E-Math

Submitted by:

Muhammad Husnain
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Supervisor:

Dr. Muhammad Muddassir Malik

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National University of Sciences and Technology (NUST),
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Approval

It is certified that the contents and form of the thesis entitled “E-Math” submitted by Muhammad Husnain have been found satisfactory for the requirement of the degree.

Advisor: Dr. Muhammad Muddassir Malik

Signature: _____

Date: _____

Committee Member 1: Dr. Shahzad Saleem

Signature: _____

Date: _____

Committee Member 2: Mr. Maajid Maqbool

Signature: _____

Date: _____

Committee Member 3: Erum Afzal

Signature: _____

Date: _____

Dedication

I would like to dedicate my work to my parents, teachers and friends.

Certificate of Originality

I hereby declare that the research titled "***E-Math***" is my own work to the best of my knowledge. It contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at SEECS, NUST or any other education institute, except where due acknowledgment, is made in the thesis. Any contribution made to the research by others, with whom I have worked at SEECS, NUST or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic is acknowledged. I also verified the originality of contents through plagiarism software.

Author Name: Muhammad Husnain

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Acknowledgement

Allah to be praised- It is through his blessings and guidance that I could manage to get this milestone achieved.

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Abstract

Technology is now being widely used for teaching and learning in institutions and organizations. Different technologies are being used in different settings. World has moved on to the use of digital games for teaching. But game without proper instructional designing and pedagogy is of no use. Current games available on Google playstore are assessment based. They don't teach concepts and logics to the users. Pakistan being developing country is lagging in the use of digital games for teaching especially mathematics. Mathematics stats of Pakistan are worrisome and need attention.

This study was conducted to find the impact of digital game in Pakistan to teach concepts of mathematics. Total 44 participants were in this research from two different schools of different areas. One school was from urban area and one from rural area of Pakistan. Two different areas were selected to compare and analyze the difference of schooling environment and their impact. Results of this study have been impactful and it shows that digital serious games do have an impact on teaching students mathematical concepts. Moreover students' engagement and motivation were also analyzed in this study. Average score of pretest in urban areas was 6.37 and post test score was 8.33 while average in rural for pretest was 7.35 and average score for posttest was 8.35.

Result of this study is, if digital games are carefully developed and used in classroom settings, they will help students in learning better and will keep the student motivated and engaged in learning process.

Chapter 1: Introduction

The world has been changed with the advancement of technology. Few decades ago the tasks that seemed impossible are now being carried out with touch of finger. Technology has revolutionized every field. Technology is being used to increase productivity and enhance efficiency. Now in this world technology has become an integral part of all processes.

Same goes with the education field. In field of education technology is helping to create more opportunities for students to learn. The classrooms have become immersive and with the right use of technology students, learning can be enhanced to certain extent. The debate has been moved from whether we should use technology in education or not to how we can effectively use technology in education. Different technologies have been used in different classroom settings. Some of the most used education technologies are videos, animations, digital games, augmented reality virtual reality. Students find these technologies more interesting hence they are able to concentrate more on this type of lesson as compared to conventional lectures.

Games have been used in teaching for centuries. Many games were developed to teach and give awareness about different subjects and topics. Digital games are now being used in many institutions and organizations to teach and train learners. Students can learn more independently through games because they are different than usual classroom settings. Students find it engaging and hence their motivation to play increases which result in enhancing their learning outcomes.

1.1 Problem Statement

Games are being developed around the globe to aid learning. Most of the games which are readily available on Google play store are assessment based. The introduction about these games is that they will teach mathematics but the entire focus is on assessment. There will be a question with four possible answers and students will have to choose the correct one. There is no part in between where they will educate the learner how to do simple mathematic operations, like addition and multiplication. If student will answer the correct answer it means he knows the answer the before and his concepts are quite good.

But what for those students who have poor concepts they will choose wrong answer and they will not be provided with the reason why it is wrong.

The games in education sector need instructional designing. The games which are right blend of instructional designing and pedagogy are the best to use for teaching. Moreover the statistics of Pakistan regarding mathematics are not that good. In all surveys conducted by different organizations either government or private have shown a very sorry picture of Pakistan. No province scored more than 50% in any of surveys. These students lack the skill of basic arithmetic functions. If the existing games were to be used in classroom settings the results would have not been different. So, in order complete that void a digital game was developed with prime focus on teaching mathematics procedures to students.

1.2 Research Questions

The basic purpose of this research was to enhance the students' capability to solve mathematical questions. For this purpose a carefully planned digital game was developed with prime focus on concepts of mathematics and procedures to solve questions.

Research questions in this research were:

RQ1: Do digital games have any impact in teaching mathematics concepts?

RQ2: Does use of digital games have any impact on motivation and engagement of students?

The whole research was centered on these questions. Data collection and intervention was centered on these questions. The data was collected to find the answers of these questions.

1.3 Purpose of the research

Purpose of the research was to find the impact of using digital games for teaching mathematics concepts to the students. Along with that research was also focused on finding the impact of digital games on engagement and motivation of students while learning and teaching mathematics. There were very few researches conducted in this area. The other reason was the declining stats of Pakistan about the students' competence of mathematics. How we can find a way to improve the students capabilities in mathematics.

1.4 Background of the research

The research was conducted in two schools. One school was from urban area and other school was from rural area. The intervention was carried out for six days in both schools. First day was dedicated for pretest to assess the present level of students. Next four days, students were provided tablets and were asked to play game for thirty minutes every day. First day they played addition section of the game and on second day multiplication section was played. Then in next two days they repeated the same pattern. On sixth day post test was conducted to assess the level of students after intervention. So, we can compare both results and can analyze whether it was an effective study or not.
Field notes and observations were noted down during the intervention, to find the common mistakes, the level of engagement and motivation by students. The research method used in this study was mixed method which means both quantitative and qualitative approaches were used in this research.

