

Augmented Reality and QR Codes for Teaching Music to Preschoolers and Kindergarteners: Educational Intervention and Evaluation

Garyfallia Preka¹ and Maria Rangoussi²

¹MSc “ICT for Education”, Dept. of Early Childhood Education, University of Athens, 13A, Navarinou str., Athens, Greece

²Department of Electrical and Electronics Engineering, University of West Attica, 250, Thivon str., Athens-Egaleo, Greece

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Abstract: This research focuses on the use of Quick Response (QR) codes, as a part of the Augmented Reality (AR) technology, in an educational intervention for early childhood education in Music. The educational methods employed are game-based and collaborative learning within a framework that uses Information and Communication Technologies (ICT) and mobile devices in indoors and outdoors activities. A modified form of the ‘treasure hunt’ game is the canvas of the intervention carried out; the learning contents implicitly taught through the game are elements of the curriculum for Music in Kindergarten. Research questions address the learning outcomes achieved as well as the development of pupils’ collaborative skills through the implemented learning method and ICT tools, given the pupils’ age and their as yet limited reading/writing skills. Evaluation results indicate that the AR-QR technology is a powerful tool that triggers and sustains children’s interest during the learning process and can enhance their cognitive skills, their collaborative skills and their social interaction. Verification of the persistence of these results over time would require a longitudinal study on the same pupils; the findings of this case study, however, indicate the strong potential of AR-QR tools for the cognitive and socio-emotional development of children.

1 INTRODUCTION

Scientific and technological progress in the field of Information and Communication Technologies (ICT) permeates all aspects of human life, education being no exception. As ICT-related concepts, behaviours and tools are becoming de facto dominant in all the younger ages, down to early childhood, a series of issues are raised and investigated by scientists of various fields, including developmental psychology, medicine, pedagogy and education (see e.g. (Bolstad, 2004) and references therein). Today research findings concede that introduction of ICT and related tools in teaching methodology and daily school practice may be beneficial for the young learners down to preschool or Kindergarten age, conditioned upon the adoption of an appropriate framework that sets both the theoretic backbone and the methodology to design and implement teaching and learning, (see, e.g., Kalas, 2010; Mishra and Joseph, 2012).

Proponents of the introduction of ICT tools such as mobile devices (smartphones, tablets) in early childhood education point out that preschoolers are already making extensive use of such devices at home, for entertainment or communication; their adoption in school, therefore, (a) would make school and learning more attractive while (b) would let them experience a more qualitative use of these devices (Zaranis et al., 2013) – a use other than gaming, if nothing else. The essential question of whether ICT tools and methods are advantageous for the cognitive, emotional and social development at such early ages remains open to research up to now.

Along these lines, the present research is an experimental study on (a) the feasibility and (b) the efficiency of the use of ICT tools, namely mobile devices and Augmented Reality (AR) applications in the form of Quick Response (QR) codes, in the preschool and Kindergarten ages. Efficiency is measured along two axes, the enhancement of learning outcomes attained and the development of social interaction and collaborative skills. For the

purpose of this study, an educational intervention is designed, developed and implemented in a mixed preschool-Kindergarten class of 20 pupils; it is staged as a 'treasure hunt' game for teams, while the subject selected as the learning content is music (rhythm, pitch, the structure of songs, the meaning of lyrics, body synchronization to music, acquaintance to musical instruments).

- Is it feasible and realistic to use ICT in class at the preschool and Kindergarten ages, in the form of mobile devices and AR (QR codes)?
- Can the teacher exploit it to achieve increased learning outcomes?
- Can the teacher exploit it to strengthen social interaction and cultivate collaboration skills in the class?

These are the main research questions seeking answers through the implementation and evaluation of the intervention. In good agreement to existing studies, evaluation results give positive answers to all three questions, indicating a strong potential of the use of ICT (mobile devices and QR code applications) in class, as to both the cognitive and the social development of young pupils.

2 METHODS AND TOOLS

The experimental and applied nature of this study is expressed through the educational intervention designed and implemented in alignment to the research questions posed. The intervention adopts certain learning methods and tools, namely, *collaborative and game-based learning, digital games and mobile devices and the AR technology (QR codes, in specific)*, in order to teach elements of the curriculum of *Music* in Preschool/Kindergarten.

