Creative Engagement: Multimodal digital games in children's learning environment in Macau S.A.R.

Filipa Martins de Abreu
CITAR Research Center for Science and Technology of the Arts, Porto, Portugal
filipa.martins@usj.edu.mo

Álvaro Barbosa
Associate Professor
University of Saint Joseph, Macau S.A.R
alvaro.barbosa@usj.edu.mo

Figure 1: Multimodal digital games used in learning environments of children.

ABSTRACT

One of the biggest challenges that we have encountered, when trying to encourage digital games in schools, is trying to explain what its benefits are in teaching and learning environments. In this pilot experimental study we explore how multimodal audio and visual games can be used in learning environments for children, specifically by fostering creative behaviors through User-Centered design approaches.

To achieve this objective, a framework is being developed with multimodal experiences based on flexible design patterns that exploits basic visual and audio elements, allowing children from three to six years of age to play and learn through fun and subsequently trigger creative behaviors. These studies are making use of tangible objects, digital games and mobile platforms. We are making use of commercial digital games to understand and discuss the affordances of these games in an educational environment and how they support creativity in learning. (Fig.1)

CCS CONCEPTS

• **Computer systems organization** → Applied computing → Education → **Interactive environments**

KEYWORDS

• Multimodal; User-Centered Design; Creative Learning; Children; Tangible Technologies; Digital Games; Mobile Devices.

ARTECH2017, September 06-08, 2017, Macau, China
 ACM ISBN 978-1-4503-5273-4/17/09. http://dx.doi.org/10.1145/3106548.3106599

ACM Reference format:
F. Martins de Abreu, A. Barbosa 2017. Creative Engagement: Multimodal digital games in children's learning environment in Macau S.A.R.. In *Proceedings of Artech2017, Macau, China, September 06-08, 2017, 8* pages.
http://dx.doi.org/10.1145/3106548.3106599

1 INTRODUCTION

A child's learning development has three main stages (Fig. 2), starting with motor response, moving on to visual information in the form of images/icons and finally reaching a state where children use words/language to express feelings, perceptions and attitudes. Technology, (Fig. 3) on the other hand, has evolved in the opposite direction. It started with the use of text/language as a form of communication, followed by the development of graphical user interfaces (icons) and finally arriving to multi-touch, virtual worlds and augmented interactions, which are part of our lives today. Today's children need new innovative skills to be productive, creativity and collaboration are the two essential

Figure 2: A Child's learning development (Bruner and Piaget - McLeod, S. A. (2008). Bruner.)

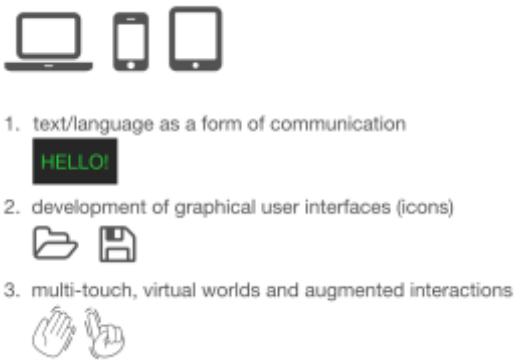

Figure 3: Technology development. (Bruner and Piaget - McLeod, S. A. (2008). Bruner.)

pillars in the learning development. Solutions involving technology can now form a bridge between Humans and their natural needs, through immersion in digital environments, rich with physical objects. Knowledge and information are changing rapidly and digital interactive experiences are progressively being studied and used as tools to address several physical and emotional difficulties during the learning process. Humans grow by tackling basic physical manipulations as part of their natural learning development.

Therefore, the cooperative and social nature of digital and tangible experiences is seen today as a vital and challenging behavior integrated in the learning development of a Human. Multimodal and augmented reality interfaces combine both the digital and physical worlds to guide actions and behaviors, providing opportunities for users to develop new/old concepts and skills. Through game-based learning, at an early stage, children effectively develop their own character and ideas by being exposed to new ways of interaction and physical flexibility.

2 CONTEXTUALIZATION

In Macau video games generally carry a negative connotation, most conservative parents believe that video games are associated with gambling.

2.1 Teaching & Learning

Macau, even though it is a territory that is open to new educational environments, is still a place where most schools consider the role of the teacher as the key holder of knowledge instead of being the facilitator. Very few schools have a different approach when it comes to the classroom-learning environment.

