Math Runner :The development of serious games in education in Sarawak, Malaysia.

Alexios Katsimpas
a.katsimpas@student.vu.nl
Vrije Universiteit
Amsterdam, Netherlands

ABSTRACT

This project discusses the design of games as an educational tool in Kuching, Sarawak in the Borneo island of Malaysia where internet connection is poor and sometimes non-existent. The project's goal is to develop a game for school students in Kuching, Malaysia taking under consideration their needs and their preferences. Interviews with local students and teachers were conducted in order to assess relevant information about Malaysian education.

KEYWORDS

educational games, ICT4D, game development, Mathematics, developing countries

1 INTRODUCTION

Digital divide is still a major problem in many developing areas. In rural areas of east Malaysia internet connectivity and modern technology are poor and oftentimes non-existent. Education is heavily affected by this divide. Many Students in Kampungs not only have to walk thirty minutes daily in order to access their school but also most of them face difficulties in school subjects like Mathematics, English and Science. In order to increase the educational level of the students in rural areas, educational platforms should be developed. Today, books are the only available resource for studying. There are many platforms that could help students with assignments and homework, however these platforms require internet connection. Following the ICT4D framework, an user-driven approach to development, this project attempts to introduce an offline gaming platform that provides educational content in order to help kids in Kampungs perform better in Mathematics.

2 PROJECT JUSTIFICATION

From our first day in rural areas of Sarawak, we understood that young students face difficulties with Mathematics. Nowadays, there is an important number of educational games and applications online, however, the internet connectivity in most of the kampungs in Sarawak is low and sometimes non-existent. Therefore, we decided to create an offline game for smart-phones where kids will be able to practice their math skills. Examples of skills are learning the basic mathematical operations like multiplication, division. This project is considered valuable in two ways. Firstly, some of the students have their own smart-phone and even the ones that have not, they use daily the smart-phones of their parents. Secondly, most of the teenagers in the villages desire to work in shops as cashiers or sellers in order to make extra pocket money to support themselves and their families.However,we noticed that even the secondary school students have problems with calculating even the simplest multiplication functions.We understand that this transition from students to employees might be hard for the kids but we believe that through our game we can contribute to an easier transformation.

3 RESEARCH QUESTIONS

- Which are the basic principles,that someone should follow when creating a serious game in developing countries?
- What are the needs and preferences of Malaysian students and teachers when it comes to educational games?

Methodology

This research investigates the ability of serious games in helping young students to improve their skills in Mathematics. Based on the Interviews that were conducted during the context analysis and the literature review, we found vital to examine this topic by developing and testing an actual prototype of a serious game.Since, we are not professional game developers we understand that building a game from scratch would take a lot of time and the result may not be sufficient. For that reason, we used Unity which is one of the most famous platforms for game developing. We used a pre-developed environment and focused on the implementations of the suggestions from the actual game users, since our main focus was to understand students' needs and collaborate with them in order to deliver the most effective result. User feedback was really important during the whole process and that is why we used agile methodology. That means that whenever we implemented something new in the game , a testing session followed in order to get students reactions and preferences and improve the game. Even though many participants took part in the process, a quantitative

research approach would be wrong. Our research is focused in young students between the age of 10 and 16. However, during our time in Kuching, Malaysia we had to interview and interact with kids from all age groups. Putting all the participants in wrong groups would affect research's integrity. So, we decided to follow a qualitative research through unstructured interviews, trying to analyze real life experiences. Also for this thesis we followed the ICT4D 3.0 approach and framework. ICT4D 3.0 is a collaborative, iterative, adaptive approach and framework for designing and building information systems targeted at marginalized groups. It consists of five stages, of which I used the following four as a guideline along which I constructed my thesis:(i) context analysis, (ii) needs assessment, (iii) use case and requirements analysis, (iv) engineering and testing.[1]

Interviews

As mentioned earlier many interviews were conducted in order to answer our research questions and to be able to create a game that would make an impact.

- Over 40 students aged between 8 and 18 were interviewed.
- 5 teachers and the principal of a Chinese school in Kuching.
- 1 Mathematics teacher from a Greek primary school.
- 1 professor from University of Sarawak in Malaysia.
- 1 experienced mobile game developer

Throughout these interviews our main goal was to find out what are the students' preferences when it comes to gaming.Some important findings were that 80 percent of the students enjoy music and sounds when they play a game.Also , when it comes to game characters the students preferred animals and superheroes.Between quiz and action games the older kids chose action games while quiz were more popular among the youngest.In addition, all of the participant told that they prefer a game where they can compete with their friends.You can find some of the more structured interviews that were conducted, in the Appendix.

4 LITERATURE REVIEW

In order to answer our first research question we conducted literature review on previous studies and we found 8 basic principles that everyone who wants to create an educational game should take into consideration.