2.1 Collaborative and Game-based Learning

In Collaborative Learning (CL), a group or team of learners join their efforts and contribute their skills to achieve a common educational goal, set by the instructor or teacher. Different definitions emphasize different aspects of CL; they all stress the importance of a common goal, though (e.g., Johnson et al., 1998). CL refers to joining efforts at a level 'deeper' or more essential than in cooperative learning, where members work independently and merge results. In modern times, CL has emerged from the socio-cultural theories on learning put forth

by Lev Vygotsky and his students. The concepts of the zone of proximal development (Vygotsky, 1978) and of 'scaffolding' young learners, (Wood et al., 1976), along with those of hands-on, experiential education and active, inquiry- or problem- based learning, proposed by the New School movement in the USA (Dewey, 1991), have pushed forward modern educational methodology and practice. Social constructivism (Vygotsky, 1978) that extends classic Piagetian constructivism (Phillips, 1969) to encompass the social framework and to emphasize its role in all learning, constitutes the theoretic background for innovative educational and pedagogical methods – and for game-based learning among them.

2.2 Digital Games and Education

The role of games and game playing in the emotional, social and cognitive development during (early) childhood could not be overemphasized. As to the cognitive domain, the educational potential of games has been recognised since antiquity. '*Anyone who makes a distinction between games and education clearly does not know the first thing about either one,*' is Marshall McLuhan's famous relevant quote. The typical European curriculum for Kindergarten considers games as its nucleus.

In the digital era, digital games have taken the lead over traditional games, as expected. They have so far earned a negative reputation as causes of youth violence, addiction to playing, anti-social behaviour, isolation and low performance at school. Digital Game-Based Learning (DGBL) is the term proposed by Marc Prensky (2001) to describe '*any marriage of educational content and computer games*'. The potential of DGBL is being extensively researched both theoretically and experimentally, under various methodological and technological frameworks, (e.g., Joyce et al., 2009). Among the many obvious features of games, such as fun, pleasure, emotion, adrenaline, motivation, flow and ego gratification, Prensky lists also problem-solving skills, creativity, social interaction and the development of collaborative skills. These later aspects that connect DGBL and CL are exploited in the present research to 'build' the educational intervention around a digital game.

2.3 Mobile Learning and Devices

Mobile learning is a form of E-learning where learners use portable devices such as tablets or smart phones and wireless communication links to connect

to servers, access learning material and/or take part in educational activities. The availability of quality portable devices, in terms of audio, video and connectivity, of broadband wireless networks and of well-structured educational scenarios is critical to the success of mobile learning, according to the relevant UNESCO guidelines, (2013).

The popularity and wide use of portable devices across all ages and population groups (Johnson et al., 2013) make them an ideal tool to motivate and engage learners of all ages, (Bradley and Holley, 2011). Portability, interactivity and social networking are features of mobile devices valued in educational contexts, (Zhang, 2015). Freedom of the learner from space and time constraints is another advantage, (Giezma et al., 2013). The *learner*, the *device* and the *social* aspect should all be considered while evaluating mobile learning, (Koole, 2009). Mobile learning has been criticized mainly due to the technical limitations of current mobile devices and relevant software (small screens, overloaded functions, inadequate H/W for quality S/W, etc.).

Existing research shows that in developed countries preschoolers are familiarized to mobile devices: at the age of four, they use this technology to play digital games, watch videos, listen to music, take pictures or communicate with relatives and friends, (Plowman and Stephen, 2003; Zaranis et al., 2013). While pediatrics warn parents and teachers against extensive use of digital devices at preschool ages, (e.g., Radensky et al., 2015), a series of studies report positive results on the influence of mobile devices in learning for preschoolers, (see Zaranis et al., 2013, and references therein). Prensky has anticipated such results and has early attributed them to the preschoolers 'nativity' in ICT. Well-structured activities designed and implemented by informed and trained instructors are considered as prerequisite for successful mobile learning in early childhood.