Some consider the classroom as a learning-by-doing approach with a very hands-on experiential methodology. The rest are still very focused on achieving the best scores by rote learning. These styles are the opposite of each other but both contain positive qualities.

In most cases, with a learn-by-doing approach, parents, students and teachers are more open to having video games as a learning tool in both inside and outside the classroom.

The apprehension of video games comes from associating that knowledge seeking, will be brushed aside in favor of the goal. Instead of finding content in knowledge, the completion of the game will take prominence. Another apprehension is that students will become more antisocial and\or violent by playing video games. [1]

"…education is not something which the teacher does, but that it is a natural process which develops spontaneously in the human being. It is not acquired by listening to words, but in virtue of experiences in which the child acts on his environment. The teacher's task is not to talk, but to prepare and arrange a series of motives for cultural activity in a special environment made for the child." (Maria Montessori, The Absorbent Mind, translated by Claude A. Claremont)

2.2 Learning & Fun

Technology has introduced various fun and innovative games that continuously provide novel challenges. Fun is one of the biggest and most enjoyable characteristic of most of the video games, since they do not only demand of players certain goals and a certain amount of skills but they also assess in fun ways the effectiveness of how they play and interact in the game while providing feedback.

Many studies focus on uncovering experiences evoked by playing digital games. [2] While games can be fun and cause positive emotions, there is an unexplored area regarding the consequences of positive emotional experiences during video game play. Playing games simply makes people happier which seems to be a crucial emotional benefit to consider (e.g., Russoniello, O'Brien, & Parks, 2009; Ryan, Rigby, & Przybylski, 2006). Experiencing self-assured feelings is a conscious inspiration that precedes play. But this is not enough for games to be implemented as tools for education.

Video games can be designed to improve the development of creativity while retaining the fun value. Offering a new generation of games that will eventually blur the lines between education and entertainment. A lot of work is focused towards investigating the potentials, [3] definition, and limitations of immersion, motivation, perception and emotion in digital games. One of the challenges of studying them is trying to define what they really mean.

However playing games is often considered a relaxed activity and gaming environments may actually nurture a tenacious, positive motivational style. This clear motivational style could reform schools and work frameworks. Players need to have designers that are sensitive and aware of their needs, be knowledgeable about the usability of concerns and be more rigorous in calculating how to create learning environments with audio and visual elements that will help the players' on improving their behaviors.

It's vital to understand and study the degree in which turning to video games to feel happier and improve behaviors is what is necessary and at what point using games becomes an evident strategy that may lead to less negative outcomes.

2.3 Schools are using Digital Games as Teaching and Learning Tools.

In Macau the implementation of video games in educational institutions is scarce. Due to that we are conducting various studies to present how video games are beneficial for children by focusing on understanding how implementing commercial video games as tools for studying contribute to a richer education.

Literacy, science, art, geography, history, mathematics, logic, communication and creativity are all areas that are positively affected by utilizing commercial games in learning environments. [4]

Some of the skills acquired by playing games are related with problem solving or negotiation: puzzle games improve judgment and analysis & strategy thinking [2]; chess games improve Communication, Networking and Creativity; Little Big Planet, Spore and Tearaway improve Narrative & Transmedia Navigation skills; Batman, Lego Super Mario Karting improve skills such as Attention, Vision and Cognition; Non-linear thinking Pattern, Grand Theft Auto. [1]

The following games have already been studied and are being used in educational environments around the world: Tetris, Sudoku, Brain Age, Portal, Hot Brain, Little Big Planet, Spore, Drawn to life, Chemicus, Re-mission, Age of Mythology, Smarty Pants, Revolution, Mario's Time Machine, SimCity, Pharaoh, Portal, Minecraft, Sims, Maps of the World, Why Ville, Angry Birds, Tiggly Shapes and Numbers, Osmo games and Cut the Rope. [2]

Not much is known on the effectiveness of these educational games in modifying behavioral or health outcomes vs the conventional methods. Medical practitioners, teachers, and researchers are not game designers, so they often develop products that miss out on the point - being fun. Students prefer commercial games as opposed to games specially designed for educational purposes. [5]

The end result is a game that looks great, but flops due to the absence of immersion, simply put, the fun factor is not present.