Chapter 2: Literature Review

2.1 Linguistic Diversity of Pakistan

Pakistan is a land of diversity i.e. Pakistan has different religions, cultures and languages. According to Ethnolouge (Languages of the world) there are 74 different individual languages being spoken in Pakistan and all of these languages are living languages. (Ethnologue, 2019). 66 languages out of these 74 languages are indigenous and the rest of 8 languages are non-indigenous. Moreover the number of institutional languages are 7 and number of developing languages are 17 while 39 out of those 74 are vigorous. Some languages are dying and some are in trouble. 2 languages are dying while 9 are in trouble. (Parekh, 2017)

National language of Pakistan is URDU which is being spoken as mother tongue by 8% of the total population. Some major mother tongues are Punjabi, Sindhi, Pashto, Balochi and several others. Punjabi is being spoken by majority of population which constitutes almost 44% of the total population, which makes it largest and widely spoken mother tongue in Pakistan. 15% of the population speaks Pashto language while Sindhi is mother tongue of 14% of population. The other major mother language is Siraiki which is mother tongue of 11% of the population. (Cs.mcgill.ca, 2007)

Language	Percentage of population
Punjabi	44%
Pashto	15%
Sindhi	14%
Siraiki	11%
Urdu	8%
Balochi	4%
Others	4%

Table 1: Languages in Pakistan

2.2 Medium of Instruction

Language is crucial in any kind of teaching and learning because it is through this language that you can communicate in any learning setup. Language is used to deliver concepts, knowledge and any useful information is known as medium of instruction.

Medium of instruction is a controversial issue in Pakistan, because of the linguistic diversity of Pakistan. Education system of Pakistan offers more than one medium of instruction to students. Urdu and English is being used as medium of instruction majorly in Pakistan but in some areas and in Deeni Madrassahs local languages are also being used as medium of instruction mostly Punjabi, Sindhi, Pashto and Balochi. (Ahmed, 2011)

Furthermore medium of instruction is different at different levels of education system. For example in college during intermediate/higher secondary school system only English is used as medium of instruction and so on in higher education also English is used as a medium of instruction. It doesn't matter whether you are comfortable or not you have to learn and write in English.

According to UNESCO position paper published in 2003, the education rights of native are addressed by the 1989 ILO Convention 169 concerning native and tribal people in Independent countries (King, 2003). Article 28 states that, "children belonging to the peoples concerned shall, wherever practicable, be taught to read and write in their own indigenous language or in the language most commonly used by the group to which they belong' and that 'adequate measures shall be taken to ensure that these peoples have the opportunity to attain fluency in the national language or in one of the official languages of the country'. The Article provides at the same time that 'measures shall be taken to preserve and promote the development and practice of the indigenous languages of the peoples concerned".

In Pakistan medium of instruction has been shuffled from Urdu to English and from English to Urdu many times. Most recent efforts were made by Punjab government in 2009 and by the government of Khyber Pakhtunkhwa (KPK) in 2014. Punjab government shifted all schools to English medium of instruction in March 2009 for all primary schools grade 1 till grade 5. Seeing the results and outcomes government decided to shift back all these schools to Urdu medium of instruction but only for grade 1 to grade 3. For

grade 4 and 5 medium of instruction will still be English. Teacher union protested against this action by government by saying that this will result in poor performance of the students. (Rahim, 2019)

Same year in which Punjab government shifted their schools back to Urdu medium; government of Khyber Pakhtunkhwa took action to change the medium of instruction from Urdu to English without any prior survey or measures. (Shaukat, 2014) Main motive behind this move was to bring government schools at par with private schools where medium of instruction is English medium mostly. But according to Annual Status of Education Report (ASER) 2012 showed that four major languages spoken by Khyber Pakhtunkhwa people are Pashto (77%), Hindko (11%), Siraiki (3.5%) and Chitrali (3%) while other languages were only 5.5%.

2.3 English as a foreign language (EFL)

Adaptation of a language as a common language between speakers whose native language is different is known as Lingua Franca. (Coleman, 2005) English language in Pakistan is not a second language, but it is a foreign language here in Pakistan. English language became an important asset to be a successful person because it was the language of rulers of Subcontinent than. Before independence and after independence there have been many movements and struggles to eliminate the English or to minimize the use of English but all the high profile personalities and elite in Pakistan were against them so we are still stuck with English.

"Education for ALL", a declaration signed by more 150 nations and Pakistan was one of those nations to sign that declaration. According to United Nations Millennium Development Goals (MDGs) a major goal of education is to eradicate poverty. (Coleman, 2017). So, by singing that declaration Education for all, Pakistan and all other nations reaffirmed that through education they can bridge the gap between individuals, national and global levels. In this context a question asked by a Norwegian educator and politician, "Education for all- in whose language?" The concept of "Education for all" will be an empty concept if the linguistic context of the basic learner is not taken into the account. The complex relation between language, power and personal and its consequences are highlighted by Chamber; he asks, "whose language and whose words

count [?] In whose language do we – or are we – compelled or induced to co-ordinate our behavior? And in whose language do we together bring forth our world?"

2.4 Student Engagement

Out of six major aspects of student engagement as explained by (Edwards, 2013) two of them are:

1. Relevant learning
2. Personalized learning

2.4.1 Relevant learning

Relevant learning means that student can see the value of their education outside of their classrooms. Teaching in past was not catering these needs and there was no connection between class and outside world. But now with increasing use of digital learning platforms one connects what's going in classroom to the outside world. The ability to connect the life of classroom to life outside has a huge impact on student's "learning disposition". It helps student in believing that school has meaning and purpose which can make huge difference in their engagement and motivation towards school and education. While working on real life problems in schools student become clearer about their lives and future goals, they become more curious about learning, show more initiatives and their analytical skills increase.

2.4.2 Personalized learning

Personalized learning is teaching students with different pedagogies, curriculum and instructions to each student to meet their personal needs and interests. Students will not lose interest and motivation in his studies because his interests are being catered well by the teacher. Every learner has different needs some are visual learners, some kinesthetic learners and some are auditory learners. Teachers have to mix all these things to make every student comfortable. This helps in boosting the confidence of students in themselves that they can learn and they can compete with fellows. Classrooms should be inclusive and universally designed for each and every learner.