2.4 AR-QR Technologies in Education

Augmented Reality (AR) cumulatively describes applications that combine or enhance real world with digital objects or information, typically of audiovisual form, thanks to the mediation of advanced technology (Johnson et al., 2013). Any AR technology should (a) combine real-world and virtual content, (b) offer real-time interaction, and (c) register to the 3-D space, (Azuma, 1997). As AR technology becomes more affordable and more widely available, its educational uses are increasing. Recent studies on the use of AR in various learning setups reveal positive outcomes in the cognitive

domain (language use, spatial registration), in personalized learning in motivation and engagement of learners – at the cost of a certain discomfort still caused by equipment (Bacca et al., 2014; Chen et al., 2016). Interestingly, almost 90% of the use of AR in schools is through mobile devices, leaving 7% to computer screens and 3% to special H/W.

QR codes are an extension of (and an improvement over) standard barcodes. They emerged in Japanese automotive industry around 1990 and have found widespread use thereafter, thanks to (a) the use of mobile devices, and (b) the freely available software for QR code applications development. QR codes are today the most popular AR technology in educational setups where they support open, innovative, active and inquiry-based scenarios (Rouillard, 2008; De Pietro and Frontera, 2012) with positive influence both on motivation and learning, for grades down to Kindergarten (Law and So, 2010). Kohler and Mishra (2009) warn against the mere 'additive' use of QR codes in class instead of their use in designed, authentic learning scenarios.

2.5 Music Education in Kindergarten

Music is probably as old as the mankind itself and an essential part of every known civilization, as a means for self-expression, creation, communication, entertainment, or even healing and therapy. Exposure to music in early childhood is critical to the person's relation with music in adulthood (Gordon, 1980) and musical intelligence is the earliest one to develop (Gardner, 2011): Kodály's music education system starts as early as in pregnancy, (DeVries, 2001). Bach and Mozart are famous examples of what early exposure to music, instruction in music and natural talent may produce.

Music education is acknowledged today as instrumental to the development of cognitive, language, motor, emotional and social skills in children. The major 20th century music/music-kinetic education systems developed by E.J. Dalcroze (*Eurhythmics*), C. Orff (*Schulwerk*) and Z. Kodály in Europe and S. Suzuki in Japan have revolutionized music education. They are the basis of practically every curriculum for modern music education – the greek curriculum for Kindergarten being no exception. Basic music skills sought are listening, playing/singing and composing.

In particular, teachers are guided towards launching activities that involve rhythm, melody, songs, oral musical games, combined music-kinetics, spontaneous creation or self-expression

through music and interaction with musical instruments. Young pupils are thus trained to distinguish the various qualities of sound and music and acquire basic skills on listening, understanding, reproducing, interpreting and synthesizing music.

The educational intervention designed for the purposes of this research aspires to propose an integral scenario on instruction in music for the Kindergarten, which involves mobile devices and QR codes in a ‘treasure hunt’ game activity aimed at teaching (music) without compromising fun or creativity. The contents are drawn from the high quality, cult greek radio musical program for kids ‘*Edo Lilipoupoli*’ (1976-80), by the famous composer Manos Hadjidakis and a team of talented young artists.

3 EDUCATIONAL INTERVENTION

The educational intervention is in fact a qualitative *action research* that took place in a public Kindergarten in Nea Ionia, Athens, Greece, for two weeks in May 2018. It has proceeded in phases: preparatory activities, design, implementation, evaluation. A class of twenty (20) pupils consisting of 17 Kindergarteners and 3 pre-schoolers was involved; they formed five (5) teams of four (4) kids each, while the ‘sixth’ team consisted of all 20 kids.

3.1 Preparatory Activities

In order to assess pupils’ existing knowledge and skills on (a) elements of music, (b) collaboration and (c) the use of QR codes and mobile devices, the class teacher (first author) has organized a number of preparatory educational activities in the class prior to the intervention, followed by a set of pre-test questions in each one.

- *Music*: pupils were asked to listen repeatedly to songs and led by pertinent questions between repetitions to focus on the lyrics – a skill they clearly did not have, as they were all focusing on the score. They were also asked to listen to sounds made by musical instruments and try to identify the instrument – a tough task for most of them.
- *Collaboration*: pupils were asked to assemble jigsaw puzzles in teams of four and later in teams of two, in a class-level competition with winners. Gaming activities of shorter duration and discussion on participation followed.

- *Existing knowledge* on QR codes and mobile devices and pupils’ skills in using them were assessed by interviewing pupils.