Successful learner

When it comes to game development for educational purposes it is highly important that the students are able to be successful learners. Successful learning refers to a number of habits which will lead the user to gain skills and be independent as a student.[2] A substantial learning environment can contribute to the engagement of the kids and help them be part of co-operative, collaborative teams. Family and teachers should encourage young students to be part of conversations in the class and overcome their shyness in order to strengthen their critical thinking. When people play games, they exercise their brains. Learning through games is not even a question nowadays, however studies have shown that when students are part of the development process, not only they gain new technical skills but also, they are extremely motivated to actually play the game. This process is known as 'learning by making'. Before creating a serious game ,designers should make sure that users are ready and eager to be successful learners.

Motivation and Engagement

Another crucial part of games in the motivation and the engagement of the user.Are there any tricks to enhance them?As we mentioned many times in this paper, kids all around the world are familiar with famous commercial games. Which means that educational games often become boring and monotonous.It is crucial for the developer to use tactics , environments, characters and elements from established games in order to arouse kids' interest. Some well-established and suitable instructional principles that were developed by famous researches are shown below[3].

Gagne's Nine Events	Keller's ARCS Model
Gain Attention	Attention
Inform of Objectives	
Stimulate Recall	Relevance
Present Stimulus / Lesson	
Provide Learner Guidance	Confidence / Challenge
Elicit Performance	
Provide Feedback	Satisfaction / Success
Assess Performance	
Retention and Transfer	

Figure 1: instructional principles

All these principles need to be taken under consideration by the game developers.Elements like rewards, missions, challenges can help keep the users motivated and engaged.

Understand your audience

One of the biggest challenges when it comes to game design is to understand in depth the target audience. It is very important to specify the exact age of your target group and examine their educational level. This should be done with the help of the teachers and the parents. For example, when you design a serious game for kids aged between 8 and 12

you have to make sure that the game can offer value to everyone in this group. Usually game developers tend to create games which can be extremely hard or easy for a big part of their target group.[4] Another interesting factor is the technology. It is common that kids these days are familiar with many technological concepts and devices. However, when we consider underdeveloped cities and rural areas it is essential to find out to what extent kids use technology not only in school but also in their household.

Users as part of the designing process

A question derived from previous studies about games in educations is, if the potential users (students) could play a significant role in the designing process and how this could be accomplished. One way to achieve that is to let users create their own game. According to Jill Denner's study where middle school girls created their own computer game, this process has a lot of positive impact to the students.[5] The students are able to learn not only from the game itself but also from the whole process of developing, where they are getting familiar with computer science concepts. However, this process usually takes months and the project should always be guided by an experienced professor in game development. Also, Denner's research found out that the students who have not prior knowledge to programming need more extensive support from the teachers and often lack motivation. Another way to include users as part of the game development process is taking under consideration their preferences about parts of the game like the design of the characters, the names, the scenes etc. When designing computer games, students take part in the designing process they become not only learners, but also creators rather than just consumers of the games[6]. The majority of the kids who took part in the game design process, developed emotions like excitement, happiness or felt smart and proud[7]. The above findings, underline that the cooperation between the students and the game developers is a highly pleasant and satisfying task which enrich the motivation of the students.

Classroom vs Home

Games in class or games at home? Games with teachers or games with parents? This is one important dilemma that the game developer should answer. Video games in schools is not a modern term, actually this subject is researched during the last 30 years. We can consider gamification in education a controversial thing since many educators find the use of games in class helpful while others believe that games have only a negative impact.[8] Our opinion is that educational games could take place in class. 'COULD NOT SHOULD'. Young students love video games for years. During the last years where the mobile games are all over our society this opinion has skyrocketed. Mobiles brought gaming into the bus , the family yard , even in schools during the break. For example, over 90 percent of U.S teens owning smartphones which means that is pretty hard to find a young man or woman who is not familiar with game applications.[9] It is essential for experts to find the right balance between gaming and learning. It is important to consider that gaming in general is a voluntary process. Players do not react well when someone tells them how or when to play. Games can be beneficial both at home and class. However, teachers and parents should understand the process of gaming and there to help and not pressure the users to play with restrictions(when,where,how).

Gender differences

It's a football game..its obviously for boys. If I started playing the game, Joe would basically describe what to do, so he'd be like, you've got to press that to do that and that. This is a sentence from Lorna, a girl which was part of a study that examined gender differences in video games.[10] However, when Lorna played the game she was extremely competitive without any previous knowledge. Sometimes there are many stereotypes following specific games generated by the marketing, the title and the users itself. When we want to develop a game with educational content it is important to take into consideration all the preconditions that boys and girls tend to desire before playing the game. The goal is to evoke the curiosity of all students. Another essential factor is gameplay time. There are numerous studies which claim that boys dedicate more time than girls to playing digital games. This happens for a number of reasons. Games in general, consist of context like scripts, texts, images, characters, styles, stories. All these parts usually are gender related. A study by P. Bonnano in 2010, which examines gender differences between Maltese and Swedish students shows that in every group, males dedicate more time to playing games than females.[11] If we combine time and preference, we can see that there is a high percentage of female students who prefer games with puzzles and with managerial concepts which arouse personal 'solo' challenge. On the other side, male students tend to prefer games with role playing, speed and 'multiplayer' mode because they enjoy challenge and social interaction at the same time. Another study by Mable B. Kinzie suggests that emphasizing in a explorative and problem solving play seems to attract both males and female students.[12] That is why, when we examine a serious game which can be used for educational purposes, it is vital to include concepts and context which will revolt both female and male users to play.