Because of this, new educational pedagogies have emerged that utilize game-based learning environments focusing on game design principles and play, which are progressively seen as tools for enjoying teaching and learning. [6]

There are schools already using games as major components of the learning environment, for example at Quest to Learn[3], a digital school for children, students improve their math, literacy, and problem solving skills, by playing travel agents in the fictional Creeptown game.

Another game used in schools is Oregon Trail, it started to be used in education because it showed children the realities of 19th-century pioneer life on the Oregon Trail.[4]

Minecraft Education[5] is an open platform game that promotes creativity, problem-solving and immersive environments that has the student as the center of it all being collaboration one other asset that this platform provides.

Media Molecule along with ConnectED, a branch of Sony Computer Entertainment focused on the education sector, developed LittleBigPlanet2 [6] that is one of the kits used by teachers in the classroom. The theme for the kit will be National Curriculum subjects. Physics, Math, Science, Art and History are all incorporated to help engage students in these subjects.

Figure 4: Osmo™ game system & Tiggly system

Osmo and Tiggly are two commercial games (Fig. 4) that take advantage of tangible physical objects and digital mobile devices.

Osmo is a game system (Fig. 4) created by Tangible Play, Inc. that is changing the way children learn and play with digital mobile devices (tablets). It's a game system that has earned a lot of recognition by being adopted by various schools to teach 21st century skills, creativity being one of them, (Scholastic Teachers' Pick, 2015)[7]. The Tangram game, or STEM, is a discovering shapes activity created by Osmo that children use to discover and familiarize themselves with shapes and colors. Children concentrate their energy on fun and interactive play, which focuses on the spatial environment as well as visual problem-solving skills, using physical wood pieces that interact with the images on the screen. [8]

Tiggly (Fig. 4) is a learning system that provides fun and engaging games that make use of hands-on "manipulatives" and digital software to engage children in the classroom.[9]

Both these systems are being used in schools as a tool for learning.

One of the main things that all these systems, platforms and new pedagogies provide is how creativity is an asset to take forward. [7, 8, 9]

2.4 How Digital Games can be used to Foster Creativity in the Classroom

The Osmo game system is useful for teaching and because of that, teachers have been communicating with the Osmo team telling them what they wanted, so Osmo has created a classroom kit that has been used in various learning environments. There are various games with a variety of levels that can be used in different kinds of learning environments, from K1, K2 and K3. [10] Games in school provide a good and meaningful way of learning. [10]

"We inspire creativity when we encourage young people to express themselves through writing, poetry, acting, photography, art, digital media, unstructured play, etc. When we notice and praise them for thinking outside the box and taking risks, their imaginations blossom." (Marilyn Price-Mitchell PhD).

Everyone should have access to Formal Education, but many question its methods and see it as a way to mass-produce herds of unimaginative sheep instead of original thinkers. [11]

The criticism arises because it is seen as an obstruction in the creative development. Knowledge is constantly evolving, so the tools provided have to evolve with it. A fixed education will not

[1] (https://www.instituteofplay.org/)
[2] (https://www.instituteofplay.org)
[3] (http://www.q2l.org)
[4] (http://www.hmhco.com/at-home/featured-shops/the-learning-company/oregon-trail)
[5] (https://education.minecraft.net)
[6] (http://www.mediamolecule.com/blog/article/fun_and_games_in_the_classroom)
[7] (http://blog.playosmo.com/post/128151628767/osmo-is-a-teachers-pick)
[8] (https://playosmo.com)
[9] (www.tiggly.com)
[10] (https://playosmo.com/en/schools)

prepare you for the future, due to this the education institutions will require to extensively revamp their thinking to accommodate creativity as the leading factor. Creativity needs to start as early as elementary school, placing elementary and secondary schools above university education. Primary education is being seen as: "...a critical stage in children's development – it shapes them for life. As well as giving them the essential tools for learning, primary education is about children experiencing the joy of discovery, solving problems, being creative in writing, art, music, developing their self-confidence as learners and maturing socially and emotionally" (Excellence and Enjoyment, p.4, DfES, 2003).

Educational institutions, starting as early as preschool and going all the way up to higher education around the world have taken action; creativity is regarded as core focus in their reforms. (INCA, 2009), (Vong, 2008), (Fryer, 2003).