Results have been used as a guide by the teacher in designing the intervention and in adjusting the level of difficulty in each activity therein.

3.2 Design and Development

A game of ‘treasure hunt’ played by teams rather than individuals is the canvas of the intervention. Pupils are prompted to move in or out of the classroom, solve riddles, answer questions, take tests on music and thus win a prize (a piece of a jigsaw puzzle). When all teams put their prizes (pieces) together, an image of the music land ‘Lilipoupoli’ is assembled; pupils modify it to serve as the board for a ‘snakes-and-ladders’ game played by the whole class.

Riddles and tests are developed on a digital platform (Google Classroom) and accessed through the QR codes ‘hidden’ in or out of the class; pupils are led to spot them, scan them using the tablet and get redirected to the platform. To complete the tests assigned to their team, members have to collaborate and develop strategies for problem solving.

Six (6) music elements are the learning ‘targets’, one for each of the five (5) teams and the sixth one common to all teams:

1. Rhythm in music (fast / slow);
2. Voice pitch (high / deep);
3. Get the meaning of lyrics;
4. Song structure (‘couplet’ / ‘refrain’);
5. Musical instruments: classes and properties;
6. Bodily expression of music (all class dances in rhythm).

Each team in turn is asked to (a) use the tablet to scan a QR code, (b) listen to a recorded message with the rules of the game and a riddle they have to solve to spot the next QR code, in or out of the classroom, (c) scan the next QR code and get redirected to the activity and test on the platform, (d) collaborate to complete the activity, (e) use the tablet to upload answers (text, music or video) to the platform, and (f) receive the prize (puzzle piece).

Before the intervention, all six (6) music activities were developed in Google Classroom by the teacher. Free software was used to design the QR codes and link each of them to the relevant platform activity. The ‘Lilipoupoli’ music land jigsaw puzzle pieces were also designed and crafted (Figure 1).



Figure 1: The puzzles pieces (prizes) and the assembled puzzle as a ‘snakes-and-ladders’ board game.

3.3 Implementation

On the first day of the intervention, when pupils came to school, they noticed a small trunk-like case left on a chair in the classroom. When they opened it, they found a message from an unknown character, ‘Q’, who invited them to a game and explained the rules. They also discovered a tablet, a photo camera and a set of questions they had to answer (the pre-test questions, in fact). They all agreed to play and to follow the rules and got organized in 5 teams of 4.

In the following days, at a certain time within the day plan, each team in turn would play the game while the other teams would watch and offer help, comments and encouragement.

Day #1: The 1st team played while the other teams were watching and offering encouraging comments and support. They started by assigning roles; they scanned the 1st QR code, listened to the riddle that sent them to the schoolyard to spot and scan the 2nd QR code. This one led them to access the platform and listen to their task that had to do with focusing on the song lyrics. ‘Q’ asked them to listen carefully to two songs of the ‘Lilipoupoli’ record and answer questions on their meaning. After some thought, discussion and help to each other, the pupils used the tablet to type in their answers and received their prize later on, (Figures 2 and 3).

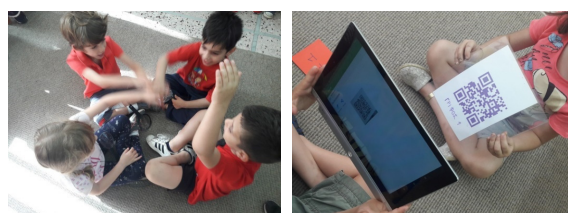


Figure 2: The first team in action: discussion on role assignment (left); 1st QR code scanning (right).

When activities of day #1 were over, the teacher would put down in the class log the observation data to be used for subsequent evaluation: details on the pupils’ activities, collaboration practices, strategies

developed to overcome difficulties and pupils’ response to the use of ICT (QR codes, mobile devices). All of day #1 phases were repeated in days #2 to #5 – the tasks varied so as to cover the six (6) music elements listed in subsection 3.1.



Figure 3: The first team in action: 2nd QR code scanning (left); their prize (puzzle piece) on the class board (right).

Day #2: The task of the 2nd team was to understand the notion of high-pitched versus low-pitched voice. They had to recognize each type of voice in a song that contained both. ‘Q’ then asked them to sing a song using both voices, record it and use the tablet to upload it to the platform.