Cultural differences

When you design a serious game, you should always have in mind the cultural appropriation. In general, the vast majority of the popular video games contain violent scenes which can possibly lead to aggressive behaviors.[13] In educational games violence is not an option. However, the developers should always conduct research and not overcome other cultural boarders.[14] For example, in India cows are considered a sacred symbol of life that should be protected and treated with respect. Imaging the negative impact that a game in schools could have, if it would contain scenes where cows are presented in a humiliating way. Another important factor is the dress code of the game's characters which can also cause problems in some countries where religion is a vital part of students' life. Additionally, the inequality of male and female characters for example in power or speed in a game can lead to appropriation. Appropriation in educational games can lead to stereotypes which might affect the way the students understand society.[15]

Video games VS Serious Games

Why most of the educational games that are developed for use in classroom fail over time? It is because it is quite hard to find interest and become engaged with video games that have a poorly designed game play (Educators trying to develop a game) or a poorly designed educational experience(Gamers trying to create educational content). In these games entertainment comes in the second place after learning and this is something that users do not like. Students even in the most rural areas are familiar with the commercially leading games, so it is important for us to combine fun and learning at the same time without the one overpowering the other one. Have you ever heard of Minecraft? Minecraft is one of the most famous video games with over 100 million active users per month [16]. Teachers around the globe are using this game as a way to engage students in their learning process and promote creativity and problem solving in a universe they already know and love. How is this possible? It is with Minecraft education edition which is like a environment for learning that is based on the actual game. It combines scenes from the actual game with educational material which is designed to promote exploration of real-world situations in imaginative worlds , digital skills and social-emotional skills.[17].

5 USE CASE DESCRIPTION- MATH RUNNER

Talking into account the previous principles and also the interviews with the students and teachers from Malaysia we our going to present our Use case Math runner.

Figure 2: ICT4D

Name

Math Runner: Exercise Maths through gamification. The name of the application is "Math Runner", derived from the words "Mathematics" and "Runner" which is the main capacity of the character of the game.

Summary of key idea

After our visits in the Kampungs, our key idea was to create an offline game for students aged from 10-16 years old in order to exercise in Mathematics. Our goal was to implement the two basic operations in Mathematics which are vital for the students and considers the two hardest. Because the educational level of the local students varies, we considered important that our game contains all difficulty levels of these two operations.Also, it is vital that the content of the Mathematics can be updated or changed easily.On top of that, we wanted to create appealing visuals in order to raise students interest and follow the 8 basic principles that were described previously on the paper.

Actors and goals

Stakeholder	Operational goal	Responsibility in the system
Students	Improve their skills in mathematics	Play the game. Inform teachers when they feel the content is irrelevant.
Teachers	Provide an extra studying resource for students. Be informed of whether the content of the game is suitable for kids based on the current curriculum.	Prepare content based on the curriculum or the students' needs.Ask Unimas for improvements.
Parents	Improve the educational level of their children.	Provide their smartphones to the kids in order to play the game.
Unimas	Improve education level in Sarawak	Provide STEM in the box and technical support of the game

Figure 3: Actors and goals

Scenario script

The student opens the Math Runner application in his smartphone or in an OLPC XO laptop. The system offers a menu with three options(play,leaderbord,settings,store). The user can choose either one. If he chooses to play, then the game starts.The user starts running and try not to hit the obstacles.If there is a hit then a question pops up.The user has 3 possible answers to choose.If he answers correct he continues the run.If the answer is wrong the game ends. While playing the system offers the possibility to the user to pause the game. After pausing he has two options, to restart the game,or quit and go back to the main menu . While player is running the high score increases and also is able to collect rewards.The user can save the high-score with his name in the leaderboard and compare it with other users.There are also missions where the user needs to gather specific elements in order to get some rewards.

Main scenario:

- The user enters the game.
- The service offers a menu with 5 choices (run,leaderboard,store,mission,settings).
- The user selects run.
- The service provides the game platform.
- The user starts playing.
- The user selects leaderboard.
- The service offers a board with saved high scores.
- The user selects an settings.
- The service offers a choice to remove sounds.
- The user selects missions.
- The service offers different mission in order to get a reward(e.gather 10 stars during game play).