2.5 Serious Games

Serious games are now being treated as a special subject in universities. Clark C Abt is formally known as the person who formally introduced the term serious games in 1970's while Ban Sawyer popularized the concept of serious games in 2002. Serious games are those games which are created for primary purpose of teaching, not for entertainment. The primary purpose can be anything either to train a person for some specific skill or to teach someone about particular topic of mathematics, science, English or history and so on. Wilkinson P. (2016)

Plato was the first person who philosophized the concept that some behaviors exhibited while playing would reinforce those behaviors as an adult. It will be fair to argue that from 19th century the play and games were considered to be imperative in development of someone's behavior. Jean Piaget a seminal development psychologist once stated that, "Play is the work of Children". This context and other contexts were main concepts in serious games.

Chaturgana is considered to be a precursor to chess developed in India around 7th century. It was the first board game to apply the military moves in a board game. This game was used to teach military moves to kings and was very popular among rulers. There were many games in pre-digital era which were used to teach social values and to give some knowledge. Landlord's game precursor to monopoly was created in 1902 to highlight the dangers of capitalist approach. (Cheng et al., 2015)

Now a day serious games are being used in every aspect of life. Serious games are part of our educational system now. Teachers are using them as pedagogies to infuse excitement and engage students in learning process. Generally it is believed that video games are closer to the reality and can provide virtual environment which students find interesting, engaging and absorbed. Serious games now a days are usually video games but as pointed by Abt in 1970 that serious games have a very clear and thought-out purpose of education and are not only to be played for amusement. Wilkinson P. (2016)

2.6 Digital game based learning

One of the most effective ways of integrating motivation in students in their learning process is the use of Digital Game Based Learning (DGBL). Many games have been developed in recent years to teach or help students in their subjects like mathematics, science, history and English etc. (Chen and Hwang, 2014). Many researches have shown

the effectiveness of digital game based learning in enhancing the interest and motivation of students. In comparison with conventional teaching approaches or pedagogies, digital game based learning has been able to provide students with more authentic, challenging and interesting environment of gaining knowledge. (Wu, Tzeng and Huang, 2014)

While many researchers and organizations are working and developing digital games, it is highly important that all these educational games should be developed around some sound educational pedagogy and learning strategies while taking account of knowledge and context of the learners.

2.7 Learning Theories

Learning theories are the framework or layout, how learning happens and how students process, gain and retain knowledge (David. L 2015). Behaviorism, Cognitivism, Constructivism, Humanism and Connectivism are some major learning theories (Educationdegree.com, n.d.).

2.7.1 Behaviorism

In behaviorism we perceive that learner is passive and it responds to external/environmental stimuli. In this theory we believe that learner will begin as clean slate (i.e. tabula rasa) and behavior will be shaped through reinforcements either positive or negative.

2.7.2 Cognitivism

Cognitivism theory was developed by Jean Piaget and it focuses more on internal activities of brain such as thinking, memory, knowing and problem solving. Knowledge is seen as schema and it is ever evolving. As these schema changes learning happens. This paradigm replaces behaviorism in 1960s.

2.7.3 Constructivism

Constructivism as a paradigm states that learning process is active and constructive process. In this theory information is constructed by learner here. Learner is actively creating knowledge with their experience and by linking it to the prior experience and information. In this learning theory learner is not a tabula rasa (i.e. clean slate).

2.8 Instructional designing

The process by which learning products and experiences are designed, developed and delivered is termed as Instructional designing (Learning & Performance Partners, Inc., n.d.). Over the years many scientist have worked on instructional designing and some of them have come up with their own model of instructional design. The instructional design model is a set of guideline or rules which help the creator to create sound learning materials by following blueprints and structured model. Although these instructional design models vary from one another but all these models have some basic instructional design principles and patterns (Instructionaldesigncentral.com, n.d.).

Use of instructional design models while developing learning materials and digital content is always beneficial. These models help developer in creating focused and customized trainings. These models incorporate interactive strategies to encourage the participant of learners. This will help user to be engaged and will increase the motivation of learners (Instructionaldesigncentral.com, n.d.). By using instructional designing models we can layout some clear deliverables and then work on those deliverables/goals. These models help us to focus on our main goals and bring consistency in the learning material. Instructional designing makes learning simpler for learners.

2.9 Pedagogy and Digital game based learning

Pedagogy and Digital game based learning goes hand in hand. Digital games are being used as a pedagogy in many institutes, classrooms and learning setting. Basic principles for sound pedagogy and an efficient digital game are often interlinked. So, for a digital game to fulfill the need of learning, it is necessary to have a sound pedagogical concepts embedded in the gameplay (University, 2012). Some concepts which are essential for a good digital game are stated as below:-

2.9.1 Maximum details

Most common mistakes made by the developers are that they missed the detailed actions. During gameplay the learner should be able to choose better actions by himself and should have enough time to make the next move by processing the already existent information. It’s a responsibility of instructional designer to make sure the smooth transition from one level of knowledge to next.

2.9.2 Context

Learning happens best when learner is being taught in the context that he is already familiar with. Context can be academic or cultural or environmental. For academic concept make sure that before playing the game learner has the minimum amount of knowledge so that he might not feel lost in the gameplay. Same goes with the environmental context, instructional designer should make sure to be as close as he can to the learners environment. Learner will learn better when he will be able to relate things to his surroundings.

2.9.3 Balance between instruction and entertainment

Main purpose of digital game in learning environment is to teach a lesson or skill. Game should be entertaining enough to keep learner motivated in the game but not much entertaining that it loses its main goal i.e. teaching. It's the responsibility of instructional designers and story boarders to make sure that they keep learner engaged and motivated while providing the platform to learn.

2.9.4 Appropriate Feedback

Feedback is one of the most significant factors in learning anything. It gives assurance to the learner that he is on the right track. Feedback is of two types, formative and summative. Both types of feedbacks are important in gameplay. Feedback can be represented in many ways in a gameplay through score, points, coins and some other kind of reward necessary for the gameplay (Chen, n.d.). Formative feedback is necessary to keep the player motivated and engaged in learning while summative feedback in digital game based learning assures the learner that he have completed a level and now he can move forward. Feedback should be provided whenever player makes an error or mistake.