Day #3: The task of the 3rd team was to recognize fast versus slow rhythm in a score or song. They had to listen to two songs and tag each as slow or fast. ‘Q’ then asked them to select a fast and a slow song sample and use the tablet to upload it.

Day #4: The task of the 4th team had to do with the structure of a song (couplet and refrain). They were asked by ‘Q’ to listen to a song, spot the missing refrain, sing it in due time and upload the recording in the platform (Figure 4).



Figure 4: The 4th team in action: discussion on role assignment (left); 1st QR code scanning (right).

Day #5: The task of the 5th team was to get to know the musical instruments and their classes. They were asked listen to a song and recognize in it as many musical instruments as possible. They were then asked by ‘Q’ to type in three instruments, of a different class each. They were thus trained to clustering and classification (Figure 5).

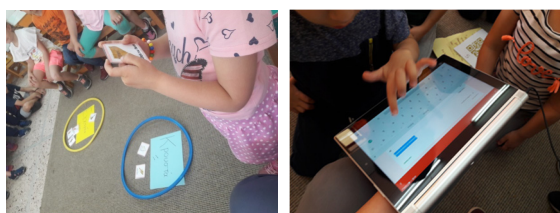


Figure 5: The 5th team in action: clustering of musical instruments (left); typing in answers to platform (right).

Day #6: The activities of this last day involved all 5 teams; each team through a representative took part in QR code scanning and listening to their task. They had to develop and practice a choreography on a familiar song, to be performed for parents and friends during the school festival before summer holidays. They all experimented and proposed various styles and movements; they then discussed and finalized it. They rehearsed the whole part and uploaded for ‘Q’ a video with parts of the rehearsal. The 6th prize (last puzzle piece) was thus won and delivered the next morning in class (Figure 6 – left).

The next day: This was planned as a day to enjoy their ‘trophy’: they assembled the jigsaw puzzle out of the prize pieces, completed it with numbered paths and stops and used it as the board to play ‘snakes-and-ladders’ on, (Figure 6 - right).



Figure 6: QR code discovery in day #6 (left); the ‘snakes-and-ladders’ game on the assembled puzzle board (right).

Follow-up: The new experiences that pupils acquired through the educational game motivated them and aroused their enthusiasm on QR codes. Throughout the intervention and up to the end of the school term, pupils would seek and discover QR codes outside the school environment, e.g. at home, and would bring them in class. They would show them to classmates and would scan them, curious to find out where they would be redirected, (Figure 7).

They thus came to understand gradually that the scope of this technology is broader than education; it encompasses commerce, entertainment, news, etc. Parents were inevitably involved on the kids ‘quests’ for QR codes at home. When questioned by the

teacher, parents expressed both their interest in the activities and their satisfaction on the engagement and enthusiasm their kids showed for the daily school activities.

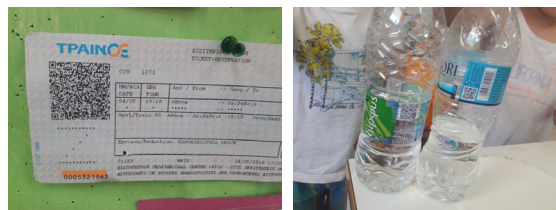


Figure 7: QR codes discovered at home on various objects and brought to school by the pupils (follow up activity).

Post-intervention activities of the pupils at school did verify their positive attitude towards the game and the QR codes technology. They freely decided to prepare drawings as farewell gifts to thank ‘Q’ for the game; they even tried to write the name ‘Q’ on these drawings, in Greek and in English (Figure 8). They brought presents for ‘Q’ and placed them in the empty trunk. Eventually, motivated by an initiative of two kids, they decided to design and develop their own similar game. They brought a new trunk in class, got self-organized in teams, constructed tests on music and music-related activities and even set up prizes. In the following days they enacted the game as a theatre play – a quite interesting, unexpected development.



Figure 8: Pupils’ drawings as farewell presents for ‘Q’. Attempts to write the name of ‘Q’ in Greek and in English.