Creativity should be acknowledged by the government and as such make it the primal force for change, but in Macau creativity in our point of view and experience is still being seen by many as something one is born with instead of being something that you can train and develop throughout life. Because of these views the implementation phase is slow, however progress has started in the form of funds for creative industries. In the rest of Asia, governments in China, Hong Kong and Singapore are already implementing creativity (creative learning) as part of their curriculums. [12]

3 OUR APPROACH

Researchers concentrate on both the positive and the difficult aspects that contribute to assessing and developing games, focused mainly on innovative behaviors, to construct various ways of assessing creativity when playing a digital game.

In our approach we will be using off-the-shelf commercial digital games to understand how creativity is tackled in the learning environment.

Our pilot study was made in Macau S.A.R. which boasts a richness in diversified cultures, such as the Chinese, Portuguese, Macanese, Filipinos, Indian, Singaporeans, and many others which makes cross-culture communication and understanding crucial in order to learn and work together. Researchers believe that this "…cross-cultural competency must be learned through practice and training" (Liu, 2014). This makes games a must to know tool for the skills of the future learning. [13]

We are conducting a comparative study in schools compromised of three different languages, Chinese, Portuguese and subsequently English, to a specific target audience that ranges from the ages of three to six.

We are exposing children to two different types of gaming systems and assess children's reactions and behaviors towards different off-the-shelf commercial digital games using an Interactive Game System (Osmo™ by Tangible Play, Inc. and Tiggly). This comparative study will allow us to understand how children behave towards these kinds of digital games in the learning environment as well as understand how they tackle actions and reactions towards creativity. One of the main specifications we are going to study is how children can comprise to be more critical and creative, in the way they think, as well as how they tend to be more creative after they have played these games in the learning environment, also demonstrating how they can be more open to different approaches and different types of learning that involve digital games as the tools that assist on successful creative behaviors.

4 METHODOLOGY

4.1 Pilot Experimental Study

In order to examine the significance of the "multimodal systems" [14] for creative behaviors in a learning environment, eighteen boys and girls aged between three and six, were observed in a similar environment. They were sat in a classroom where they played Tangram, a game that was first used in China for psychological test, although it was created for fun and not for analysis.

All of the observations were recorded for each subject from the time they began playing the game to the time they stopped.

4.2 Design

The pilot experimental study was conducted in a primary school in Macau. We focused our study in understanding how the participants interacted and understood multimodal games and how this could be implemented to nurture creative behaviors.

To understand this we made use of the Tangram game. We laser cut plywood pieces and painted them with the respective Tangram colors and sizes resembling the Osmo wooden physical pieces.

We organized the research study in three sessions, the first two sessions we used two groups of three participants from levels K1, K2 and K3. The last session was a free play environment by combining the two groups and repeating the study in all the levels.

In the 1st session, the study was done with two groups of three participants with the printed version, in the 2nd session, the study was done with the same two groups of three participants with the digital version and the physical pieces. In the 3rd session both groups were assessed together in a free play environment, which included a combination of the print and digital phases.

In the 1st session when we organized the study, the first group of three participants sat down in a random manner at the table and three sets of Tangram pieces were given to the participants with the respective Tangram image based on the 1st level of the Osmo game system. Each of them had their own set of plywood pieces and their own A4 paper where the Tangram image was printed on. The printed image pieces were the same size as the respective Tangram physical pieces.

In the 2nd session when we organized the study, the first group of three participants sat down again and three sets of Tangram pieces were given to the participants as well as the Osmo game system. Each of them had their own set of plywood pieces and together they tried to play the game.

In the 3rd session of the study all six participants from their respective kindergarten levels, got together and sat down in a random manner, they played both the paper version as well as the digital version.

4.3 Sampling

In this pilot the school psychologist pre-selected eighteen participants from different cultural backgrounds including gender and nationality. We had no control in this matter.

Qualitative Analysis – The selection was not random, the parents consent was a factor.

Quantitative Analysis – The psychologist selected all the participants, we had no interference.

The psychologist was given a set of requirements of what was needed, this included six participants from each of the kindergarten levels, K1, K2 and K3.