2.9.5 Appropriate challenges level

Every next level should be tougher than the previous one. If the difficulty level is not challenging for player, he will lose interest and will not be focused and engaged. On the other hand if difficulty level is extremely high for the standard learner then player will feel stuck in that level and will lose interest eventually. It is responsibility of the instructional designer to make sure that each user is motivated and engaged meanwhile learning through the gameplay (Majumdar, 2014).

2.10 DGBL in Developing country

Developed countries like America, England and Australia have deployed ICT in their classrooms and teachings from last 25 years. But still the use of ICT in classrooms is neither accepted nor rejected totally by teachers. Some teachers still finds it to be waste of money and some find it interesting to integrate in classrooms. The results of implementation of ICT in learning have not shown promising results. But in research the results have been very encouraging and it shows it can be beneficial to integrate ICT in learning. ICT includes both hardware and software. Computers, handheld devices and tablets fall under hardware category while digital games, video lectures and online resources fall under software.

Policy makers and third party organizations of developing countries still focus on many aspects like, introduction of ICT, quality education, equal opportunity of education for both males and females (equity), better implementation of ICT and capacity building in the usage of ICT for education. The ICT programs should be designed by government with third party organizations and they should be adopted according to the needs and context of the country and designed accordingly.

Technology is evolving day by day. Digital games have been shifted from computers to handheld devices and now with the rise of virtual reality and augmented reality challenges for developing countries are rising rapidly. To implement the ICT in developing countries needs long term planning and resources, which should be planned from the beginning.

But the use of digital game based learning in developing country is on the rise. Third party organizations are working more in this sector with help of some donors and funding but sustainability is missing.

2.11 TPACK and Mathematics

Technology pedagogical content knowledge (TPACK) is the knowledge required by the teacher to integrate technology in classroom. (Koehler, 2017) TPACK is the extension of Shulman's idea of pedagogical content knowledge (PCK). TPACK consists of seven elements, Technology knowledge (TK), Pedagogical knowledge (PK), Content knowledge (CK), Technological pedagogical knowledge (TPK), Technological content

knowledge (TCK), Pedagogical content knowledge (PCK) and Technological pedagogical content knowledge (TPACK).

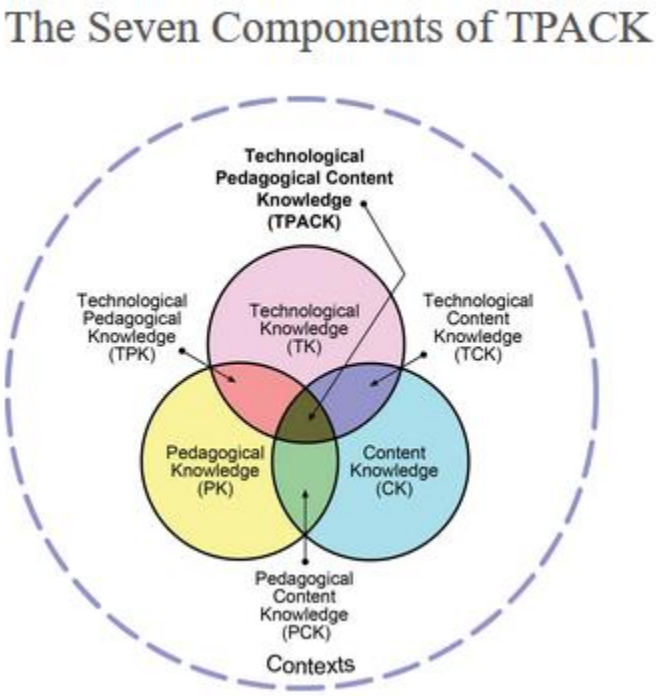

Figure 1: TPACK

The guiding principle in National Council of Teachers of Mathematics (2014) is the use of tools and technology to make sense of mathematics, reason mathematically and communicate mathematical thinking. The National Council of Teachers of Mathematics (2014) suggest that meaningful and effective learning happens when tools and technology is used efficiently and appropriately. But many teachers are hesitant in the use of technology to teach mathematics or in the use of technology in classroom settings. There are two types of barriers to integration of technology by teachers. First order barriers are associated with money and resources while second order barriers are the beliefs of teachers. First order barriers can be eliminated by providing resources and allocating money. First order barriers are easy to handle while second order barriers have to do with the mindset of teachers and beliefs. They can be handles too but require more effort and trainings.

2.12 Mathematics concept and DGBL

A subject which we deal most often in our daily life is mathematics. But still majority of students mathematics feel anxious while learning mathematics. Failure rate in mathematics is highest among all subjects. This higher rate of failure is because majority students termed mathematics as most frustrating subjects. Number of factors affecting the performance in mathematics has been studied and those dealing with emotional and intelligence are most significance. Anxiety is one of the major problems faced by students in mathematics. Researches have shown that there is a direct link between anxiety and performance in any subject. To help learners enjoy mathematics, they should be taught in a pleasant way.

For young learners game represent as joy and pleasure. If mathematics and games are embedded together in teaching mathematics, this can reduce the fear of learning mathematics. In games person feels engaged and is always trying to do something new. The engagement of students in games keeps them motivated and eager to learn mathematics.

2.13 Summary of Literature Review

Literature has shown that digital game based learning is of great help if developed and used right. Previous researchers have implemented digital game based learning all around the globe and have studied their impact and usefulness on students of different age groups, social backgrounds and different cultures. Case studies, pilot projects, actual interventions and experimental studies have been conducted and results have backed the claim of researchers on the usage of digital game based learning for different subjects. My research is based on the use of digital games to teach students mathematical concepts. Past researches have proved that with right blend of instructional designing and use of sound pedagogies in the gameplay can actually help students in learning better and the retention rate is also better among students.

Chapter 3: Design and Development of Tool

In this chapter the process of designing and development of digital game used for this study is discussed in detail. The process of design and development was subdivided in small sections. All sections of design and development are stated in this chapter.