3.4 Evaluation

The research tools employed for evaluation of the game and the intervention are

- Pre-test, delivered as a structured interview of each pupils with the class teacher;
- Observation of the pupils while playing;

- Observation sheets kept by the class teacher upon completion of the activities of each day of the intervention;
- Digital recordings (videos) of all days;
- Post-test, delivered as a structured interview of each pupil with the class teacher.

Pre-test was aimed at assessing (a) existing knowledge on elements of music, (b) existing collaboration skills, and (c) existing knowledge on QR codes and mobile devices and pupils' skills in using them.

Post-test was aimed at assessing the same three dimensions as in pre-test, in order to measure the change brought up by the intervention.

A practical limitation is that the evaluation load was carried by the class teacher alone, because it has not been possible for the school to assign an assistant or colleague who would aid in the intervention and would help the teacher in the evaluation activities. In light of this situation, the video recordings have been indispensable, valuable aids for observation of pupils' actions, interaction, verbal and non-verbal exchange. Detailed evaluation results are given in the next section.

4 RESULTS AND DISCUSSION

4.1 Pre-test (Interview) Findings

The purpose of the pre-test was two-fold: to assess the familiarization of pupils with mobile devices and QR codes, and to measure existing knowledge on basic music elements to be taught through the intervention and game.

All pupils use mobile devices regularly at home (smart phones: 13 kids (65%); tablets: 6 kids (35%); both: 1 kid (5%)); popular uses are playing digital games (70%), watching video/animation (45%), listening to music (45%) and viewing photos (20%). Knowledge on QR codes was clearly zero – which explains the enthusiasm and exploratory attitude the game aroused in them.

Their existing knowledge on music was varied: only 4 kids (20%) could differentiate fast versus slow rhythm and name known songs as examples; no one (0%) could do so for high (high-pitched) versus deep (low-pitched) voice; 18 kids (90%) confused voice type (high/deep) with voice level (loud/low or soft); no one (0%) knew the meaning of the 'refrain' (chorus) in a song. In the questions on musical instruments, 5 kids (25%) could name 3 or 4

instruments; the rest 15 kids (75%) could name 0 to 2 instruments – typically, the piano and the guitar.

The overall pre-test conclusion is that, although pupils were obviously enthusiastic and eager to answer right, they had very limited knowledge on the subject to be taught through the intervention.

4.2 Findings from Intervention Videos

All intervention sessions have been recorded on video for subsequent analysis. The use of digital media was a necessary aid for the class teacher (first author) who could not carry out the intervention and keep observation sheets in parallel. The analysis of the videos aims to document (a) the collaboration among team members, (b) their interaction and handling of adversities, (c) their progressive familiarization with the use of the tablet to scan the QR codes.

It is clear that discussions during role assignment within a team were mostly on the use of the (unique) tablet: all members wanted to hold and use it to scan QR codes. They showed more anxiety and restlessness in that than in achieving goals or answering questions.

Despite the long waiting for their turn to play, all teams and all members remained interested, focused and engaged in the process throughout the intervention, either while playing or while watching other teams play. In the rare cases of a technical problem (e.g., a QR code shot out of focus) they were all willing to help get a clear second shot.

The level and quality of team and class collaboration become evident through the videos. Dialogues or silences, the exchange of encouraging or urging comments, the offering of help and directions, or the uttering of mere comments and observations established a close and rather smooth collaboration. All teams, formed ad hoc, seemed to understand and respect the need for fair sharing of resources and for smooth collaboration as terms or prerequisites both for success and for having fun. No one would take distance from the centre of action and, on the other hand, no attempt to exclude any member was detected. They expressed their will to collaborate bodily, as they kept their bodies turned towards the centre of the team during game play.

Upon completion of their part, each of the teams would hold a discussion on the process, recall the role of each member and comment on the level of collaboration. The other teams would attend these 'debriefings' with utter interest; they got ideas that they put to practice when their turn came to play. In that sense, the level of collaboration was increasing during the game. The ultimate verification of

successful collaboration has been the completion of all missions by all teams with no dropouts.

4.3 Post-test (Interview) Findings

The post-test was held in the form of a structured interview aimed at assessing the results of the intervention on (a) the cognitive domain (learning outcomes), (b) the social domain (interaction, collaborative skills) and (c) the emotional domain (experience with AR-QR codes technology and fun during game play).