Use Case Diagram

The use case diagram for Math Runner game is displayed below. The goal of this diagram is to present how the actors relate and interact within the system. The school students, should play the game and practice their Mathematical Knowledge.Since gaming is something voluntary the platform should offer gamification aspects like all the commercial video games in the market, so the students stay motivated and engaged. The teachers, as well as the parents can check the performance results of the students. Moreover, the teachers can also check the content of the exercises, make edits and adjustments to follow their needs.Those changes can be updated in the system by Unimas.

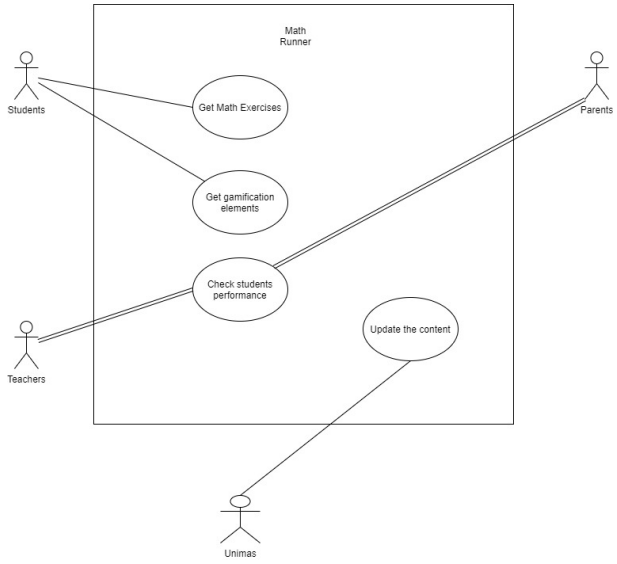

Figure 4: Use case diagram

Technology Infrastructure

Our game application will be hosted in STEM in the box.Based on the interviews that we conducted in the kampungs we strongly believe that a smartphone game is the best solution, however it will be possible for the game to be implemented in OLPC XO's or even in modern laptops. The users will have to connect to STEM in the box and download the application only once.

Cost considerations

For our game, there is only one resource required that costs money. The application should be accessible through a STEM in the box device, which is a low cost credit-card sized computer that plugs into a computer monitor and can provide a local internet connection.For now, Unimas can provide us the device however, if schools and students want to have access to the game in the upcoming years, the schools should

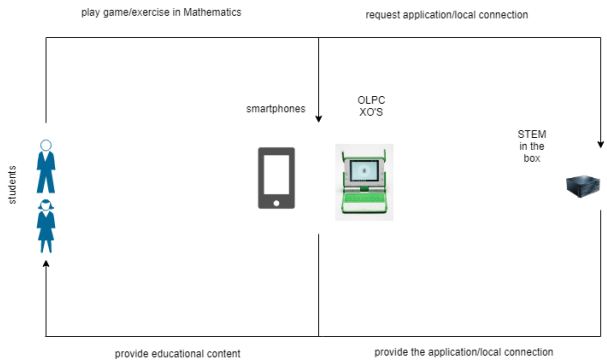

Figure 5: Technology Infrastructure

purchase it. However, this cost is not related directly related to the game. The application is already developed and ready to be deployed. Another cost which is also not directly related to our application is the cost of the smartphones or the laptops in order to play the game. Based on our research we can assure that even in the most rural villages of the city, there is at least one smartphone per family.

Feasibility and sustainability

When it comes to technical feasibility all that is required, is a STEM in a box platform which can be easily installed in a computer in a primary school. Then the kids, the teachers or even the parents can connect to the device and download our application. The most challenging part of the game when it comes to sustainability is the mathematical content of the game. During this stage, the application contains content based on two basic mathematical operations multiplication and division. However, we believe that it would be helpful to implement more mathematical methods based on the school curriculum. Teachers can prepare relevant materials for the game based on their curriculum, but the implementation of new content can only be done by people with coding knowledge. We strongly believe that UNIMAS students are able to provide technical support in the upcoming year and add content to our platform. UNIMAS continuously do projects with Kampungs, so we believe that the university can provide resources for the continuation of the game. Also, students from UNIMAS were involved in the development of the game. Even if it looks like the game is totally depended on the university we do not consider it as a major problem because UNIMAS was closely involved during the whole project.

Key requirements

An important part of the ICD4D 3.0 is the identification of the key requirements. The requirement analysis is vital for the successful development of our game. All the requirements should be documented and associated to the needs of the users.The next picture illustrates which are the key requirments to our system, using the MoSCow method.

Must have	*Should have*	*Could have*	*Won't have*
Educational Math content	Math content should be based on the Malaysian curriculum	Check performance section Easy methods to add/change content	Advertisements.
Offline availability	Gamification aspects like sounds and visuals	Rewards	In-game purchases
Math content must be based on students' needs	Multiple choice questions	Ability to create a personal profile	Material different than mathematics
Math content must be divided into levels based on difficulty	Check performance section	Time spent on the app	

Figure 6: Key Requirements

6 REPORT OF USER TESTING

As mentioned before the actors of the game is the most valuable piece of our development process.Below we describe the testing sessions that took place in Kuching and the improvements that were made in our prototype game.