3.1 Concept Development

Idea for the digital game was based on the interview conducted in need analysis. There was a need of digital platform to help teachers and students in teaching and learning. Many different digital platforms were discussed in depth like, virtual reality, augmented reality, smart web application, video animations and digital games. Most were rejected due to limited resources and there was no high usage in Pakistan education industry due to local context. Video animations were rejected because of the lack of engagement and interaction. The best and most viable solution was to develop the digital game considering the contextual background of Pakistan.

3.2 Content Selection

Mathematics was selected for this research study. Because mathematics is essential for a country development. The data about current situation of mathematics in Pakistan was worrisome because all the stats were below 50%. More than 50% of all students in Pakistan cannot perform simple mathematics operations. That's why mathematics was chosen. The basic mathematics operations are division, multiplication, addition and subtraction (DMAS). These operations are introduced in 3rd grade and 4th grade curriculum. Addition and multiplication was chosen for this research study. Because they both are inter related in some manner. So, the content to developed was mathematic operation of grade 3 and 4.

3.3 Pedagogical principles

The best educational game is the right blend of pedagogical principles. To incorporate the pedagogical principles in digital game, the principle of universal design of learning was applied in the game. Universal design for learning (UDL) means you have to think of every possible learner and their preferred method of learning which can be from visual, audio or kinesthetic. To keep every learner interested in the digital game and to enhance the outcome of the game. Storyboarding of the game was now dependent on the universal

design for learning principles. There should be interaction, audio and video learning for every student.

3.4 Storyboarding

The need for developing the game was established, the content was selected and some principles were laid out for developing storyboard. Storyboarding is visualizing what the end product will look like. Storyboard can be audio, visual or written. The storyboarding for this study was visual and story was developed and drawn on white paper. Storyboard is most important part in development of a digital game. Because what the game will look and how much interaction it will have will be decided in this phase. Storyboarding and instructional designing goes hand in hand. Instructional designing is some set principles by researches how to incorporate different strategies and principles in game to make it more interesting, engaging and educational.

3.5 Instructional Designing

Instructional designing coupled with storyboarding is heart of an excellent digital game. The best part of instructional designing is that we have set rules and principles of previous researches. The different models used in this study are discussed as follow:

3.5.1 ADDIE Model

ADDIE model is one of the most used models by different instructional designers and trainers. ADDIE model is popular because it allows the flexibility to develop something, evaluate and then if needed repeat the same process over again. ADDIE model is acronym of Analysis, Design, Development, Implementation and Evaluation. This model helps in saving time and gives us a pathway to work on. First we analyze the problem in hand and find the appropriate and viable solution. Then we design the prototype of that solution. Best way to use this model is rapid prototyping. In this way prototypes are test and evaluated while other prototypes are being created and implemented. This way we save a lot of time and money. This model increases the speed of work and hence increasing the efficiency of work. In design we create storyboard and implement instructional designing. User interface is created and prototypes are created in design phase. Then in development phase digital game was developed on the storyboard. And then in last the developed digital game is implemented in the real world. After the

implementation phase comes the evaluation phase. In evaluation phase the bugs and errors are reported. All the errors and mistakes are reported and then repeat the cycle again.

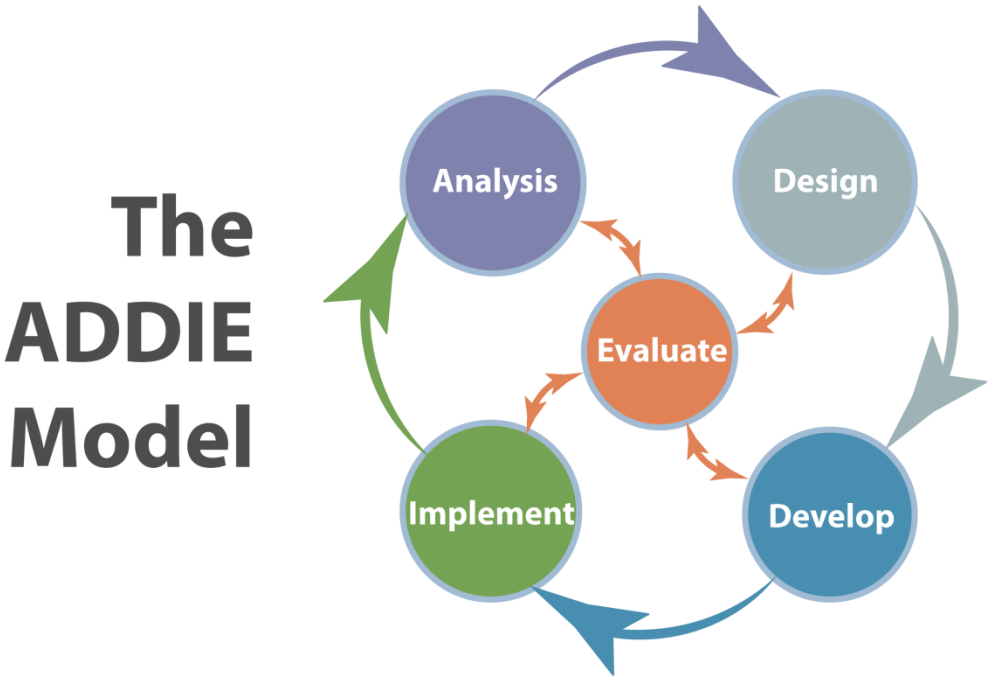

Figure 2: ADDIE Model

3.5.2 ARCS Model

Motivating learner is the hardest part of teaching. Because motivation plays a huge role in learning anything. To keep students motivated in learning Jhon Keller an American educational psychologist introduces an instructional design model ARCS in 1979. ARCS represents Attention, Relevance, Confidence and Satisfaction. To keep students attentive the element of surprise and novelty can be used according to need and requirement. In this research element of novelty was used in digital game. Students will get new questions every time they solve any question to keep them going without any delay. Questions were hard enough to make them think but not so hard that they get furstrated and engagement is lost.All questions were from their zone of proximal development.