4.3.1 Cognitive Domain

Four (4) questions in the interview refer to music:

1. *Can you explain what is fast/slow rhythm in a song? Can you give an example for each?*
2. *Can you explain what is high/deep voice?*
3. *Can you think of a percussion/wind/string musical instrument?*
4. *Can you explain what is 'refrain' in a song?*

Answers are tagged by the teacher-interviewer as 'right' or 'wrong' depending on the correct or incorrect examples given by each pupil:

- The question on rhythm received a 100% score of right answers: all 20 kids could sing a fast and a slow song.
- The question on voice pitch received right answers by 17 kids (85%); 3 kids (15%) still could not distinguish high/deep pitch.
- The question on the classes of instruments received right answers by 19 kids (95%); 1 kid (5%) could not give three correct examples.
- The question on the 'refrain' was an open one: each kid attempted a definition. 18 kids (90%) gave right answers along the line '*refrain is the part heard many times in a song*'; 2 kids (10%) still could not define the term.

4.3.2 Social Domain

Three (3) questions in the interview refer to collaboration and social interaction:

1. *Have all members of your team taken part in the game?*
2. *Was it easy for you to collaborate with others?*
3. *Can you recall what your role was in the game?*

Answers are judged as positive/negative by the teacher:

- The 1st question received positive answers by 19 kids (95%).
- The 2nd question received positive answers by 18 kids (90%), who stated that collaboration was easy, role assignment ran smoothly and

that they had been glad to help others, in or out of their team.

- The 3rd question received positive answers by 18 kids (90%), who recalled accurately their role in the team; 2 kids (10%) could not state their role clearly.

4.3.3 Emotional Domain

Five (5) questions in the interview refer to pupils' experience with the QR technology and the game:

1. *How did you like the game (Not at all/A little/A lot/Very much)?*
2. *What did you liked the most about it?*
3. *Was there any point of difficulty?*
4. *Would it be easy for you to play with QR codes again?*
5. *Do you want to play a game with QR codes again?*

Answers are grouped by the teacher:

- As to the 1st question, 17 kids (85%) liked the game 'very much'; the rest 3 kids (15%) liked it 'a lot'.
- As to the 2nd question, 9 kids (45%) referred to game elements (puzzles, prizes, musical tests, etc.); 6 kids (30%) referred to the use of the tablet; 3 kids (15%) referred to playing in teams and 2 kids (10%) referred to music and the songs they sang.
- The 3rd question received negative answers (no difficult points) by 17 kids (85%); 3 kids (15%) found the musical tests tough.
- As to the 4th question, 17 kids (85%) consider it easy to use QR codes again; 3 kids (15%) consider it difficult.
- All 20 kids (100%) want to play games with QR codes again.

The final, open-type question "*What would you like to say to Q?*" was posed to investigate the pupils' overall experience during the intervention. The response was enthusiastic: '*Thanks for the game, Q!*', '*That was a perfect game!*', '*Q, send us another game, please!*' are sample answers. The drawings the pupils have prepared as farewell to 'Q', shown in Figure 8, reveal warm, positive feelings in verification of their answers to the 5th question.

4.4 Comments on Findings

The progress achieved in the cognitive domain becomes clear when pre- and post-test findings are viewed comparatively (see Table 1). In the case of musical instruments, e.g., the vague ideas and

limited knowledge pupils had before the intervention have become much more clear, accurate and detailed afterwards; new knowledge on classes of instruments has been successfully constructed. The pupils' answers to the questions on music show that through the game they did construct new knowledge on the targeted elements of music. What is most important is that, *while they did so, most of them thought they were just playing a game with a tablet* (see answers to Question 2 in the Emotional Domain questions). The educational aspect of the intervention passed unnoticed – a highly desirable situation in all educational games.

Table 1: Progress achieved in the cognitive domain.

Question	Pre-test	Post-test
Music rhythm (fast / slow)	4 (20%)	20 (100%)
Voice pitch (high / deep)	0 (0%)	17 (85%)
Meaning of 'refrain'	0 (0%)	18 (90%)
3 Musical instruments/classes	5 (25%)	19 (95%)

It is interesting that pupils valued teamwork, interaction and collaboration as a positive experience: *'it is fair that everyone can play and that we all help each other'*, as they have put it. The strongly positive answers they gave to the social domain questions may be a result of the general enthusiasm caused by the game – even so, it is important that they made such statements.