Figure 7: Testing sessions

Testing cycle 1

During the first week, we visited kampung Muhibbah to interview some primary school students and test our prototype game Math Runner. At that point, only the subject of the addition was implemented in the game. A total of six kids were playing the game for almost one hour. All six students liked the game however addition was quite easy

for all of them and they asked us to implement other mathematical operations in the game and especially multiplication and division, which they found difficult. The kids also mentioned that they would like to have a personal high score while they playing the game, so they can compete with their friends.Two days after we visited kampung Pinggan Jaya, a small village nearby kampung Muhibbah, to test the same prototype of Math runner. 15 kids played the game for two hours and gave us valuable feedback. Most of the kids asked us to implement other mathematical operations in the game. Some of the young students (age 8-9) had problems with the addition and they were just pressing buttons on the screen without knowing the answer. Also, some of the kids could not understand some basic signs on the game. In contrast, older kids (11+) found the addition part very easy and told us that they would prefer more difficult exercises.All kids were asked to select their favorite character and also their favorite game elements from a wide variety that the platform we were using, offered.

Improvements 1

After our first two testing sessions, we tried to improve our game platform based on kids' feedback and our observations. We implemented mathematical exercises for other mathematical operations also, so the students would be able to practice not only in addition but also in subtraction, multiplication, and division. Also, we added different characters and game elements like cars and objects so the platform would be more appealing to the kids.We also added the high score.

Figure 8: Testing Session

Testing cycle 2

During our second week, we visited SJK Chung Hua Batu 4 1/2, a Chinese school in Kuching. We presented the game to five Mathematics teachers and to the principal of the school. After our presentation, we interviewed them in order to get feedback about the gameplay and all the features that they would like to see in the platform. The teachers proposed a section where the users would be able to see their score which would help also the teachers to see which kids perform better.In addition, they mentioned that it would be helpful for the kids to be able to answer again the exercises which they previously answered wrong.All the kids were asked again to select their favorite game elements that they wanted to see in the game.

Improvements 2

After our visit to the Chinese school and the discussion with the math experts, we tried to implement two important sections on our game.First we made the math questions to be repeated after a while.That means that when a user answers wrong , he will have the chance to answer correct some minutes later.Also we made the game endless.That means that as long as a user answers without mistakes can play without a time restriction. These changes can help students to study maths through a fun way and also keep them motivated.

Testing cycle 3

During the third week and after all the game improvements we visited kampung Pinggan Jaya again for another testing session with the kids. 15 kids played the game for two hours. We understood that the level of the kids in maths varies. While young students had problems with the exercises, the older kids performed better. All students agreed that they prefer playing the game on smartphones than on laptops.Also, We showed them a tutorial part where they could watch videos related to Mathematics but most of the kids seemed interested.Another important information was that the majority of the kids told us that the speed of the game was quite low.

Figure 9: Testing Session

Improvements 3

Based on the feedback of Pinggan Jaya students we added a variety of multiplication and devision questions in the game.We removed addition and subtraction since it was to easy for the users.We also used mathematical equations from school books.With this addition, we made sure that the game can provide useful math exercises for not only the kids in kampungs but also for the kids in the city. Moreover, we increased the speed of the game since users find it more appealing.

Testing cycle 4

Our last testing session took place in the Chinese school, SJK Chung Hua Batu 4 1/2. A total of 20 primary school students, from 8 to 12 years old played the game. The standard of the kids was quite high compared to the kids from the kampungs.The majority of the students was really efficient in Maths. Also,they told us that they would prefer a higher speed in the game. We can also say that the students were not interested in the addition of a tutorial section and focused only on the game-play. Moreover, most of the kids asked us if they can download the game at their personal computer at home.

Figure 10: Testing Session

Improvements 4

After the last testing session in the Chinese school, we tried to make the game more appealing for the students.We implemented the character , game elements and sounds that kids chose.We did not add the tutorial section but added a missions section.For example, solve 10 questions without any mistake to gain a reward.We also changed the gameplay.We removed lives and decided that when the users answers wrong the game will be ended.This made the whole game more challenging and we believe made the kids more engaged.

Figure 11: Testing Session

7 FINAL PROTOTYPE DESCRIPTION

For the use case that was previously described, an educational game was developed for children in Kampungs to exercise Mathematics in a playful way. The game can run in many platforms offline, however after our visits to the Kampungs, we strongly believe that smartphones are the best solution, since all children are familiar with smartphone-games and the majority of the families own at least one mobile device. The users must download it only once through STEM in the box. The application is named Math Runner. The basic concept is that a cat is running and it has to avoid the collision with the obstacles. In every obstacle there is a mathematical exercise that the user needs to answer to avoid it. The game provides exercises for basic mathematical operations like division and multiplication. It is possible to change the content of the exercises and include other mathematical methods according to local requirements in different Kampungs. After our testing sessions we saw that the kids are really interested in these kind of games and we strongly believe that our application can be quite popular among the students not only in the Kampungs but also in the city.