All the students at the specific kindergarten level were chosen after the parents had given their consent to participate in this study. A letter of consent was created in three different languages explaining to the parents what we were going to do at the school.

5 DATA COLLECTION

Table 1: Specifications of the participant's sample to be analyzed in this First Pilot Experimental Study.

FIRST DAY **K1 / 3 – 4 years old**	**SECOND DAY** **K2 / 4 – 5 years old**	**THIRD DAY** **K3 / 5 – 6 years old**
- 6 participants total **- 15 minutes each session**	- 6 participants total **- 15 minutes each session**	- 6 participants total **- 15 minutes each session**
First Group // 3 participants 1 Boy - 2 Girls **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces	**First Group** // 3 participants 1 Boy - 2 Girls **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces	**First Group** // 3 participants 2 Boys - 1 Girl **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces
Second Group // 3 participants 2 Boys - 1 Girl **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces	**Second Group** // 3 participants 2 Boys - 1 Girl **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces	**Second Group** // 3 participants 1 Boy - 2 Girls **1st Session** - print (A4 paper guideline) + physical pieces **2nd Session** - digital (Osmo game system) + physical pieces
Both Groups in a Free Play Session // 6 participants 3 Boys - 3 Girls - print (A4 paper guideline) + physical pieces - digital (Osmo game system) + physical pieces	**Both Groups in a Free Play Session** Free Play // 6 participants 3 Boys - 3 Girls - print (A4 paper guideline) + physical pieces - digital (Osmo game system) + physical pieces	**Both Groups in a Free Play Session** // 6 participants 3 Boys - 3 Girls - print (A4 paper guideline) + physical pieces - digital (Osmo game system) + physical pieces

PUBLIC SCHOOL IN MACAU S.A.R. // Background of the sample participants: Chinese, Portuguese, Macanese, Filipinos, African and Vietnamese.

We collected the data by using two video cameras and a sound recorder in the room. We have collected 135 minutes of video data as well as 145 minutes of sound data. We have analyzed the content observed based on the following parameters: time, spatial awareness, motor skills, shape recognition, flexible thinking, patience towards the task on hand, fun, difficulty, alternative ways of thinking and collaboration.

There are a wide range of responses, analysis and scores in this preliminary study and the preliminary analysis will be explained in the data analysis section.

We did not use the original pieces of the Osmo system, instead all printed and physical materials including the wood pieces were created by us and were readable by the game system. This was done so both individual and collective data could be obtained simultaneously.

The research student was the person collecting the data and all the participants had preliminary instructions and explanations on how to play the game and what the objective was.

6 RESULTS & DISCUSSIONS

6.1 Data Analysis

6.1.1 Content Analysis - Kindergarten level 1 – Day 1

Group 1 – session 1 and session 2

In this first session (Fig. 5A) study the participants were a bit scared of touching and playing the game, the first group was quite shy compared with the second group. We tried first to see how they would react without any outside interference but soon we found out that they would not touch the game if we did not explain what was needed. What we first tried was to have them relax by carefully explaining what was needed so they would not be afraid to collaborate with us. They did not know the researcher so they were reluctant to start or even talk. All three participants in the first group were very happy to be playing the game, but two of them would look at the researcher to see if what they were doing was correct. The researcher told them not to feel any pressure.

One of the participants started to play with the pieces by herself and did not pay attention to what was the goal of the game (task on hand). This was quite interesting, she was not afraid of exploring beyond the instructions given, which was something that we hoped to observe. What was important to us was how she made alternative connections between the pieces and the puzzle, and experimented with different solutions. We asked if she needed help with the game and asked the others, who had already finished, if they could help her. Both agreed to help, although one much more open to collaboration than the other. When they started to help, by placing the pieces correctly, an interesting thing happened, she said that she knew how to complete the game and proceeded to do so by herself. This means that she was making connections and seeing the relationships between the pieces and eventually finding new solutions/ideas.

