can be used in laboratories, on classroom boards, in the assessment of classes, assignments, and in school corridors to enrich and support the teaching process. Studies can be conducted to put forward further recommendations on how this technology can be used by teachers and students in the learning and teaching process. We recommend further scientific studies to examine the opinions of students and teachers on the use of QR codes to be prepared in different ways in science education. Classroom applications can reveal the effects of QR codes on students' achievements in science classes, their motivations and self-efficacy. Furthermore, further studies can be conducted to find out what to pay attention to when using QR codes in education.

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Sample materials