Tool

For the development of the game we used a platform called Unity3d. Unity3d is a cross-platform game engine developed and introduced by Unity Technologies, in June 2005. Today, the game engine can support more than 25 platforms. Unity offers both free and paid services and it is the one of most famous game engine for game development worldwide. Also

with Unity3d it is possible to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, as well as simulations and other experiences. We used the 2D platform to develop our game.[16]

Menu section

When the user opens the application, a start menu shows up. The menu consists of five basic elements. On the lower part of the menu the user can see the main buttons. The leaderboard button, the run button, the store button, the missions button and the settings button. In addition, the logo of the application is located on the top-center part of the menu. On the top part of the menu there is also a section where the high-score of user's activity it is presented.

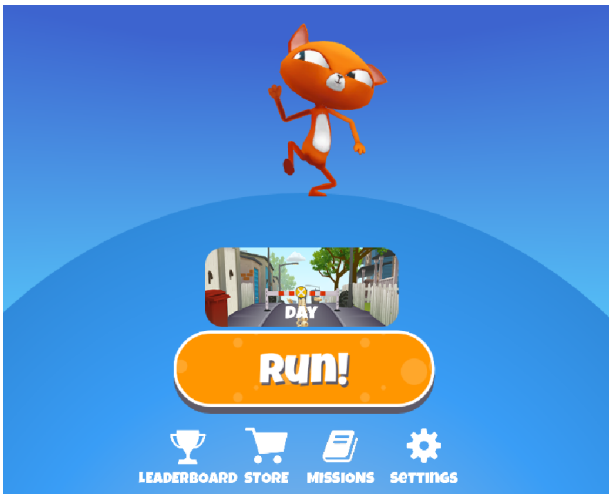

Figure 12: Menu

Playing

The user starts running and try not to hit the obstacles.If there is a hit then a question pops up.The user has 3 possible answers to choose.If he answers correct he continues the run.If the answer is wrong the game ends.

Figure 13: Running

Leaderboard section

In the leaderboard section there is a board where the player can see the high score.We consider this section vital because kids love to compete with each other and keeps them motivated.Also a big score indicates a great performance not only on the game but also in Math exercises.

Figure 14: leaderboard

Mathematical Content and Difficulty

After multiple interviews with students, teachers and also parents we decided to implement mathematical exercises based on school curriculum.We added equations with a range of numbers between 1 and 50 which can generate both easy and difficult questions.Figure 19 shows the part of the code were the questions are created.This is really important because it is easily adjustable and people with minor coding knowledge are able to add their questions based on their needs.

Figure 15: multiplication question

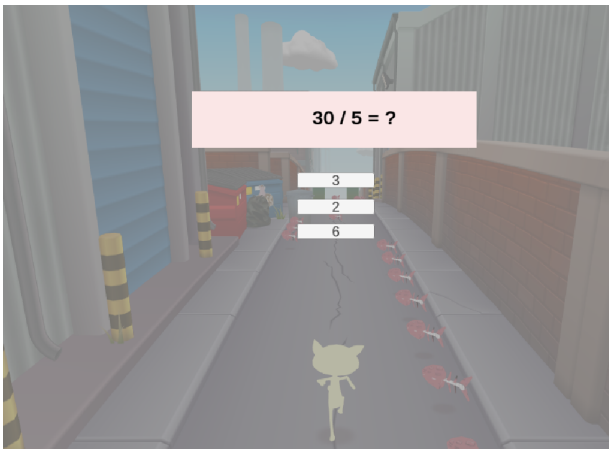

Figure 16: division question

Missions

In this section, the game offers missions.For example the users while running can collect various rewards in the game like fish bones.If they gather enough fish bones they complete a mission and get a reward.When they answer wrong they lose.However they can use their reward in order to have a second chance with the math question and not lose immediately.If their answer is correct on the second time they can continue the game and the high score increases.

Figure 17: Missions

Gamification aspects

Unity offered a wide variety of pre-made elements to put in the game.In order to make the game more attractive to the Malaysian students we tried to implement the elements which they preferred during our interview sessions.

Characters and Animation

During our interviews with the kids we showed them different characters like animals and superheroes. The majority of them loved the animals, so we decided to choose the cat as our main character since the city where the whole research was conducted is Kuching.Kuching in Malay means cat. Also game elements like fish bones were more appealing to the kids so we implemented them into the game.

Sound

For every section of the game there is a background music. In addition, during the gameplay there are sound effects like the sound of crash when the cat hits the obstacle or the "slide" sound and so on.