Relevance is necessary for learning because using the prior experience is necessary for better and deep understanding. To make the game more relevant to the students language used in the game was English because they all were students were from schools where supposed language of instruction was English and local language. So, the audio in background was Urdu because teachers mostly use Urdu as medium of instruction. That's why the gaame was bilingual because it had instructions in both languages. Written instructions were in English but audiotry instructions were in Urdu.

Confidence the other key element of ARCS model ensures that every student feels comfortable while playing the digital game or learning. Confidence makes sure that every student understands and feels comfortable to apply their skills and knowledge in game. Scaffolding is necessary for user at every step to know if they are doing right or wrong. In this game a tutorial was shown when user start the game to make them familiarize with the gameplay. It's necessary because user may lose engagement and motivation if he doesn't know what to do or how to move around in gameplay.

Figure 3: ARCS model

Satisfaction of user during gameplay is associated with the rewards and feedback he receives in gameplay. In this digital game feedback provided to student on every right step and right answer. Same feedback was provided when student made any mistake in gameplay. This feedback makes sure that they know what's right and what's wrong and help them progress in game.

3.6 Design Phase

The assets used in the game were designed in Adobe Illustrator. The assets were defined during storyboarding and instructional designing. All the scenes were designed for the game step by step. These scenes helped during development of the game in unity3d. Below are some samples of the design of the game scenes which were created in Adobe

Illustrator. The game was developed in 2D because it is efficient to make 2D games because 3D games require more resources and time.