The videos showed that the game was 'pitched' at the right level of difficulty for the pupils to challenge them, gain their interest and yet be enjoyable. The technical aspects have been difficult just enough to make pupils try harder, remain engaged and get satisfaction from success. It is notable that in the post-test the majority would recall in detail the activities and personal roles and were willing to share their experience with the teacher.

4.5 Discussion

Analysis of the video recordings of the intervention along with the findings of the interviews reveals that the intervention has had a detectable positive influence on all three domains investigated (cognitive, social, emotional).

The successful completion of all missions of the game by all teams indicates that the use of AR technology and the handling of mobile devices are feasible and realistic for pupils of the Kindergarten and preschool ages. The user-friendly interface and straightforward functionality of the QR codes are well suited especially to these target groups (a) who have not yet fully mastered reading and writing and

(b) who currently hold the role of users and are therefore expected to benefit from the use of AR technology as a tool towards an educational end and not as a subject to study and master, on its own right. Usability of QR codes accounts for the active participation of all pupils and for the 'transparent' use of this technology in learning while playing. A tacit advantage is that pupils have experienced an alternative use of mobile devices at school to their standard 'gaming gadget' use at home or at leisure.

It is interesting that, despite the availability of a single tablet and the utter individuality and single-user nature of these devices that are conceived and implemented as 'personal assistants' rather than collaboration tools, the collaborative educational framework within which the tablet has been employed has dominated and has imposed a social interaction 'around the computer' and 'through the computer' character to the intervention.

The suitability of QR codes for applications in any subject has facilitated their use in the present intervention. Post-test questions on music register a positive 'delta' in all taught elements of music. This should not be attributed to QR technology alone, though: the use of technology has been in fact *blended* with standard Kindergarten practices and formulated as a *game*; moreover, the very *music* and *music-kinetic* content selected is known to be a favorite subject at these ages. Due to practical limitations of this study, however, it has not been possible to methodologically disentangle these factors and study their effects independently.

As to the positive outcomes in the social domain, apart from the very design of the intervention and the game as a collaborative activity, two influential factors are (i) that it has been clearly explained beforehand to all pupils that collaboration and teamwork are *prerequisites* for the success of any one team, and (ii) that the game was not designed to be highly competitive and to produce a single winning team; rather, all teams could become winners upon completion of their missions – which they did, in fact. This has led them to connect through experience the participatory, inclusive, collaborative behavior to successful results and to feelings of accomplishment and satisfaction.

Another limitation of this study is the lack of resources (a) to follow up the same group of pupils into the next school year, in order to establish the persistence of detected outcomes, especially in the social and emotional domains, and (b) to compare intervention results to a control group of similar characteristics, taught the same music elements without QR codes and/or without involving a game.

5 CONCLUSIONS

An experimental study on the feasibility and efficiency of AR technology (QR codes) and mobile devices as learning tools for the preschool and Kindergarten ages is presented. The study is based on an educational intervention designed as a 'treasure hunt' game, played collaboratively in teams. Research questions investigated through evaluation data refer to the progress the pupils made in the cognitive, emotional and social domain.

On the basis of the evaluation results, it may be argued that the most important outcome has been the hearty and enthusiastic participation of all kids and their full motivation and interest in the game and in the technology used. Under the cover of the game, they in fact learned new things on music and on AR technology. They also developed new strategies on problem solving, practiced collaborative behaviors and offered and received help, support and encouragement from classmates in other teams. In all three axes evaluated (cognitive, emotional, social), the pupils have showed measurable improvement, the cognitive domain 'delta' being the most conspicuous one. Instrumental to the success of the intervention have been the choices of (a) the subject of music, (b) QR codes used through mobile devices, (c) a game with riddles, puzzles, prizes and (d) the specific music content ('Lilipoupoli'), an oeuvre of high artistic and pedagogical quality ideal for these ages.

In conclusion, results indicate that the QR codes and the mobile devices may be efficiently employed in preschool and Kindergarten ages as learning tools; they show a significant potential for improving learning outcomes, for cultivating collaboration skills and for developing a positive attitude towards technology as an integral part of modern education.

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