8 CONCLUSION AND FUTURE WORK

This study examines how an educational game should be created taking under consideration the local limitations and the needs of the users.After, researching previous studies about serious games and following the ICT4D 3.0 protocol we arrived into a prototype game focused on Mathematics.Through this project, it was obvious that the level of the Mathematics knowledge of the kids mostly in rural areas of Kuching was low due to the limited resources. We tried to retrieve as much as relevant information we could from the actors. Interviews with local teachers were conducted in order to explore the content of Mathematics in school and try to implement relevant content to our game. Also,the existence of physical resources like computers and phones played an important role during the process. After, visiting many households in the Kampungs we found out that in every family there is at least one modern smartphone, so we believe that the game should be played by students in phones. However, it is possible for the game to be implemented also in computers or OLPC laptops. In addition, there was a daily interaction with the students which was a vital piece of our research. Kids chose their favorite characters sounds and elements that we implemented in the game. This, reassures the engagement of the users since we believe that it is important for the user to feel like he created his own game. Through the testing sessions it was obvious that the Malaysian kids liked the competition with their friends. However, young kids aged 7-9 were trying to play the game based on a lucky choice rather than actually thinking about the correct answer. For that reason and also based on the math exercises in the game our main target group is kids aged between 10 and 16.During all the testing session the students seemed to enjoy the game and many of them asked us if they can have it in their phones or computers. Unfortunately, we did not have the time to see if the game could actually make an impact and help the students get better in Mathematics. We believe

that this process can take months in order to be able to notice their progress through our game.Coming into conclusion, we strongly believe that before creating a serious game, the developers should take into consideration all the limitations and challenges that every country/city/village/school has, if they want the game to be successful and popular among the users. We feel that this paper can be a guide for future people that want to introduce gaming in schools in developing countries. Working in a completely different cultural environment with unknown teaching methods and restricted available resources made the whole process difficult but also rewarding. Games in education should be available to every kid on this planet.

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Supervised by: Anna Bon (a.bon@vu.nl)
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11 APPENDIX

Below, you can read some of the interviews that were conducted in the field in order to understand the relationship between Mathematics and students.

Interview with 3 teachers in a Chinese primary school in Malaysia

-When children start to learn Mathematics?
-From year 1 in primary school. However, they have already been introduced to some first mathematical concepts since pre-school.
-In which language do they teach Mathematics?
-We teach Mathematics in Mandarin. Other schools in Malaysia teach in Malay and some of them in English.
-How many hours per week do they teach Mathematics?
-We teach around 6 times per week for 30 minutes. So I would say around 3 hours per week.
-Do Students have homework in Mathematics?
-Yes, they have homework in Maths and also in other courses. The time in class is not enough.
-Do you believe that games like the one that we presented today to you, can actually help students with Mathematics and have an impact in their educational skills?
-Yes, we find it very interesting. This can be very helpful. If kids like it and play they will get more motivated about Maths.
-When it comes to games in general, there are differences between boys and girls. Do you believe that there are also differences between boys and girls in school courses? For example, is there any sign that girls like more Mathematics than boys?
-No we have not seen something like that.
-Do students have help when they are doing their homework?
-Most of the times when they face difficulties, they have help from the parents.
-Do students take private courses, outside of the school environment?
-Not really, there is the tuition class where kids go after school until their parents come back from work. There, they can do some homework or study a different subject. It depends from the teacher.
-What subject do students find the most difficult based on your experience?
Mathematics, English and Science
-Do students have smartphones in school?
We know that they know how to use smartphones but in school it is not allowed.
-Do you believe an educational game should be implemented during class hours or at home?
We believe at home. Because in school we do not have much time.
-How much can teachers be involved?
-It would be nice if we could check their performance in the game. Also, it would be helpful if the Maths in the game are similar with Maths in class.
-What is your opinion on VLE?
VLE was really bad designed. We did not like it and also we did not have time to work with VLE.I think they already cancelled it.
-Is there a different book in Mathematics every year?
Yes there is a new book for Maths.
-Do you have equipment in School like computers?Do students play games in school?
-There are some computers in the lab but not many.Sometimes kids play quiz.They like the competition.
-Do kids have exams in Mathematics?
-Depends on the level(age). Some levels have exams twice per year. Kids really like the rewards.

Interview with a Greek teacher(Kyriaki Koutsogianni

-When children start to learn Mathematics?
-They start learning in pre-school around the age of 5.
-In which language do they teach Mathematics?
-We teach all the courses in Greek.
-How many hours per week do they teach Mathematics?
Depends on the age. Between 1 hour and 6 hours per week.
-Do Students have homework in Mathematics?
-Yes, they have homework almost daily.
-Do you believe that games like the one that we presented today to you, can actually help students with Mathematics and have an impact in their educational skills?
-Yes, we already know that kids play games many hours per day.If they can learn something out of it, it would be great.
-When it comes to games in general, there are differences between boys and girls. Do you believe that there are also differences between boys and girls in school courses? For example, is there any sign that girls like more Mathematics than boys?
It really depends. I would not say that there are major differences.
-Do students have help when they are doing their homework?
-Yes they usually have help from their parents.
-Do students take private courses, outside of the school environment?
-Yes, in Greece it is quite common for students to take private courses in subjects that they find hard.
-What subject do students find the most difficult based on your experience?
-Mathematics, Science, History.
-Do students have smartphones in school?
-Some of them bring their phones at school however it is not allowed.