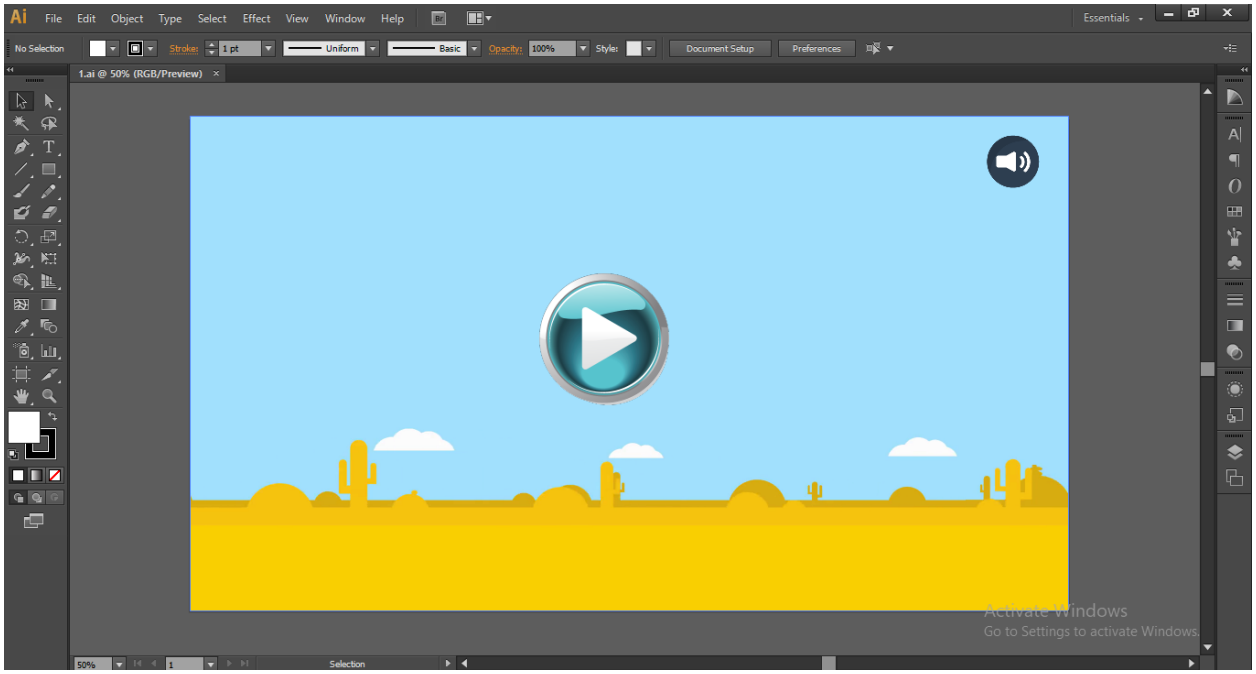

Figure 4: Creating Assets

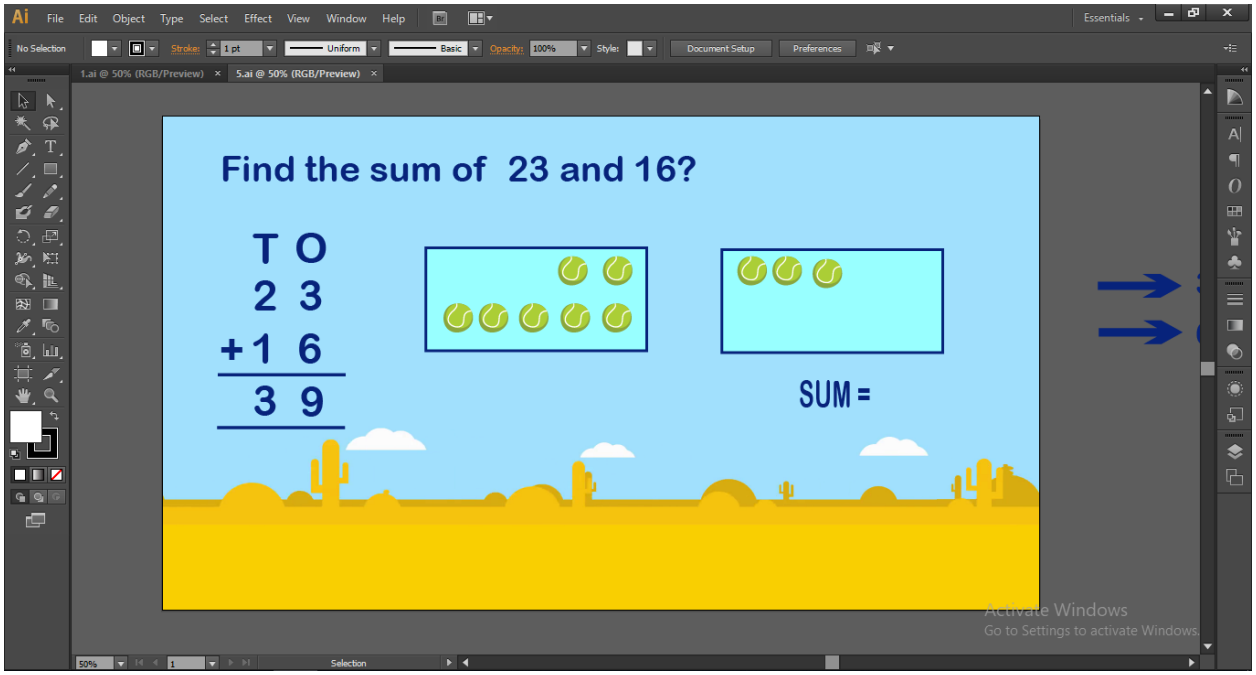

Figure 5: Creating gameplay

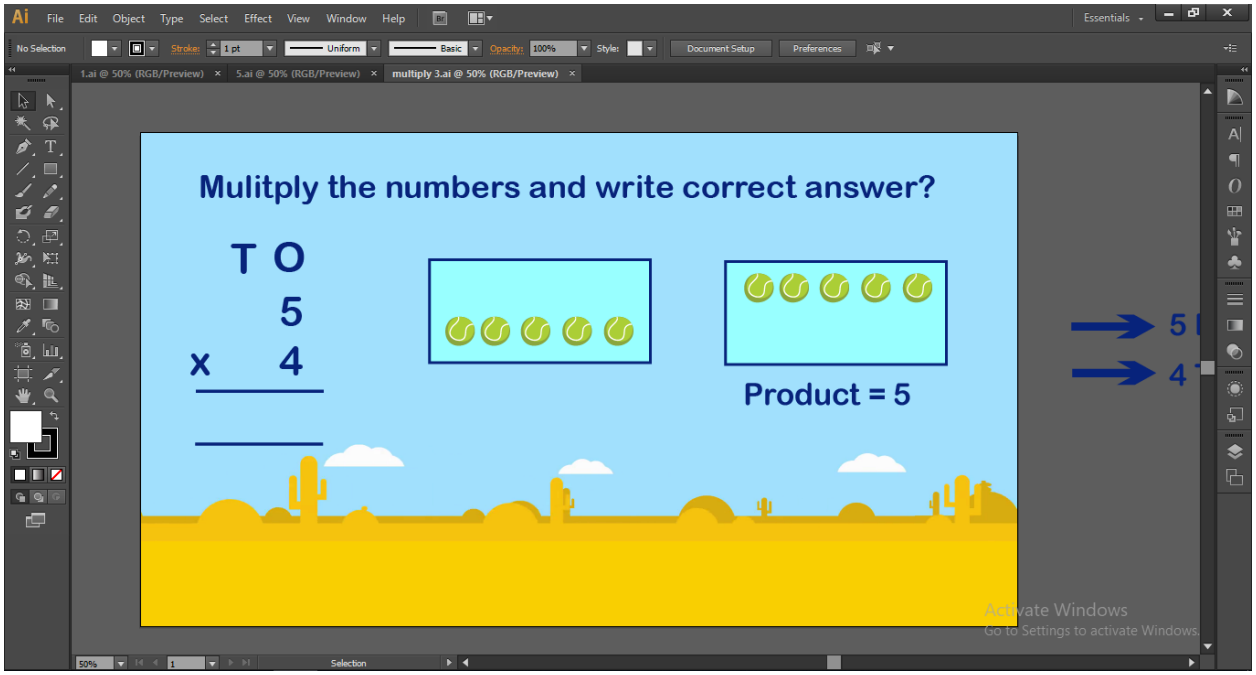

Figure 6: Creating gameplay multiplication

Figure 7: Creating end screen

The color scheme used in this game was selected considering the age and context of the participants in the study. Written instructions were minimized because the participants lack the ability to read and write in English. That's why icons were used in buttons instead of text.

3.7 Development

Game was developed in unity3D. Free software by Microsoft for game development. Language used for developing the game was C#. The development was exactly what they storyboard was developed. Tutorial of playing a game was deployed in the game. Whenever user loads a game for first time, he will have tutorial and instructions about how to play the game efficiently. Audio used for instructions in game was recorded separately. The quality of audio was enhanced using audacity and unnecessary noise was removed from the audio. The game was developed for Android because Android devices are used in Pakistan more often than Apple or other devices.

3.8 Testing

The testing scheme used for testing this game was heuristic testing. Heuristic testing is when a professional and expert examine the game. The game was tested by 3 professionals. The recommendations and errors identified by experts were noted and all errors and recommendations were incorporated in the game. So, the game was developed in the best manner possible.

Chapter 4: Methodology

This chapter includes the details of methods and tools which were used to carry out this research. This study was conducted to investigate the impact of bilingual digital games for teaching mathematical procedures. This study also examined the motivation and engagement of learners. This chapter describes the research settings, research paradigms, participants, tool designed, developed and used in this study. Moreover this study also explains the data collection techniques and variables of this study.

4.1 Research Paradigm and Design

In research a paradigm is a set of beliefs, thought patterns, which involve theories, research methodologies, research hypothesis and it is standard to what contribute in a particular field. According to another definition by Schwandt is set of values and discipline that guides how a problem will be solved. Research paradigm is helpful in conducting research because it helps in collecting data, helps in defining variables for our research and helps in analyzing the data as well.

Every research differs from one another but the scientists and researchers have made it easy by categorizing the research paradigm to suit the nature of our study. Interpretivism and Positivism are used more often.