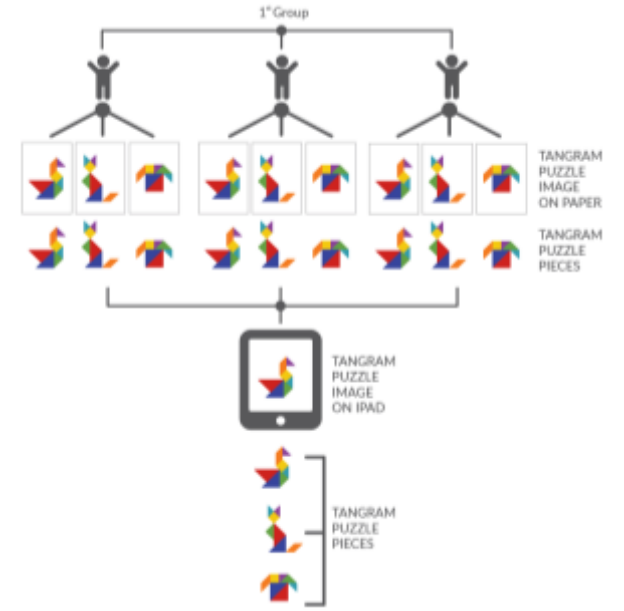

Figure 5 A: Framework for the pilot study approach, session 1 and session 2. This is an example of the study for the first group.

This setup was for all the K1, K2 and K3 experimental studies for session 1 and session 2.

Overall all the participants identified the physical pieces, colors and the puzzle images. They all understood the instructions on how to play the game clearly, but one of them wanted to explore what else could be done with the pieces.

During the second session the participants got excited and did not hesitate to play with the Osmo game system, but they did not understand how the pieces worked in context with the game. They continuously tried to position the pieces directly on the screen (screen was positioned vertically). They did not grasp the spatial/visual relationship between the pieces and the game system.

They had no trouble with the multi-touch functionality and using their index finger, however by placing the pieces on the screen and having no reaction from the game they got frustrated and eventually just focused on playing with the physical pieces. Collaboration was quite strong in this session since they tried to help each other to find a solution.

Group 2 – session 1 and session 2

In this session the participants (Fig. 5A) were calmer and quieter. The girl from this group did things fast but had trouble flipping the pieces, one of the boys also had the same problem. They knew how to complete the game with little instructions from the researcher. They enjoyed the game and actually wanted more puzzle images. One of the boys in the first session, tried to do something different with the pieces, just like the girl from group 1, he tried to find other creations for the pieces.

In the second session, even though they had a better understanding on how to interact with the Osmo game system, they still required help from the research student to find the solution for the puzzle.

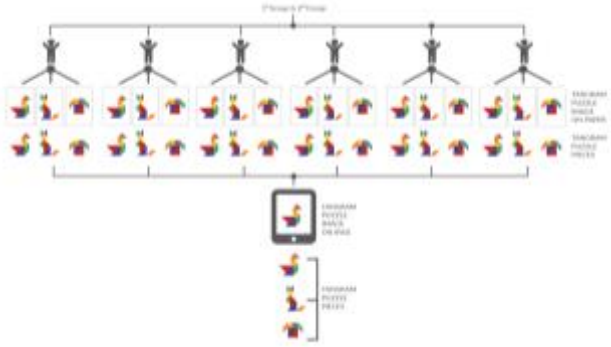

Figure 5 B: Framework of experimental study approach by group. This was the setup for all the groups in K1, K2 and K3 related with session 3.

Since they were unable to complete it alone, the research student motivated them by placing the paper image in front of the screen so they could place the pieces on the paper in order to complete the puzzle. Even though they became more enthusiastic with this solution two of them ignored the game system and tried to do something else on the table with the physical pieces.

Another observation was when two of the boys grabbed the device with the research student and positioned it flat on the table and placed the pieces on top just as they were doing with the paper puzzle guideline. At the same time they interacted with their index fingers on the screen. They did this for quite some time while the girl kept constructing her own shapes on the side, and finding new ideas. Finally at the end of the session, because they understood that the digital puzzle reference was identical to the paper puzzle reference, they asked to play with the paper puzzle again from the first session. They wanted the digital game system to work the way it was when playing the paper game puzzle.

Group 1 & 2 – Free Play Session – Collaboration

The third session (Fig.5B) consisted of a collaborative play where both groups played with the paper puzzle and the digital game system.

When they played the paper puzzle they were focused, collaborating and happy. Once they switched to the digital puzzle, while some were engaged and played together, the rest were demotivated. After some time, two participants from the first group and one participant from the second group sat down together and played both the paper and digital puzzle at the same time. However all participants in the third session were unable to complete any of the digital puzzles without the help of the research student or each other. They wanted very much to do it by themselves.