-Do you believe an educational game should be implemented during class hours or at home?
-I would say during class. Because we can control what are they doing and how much time do they spend weekly.
-How much can teachers be involved?
-I believe the teacher should be heavily involved. As, I said in the previous question the teacher should be able to control what kids are doing and how often. Also, the teacher should always check the content of the game to see if it is going to be helpful or not.
-Do you have equipment at School like computers?Do kids play any games?
-We have a few computers, so students can be introduced to the digital world.However,we do not have any games.Most of the time the teacher uses the computer and students watch.
-Is there a different book in Mathematics every year?
-Yes there is a new book in Mathematics every year.
-Do kids have exams in Mathematics?
-After 10 years old they have a test once every 3 months.

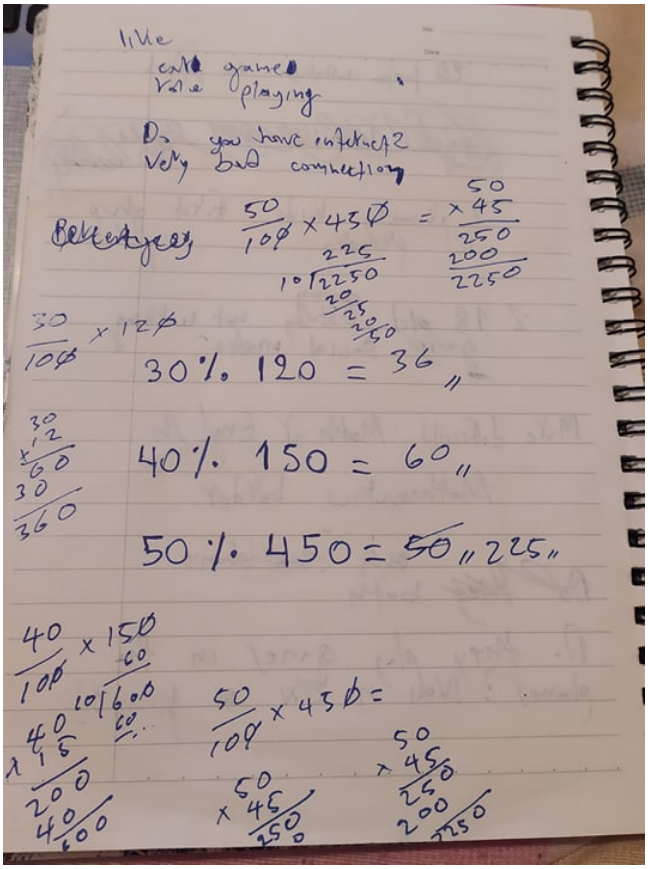

Figure 18: Math Test with a 17 years old student

Mathematics practice with a 17 year old girl

During an interview session we had the chance to talk with a 17 years old girl in Kampung Pinga Jayah.She will be going to college next year and we wanted to see her mathematical knowledge.She had to solve 3 mathematical equations(30*120/100, 40*150/100 and 50*450/100).She solved them all correctly.However she took over 30 minutes and even if we considered these 3 questions quite simple, she had to write everything down on paper.She also said to us that she uses her smartphone everyday to listen to music, play games and watch movies.She does not own a laptop.She does all her homework on paper.

Link to source code

The code is publicly accessible through GitHub https://github.com/thskdkts/MathRunner

```
public class QuestionPicker
{
    1 reference
    public Question GetRandomQuestion() {
        List<String> Operators = new List<String> { "*", "/" };
        Question q = new Question {
                                    number1 = UnityEngine.Random.Range(1, 50),
                                    number2 = UnityEngine.Random.Range(1, 10),
                                    op = Operators[UnityEngine.Random.Range(0, Operators.Count)]
                                  };

        if (q.op == "/") {
            // number2 must always be less or equal than number 1
            // The division between number1 and number 2 must give mod 0
            while(q.number2 > q.number1 || q.number1 % q.number2 != 0)
                q.number2 = UnityEngine.Random.Range(1, 10);
        }

        // Calculate the result using the randomly picked operator
        int result;
        if (q.op == "*")
            result = q.number1 * q.number2;
        else
            result = q.number1 / q.number2;

        // Place correct answer into random order
        int answerPosition = UnityEngine.Random.Range(1, 3);
        if (answerPosition == 1)  {
            q.answer1 = result;
            q.answer2 = result + 10;
            q.answer3 = result - 3;
        }  else if (answerPosition == 2) {
            q.answer1 = result + 10;
            q.answer2 = result;
            q.answer3 = result - 3;
        } else {
            q.answer1 = result - 3;
            q.answer2 = result + 10;
            q.answer3 = result;
        }

        return q;
    }
}
```

Figure 19: questions Generator