6.1.2. Content Analysis - Kindergarten level 2 – Day 2

Group 1 – session 1 and session 2

These participants, in the first session (Fig. 5A), completed the puzzle on the sheet of paper quickly. They also tried placing the pieces directly on the table using the paper puzzle as a guide. They only completed one of the puzzles and tried doing other shapes outside of what was instructed. The two girls where always engaged and the boy was distracted and tried distracting them.

Figure 6: Experimental study environment at the school, session 3.

In the second session, they were happy to see the game system, mentioning that they play with this device at home. They were able to complete two of the digital puzzles by working together. The boy continued distracting the girls but he was very active in regards to playing the game. One of the girls was calmer when playing with the other girl, together they tried finding the solution for the puzzle.

Group 2 – session 1 and session 2

In this session, (Fig. 5A), two of the participants were very calm while the other was very active and interfered with the playing of the game, the research student had to be stricter with him. Despite the interference, the digital puzzles were completed. The calmer participants helped the more active participant, who had trouble focusing, finish the puzzle.

On the second session they all worked together with just one set of pieces to play. They were able to complete various puzzles together despite being a very active session. This group apart from being one of the most active they were also one of the most experimental, since they already had experience playing with this type of device at home. The most active participant was focused and engaged when playing with the device, he understood the game visually and audibly. In fact he enjoyed sound so much, he wanted to hear sound when playing. All of them understood the gameplay and how to play. The calmest participant always collaborated with the others and tried to play each chapter of the game, providing engagement for the girl participant.

Group 1 & 2 – Free Play Session – Collaboration

In the third session (Fig. 5B) and (Fig. 6), they played the paper puzzle both individually and together and completed all the puzzles. Some wanted to play with the digital puzzle, since most of them were already used to playing this game and wanted something different.

6.1.3. Content Analysis - Kindergarten level 3

Group 1 – session 1 and session 2

In this session, (Fig. 5A), one of the participants required special attention.

They all completed the puzzles, with and without the paper. Two participants, a boy and a girl, required help from the research student and the other participant to solve the puzzles outside the paper guideline. They managed to complete all the puzzles as well as the bonus puzzle. They mentioned that they really liked to play these kinds of games.

On the second session the participants were happy with the digital puzzle. Not only did they play collaboratively, helping each other, they also swapped places so each of them could play the puzzle game alone, while being aided by the others.

Group 2 – session 1 and session 2

They all completed the puzzles, (Fig. 5A), with and without the paper. Once all the puzzles were completed along with the bonus puzzle, they played on the table without any visual guideline. They used the physical pieces to create original designs, before the second session started. Some had difficulty flipping the pieces.

In the second session they were able to play the game without issues, they understood the spatial relationship of the pieces in relation to the game system. They collaboratively played, and swapped places to play individually, helping each other completing the puzzles. This group was calm, focused and engaged. However one of the two girls was afraid of failing.

Group 1 & 2 – Free Play Session – Collaboration

In the third session (Fig. 5B) they all played the paper puzzle individually and together, they completed the puzzles. Only a few wanted to play with the digital puzzle.

6.1.4. Achievement of Outcomes

Our first intended outcome was for the participants to be able to play the game on the table by using an A4 size image paper as a guideline, and observe how they interacted with the pieces and the image puzzle. We are satisfied that all of the kindergarten levels, K1, K2, K3, could do this with almost no issues.

Our second intended outcome was to observe how the participants engaged with the game system platform, noting their age, gender and cultural background. We noticed that the participants had some issues flipping the pieces as well as identifying the colors based on their level of learning. Completion was done not individually but through collaboration.

Our third intended outcome was to observe how they would search for new ideas and solutions.

We are satisfied that all the kindergarten levels, K1, K2, K3, were able to show that their imaginations went beyond of what they were seeing and hearing. They knew what to do with the puzzle pieces but they also found new ways of creating new designs and have new ideas using the same pieces.

This study also showed that children in this age group are quite creative and imaginative. We hope they keep nurturing these skills throughout their life.

7 CONCLUSIONS

In summary, in this paper we have described a pilot experimental study where we introduce multimodal digital games to three kindergarten levels, in a primary school in Macau S.A.R.. We also learned that in this public primary school digital mobile devices are not used in classrooms as learning tools.

We used a commercial out-of-the-shelf game system that is already being implemented in learning environments and educational curriculums around the world. We have gathered data in this preliminary study that gives us insights into how children

interact with digital devices and physical objects in the learning environment.

We have also learned that this digital system has a great impact in engagement when it is being used in a collaborative environment. Also, that creative behaviors surface once freedom is given to children in a specific dynamic environment. Collaborative engagement is observed as strongly supported when games are used in these environments. Children when exposed to new interesting, fun and challenging environments will create different solutions for the task on hand.

This was a preliminary analysis of this pilot experimental study. Our future work will consist of deeper analyzing this pilot experiment and use it as the basis of understanding how creative engagement can be implemented in other more complex studies.

At this current stage we are developing surveys and questioners for teachers, students and parents to further understand what are their behaviors in a learning environment at school and a learning environment at home, when using mobile digital devices. We are organizing a second experimental study, located in a private school, to further collect information on creative behaviors, for the purpose of comparing and analyzing both different learning environments in Macau S.A.R.

Having this data analyzed, compared and understood we will continue to explore new ways of incorporating multimodal digital games in learning environments in Macau S.A.R..

Taking these studies in consideration we will develop a proof of concept framework, to be evaluated by Human-computer interaction and child Psychology methodologies that uses multimodal experiences based on flexible design patterns.

ACKNOWLEDGMENTS

This work was partially supported by Carlos Sena Caires, Gerald Estadieu, Daniel Farinha, Marco Leong, João Cordeiro, Tomé Quadros, Karen Tagulao, Rui de Abreu. Thank you to my family.

REFERENCES

[1] GREITEMEYER, T. AND OSSWALD, S. 2010. Effects of prosocial video games on prosocial behavior. *Journal of personality and social psychology 98*, 2, 211–221.

[2] GRANIC, I., LOBEL, A., E, C.M., AND ENGELS, R.C.M.E. 2014. The benefits of playing video games. *American Psychologist 69*, 1, 66–78.

[3] NACKE, L.E. AND LINDLEY, C.A. 2010. Affective Ludology, Flow and Immersion in a First- Person Shooter: Measurement of Player Experience.

[4] SANFORD, R. AND WILLIAMSON, B. 2005. Games and learning/A handbook from Futurelab. 30. https://www.nfer.ac.uk/publications/futl27/futl27handbook.pdf

[5] BAKAR, A., INAL, Y., AND CAGILTAY, K. 2006. Use of Commercial Games for Educational Purposes: Will Today's Teacher Candidates Use them in the Future? *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006*, 1757–1762.

[6] LEE, JOEY J. 2009. *Understanding how identity supportive games can impact ethnic minority possible selves and learning: A design-based research study*. The Pennsylvania State University.

[7] SCOTT, C.L. 2015. The Futures of Learning 3: what kind of pedagogies for the 21st century? *Education Research and Foresight*, 1–21.

[8] LENTO, E.M. Transforming Education for the Next Generation A Practical Guide to Learning and Teaching with Technology. http://www.intel.com/content/dam/www/public/us/en/documents/guides/transforming-education-next-generation-guide.pdf

[9] ROBINSON, K., AND LOU A. 2015. Creative schools: Revolutionizing education from the ground up. Penguin UK.

[10] GROFF, J., HOWELLS, C., AND CRANMER, S. 2010. The impact of console games in the classroom : Evidence from schools in Scotland. *Learning*, 98. https://www.nfer.ac.uk/publications/FUTL25/FUTL25.pdf

[11] SHAHEEN, R. 2010. Creativity and Education. *Creative Education 01*, 03, 166–169.

[12] LIN, Y.-S. 2011. Fostering Creativity through Education: A Conceptual Framework of Creative Pedagogy. *Creative Education 02*, 03, 149–155.

[13] MCGONIGAL, J. 2010. *Future Skills Update and Literature Review by Institute for the Future – IFTF*.

[14] BERTI, S. AND PATERN, F. 2005. Development of multi-modal interfaces in multi-device environments. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 3585 LNCS, 1067–1070.