4.2 Interpretivist Paradigm

Interpretivist paradigm is an approach to understand the qualitative characteristics of research and is more subjective in nature. Interpretivist paradigm helps in digging deep and exploring a certain question with different perspectives and provides deeper analysis of a question. This is mostly used in social sciences research because it allows analyzing one question with different views and opinions. Interpretivist approach allows answering one question by understanding every context involved and accepts more than one answer to the question. Interpretivist paradigm was implemented and used during this whole research study.

4.3 Positivist Paradigm

Positivist paradigm is an approach to understand the quantitative characteristics of research and is objective in nature. This paradigm is unbiased and does not offer multiple answers to one question. There is only one answer in positivist paradigm.

4.4 Research Methodology

Methodologies that have been used in researches all over the world are quantitative qualitative and mixed method. Qualitative methodology is more subjective and allows in depth analysis of research questions while quantitative is more objective and allows one answer to the research question. Mixed method allows using the suited concepts and techniques of both methods to find the appropriate answer to the research question.

4.5 Qualitative Methodology

Qualitative research is investigative research. Qualitative research is mostly used to unearth the hidden reasons, motivations and point of views of participants. Qualitative research helps to dive deeper into the research questions, opinions, behaviors and other predefined variables. Qualitative data collection involves mostly selected sample size. The sample size is smaller. The tool used in qualitative research varies according to the research but most commonly used tools are interviews, group discussions, field notes and observations.

4.6 Quantitative Methodology

Quantitative methodology is used to quantify the data into usable statistics to show the answer to the research question. Opinions, observations, behaviors and other predefined variables are quantified. Quantitative methods are more structured than those in qualitative methodology. Tools used in quantitative research are mostly surveys and questionnaires. The data is usually numeric and easily shown in stats. Sample size in quantitative research is usually bigger than the qualitative and is chosen more randomly to avoid biasness in research.

4.7 Mixed Methodology

Mixed methodology is an amalgam of both quantitative and qualitative researches. The researches mixed both methods to get the better understanding of the research question. Tools used for data collections are mostly intermixed with both methodologies. In this study mixed method is used because research was divided into two phases. In first interviews of teachers were conducted and recorded to analyze the need of this research. In second phase after developing the digital game for student quantitative method was

implied in the form of pretest and posttest. In second phase observations and field notes were also noted making it mixed method.

4.8 Research Methods

As already stated mixed method approach covers both quantitative and qualitative aspects. So, to gain better understanding of the research problem on hand mixed method approach was used in this study. Research variables for both studies are different and are stated in the table below:

Research Methodology	Variables	Research Methods
Quantitative	Procedural understanding	Pre and Post test
Qualitative	Motivation and Engagement	Field Observations and Interviews

Table 2: Research Method

4.9 Variables

Variables were selected so, that we can analyze the data better and meaningfully.

4.9.1 Procedural learning

Main problem with students of mathematics was that they do not know the right procedure of solving mathematical questions of multiplication and addition. So, the main purpose of this study was to familiarize students with the concepts and procedures to solve questions of multiplication and addition. Choosing this as a primary variable was based on the study of existing games in mathematics on Google play store and other games available. Existing games were usually meant for only assessments. So, the game was developed to teach students procedure of solving questions.

4.9.2 Motivation

Motivation is key element in every study. Students are not usually interested in mathematics and find it rather boring. Literature review has supported that students learn better when they are motivated and digital games are great source

of enhancing motivation among students. So, motivation is measured and analyzed in this study because it helps in understanding the factors which enhances the results and outcomes.

4.9.3 Engagement

If interaction is removed from game then it is just a video animation to teach students and nothing more. Engagement is directly linked with interaction of students with learning materials, either digital or non-digital. This variable was necessary to understand the level of engagement in the game and learning. These variables i.e. engagement will help us to analyze the effectiveness of the tool developed for this study.

4.10 Research Methods

Research methods used in this study were pre & post-test and field observations and interviews.

4.10.1 Pre Test

Pretest was conducted prior to the development of digital game. Pretest was necessary to assess the understanding of students before the study so, that we can justify the impact of the research on students. A simple questionnaire was designed consisting five questions of addition and five questions of multiplication. Students were given the proper time to solve these questions.

4.10.2 Post-test

Post-test was conducted to show the difference between students understanding of mathematical concepts. Format of the questionnaire was the same as pretest with same number of questions, five questions of addition and five questions of multiplication.

4.10.3 Field Observations and Interviews

Field observations and interviews are part of the qualitative aspect of this research. Observations and field notes were taken during pretest, post-test and during intervention. Interviews were conducted with teachers before the start of this research and after the research to gain the teacher's point of view this study. Teacher's point of view was very important to understand the engagement and motivation shown by students when there was no intervention going. The

difference in regular class and during this intervention was very prominent according to the teachers. Most important part of this study was the field notes because they were taken during the interventions and tests. The common mistakes were noted and some misconceptions about the procedure of solving those questions.

4.11 Need Analysis

For the effectiveness of this need analysis was conducted in different schools. The purpose of need analysis was to identify the needs and aspects that will be necessary to cover in digital game. It also helped us in formulating our research questions. Many teachers pointed out that student are struggling because they cannot comprehend the procedure of solving mathematical problems. They were some common mistakes identified by the teacher. So, our digital game was developed on this analysis. In order to minimize the mistakes by students and to maximize the learning among students.

4.12 Data Collection Tool Development

Research participants were students of 3 and 4 grades in this study. They were already familiar with solving questions on question paper and they can understand the mathematical terms like, addition and multiplication. So, they were provided a simple questionnaire consisting of mathematical questions and all students were provided with the same questionnaire. The questionnaire was used to assess the understanding of procedure for solving mathematical questions. The other variables motivation and engagement were observed all the time during intervention. Field notes and observations helped in understanding the motivation and engagement.

4.13 Research Questions and Hypothesis

This research was focused on the learning/understanding of mathematical procedures among students and their motivation and engagement during the process of using digital games for learning. The research questions and hypothesis to analyze this study are stated in the following table.

RQ 1	Do digital games have any impact in teaching mathematics concepts?
Hypothesis 1	Digital games don’t have any impact in teaching mathematics concepts

RQ2	Does use of digital games have any impact on motivation and engagement of students?
Hypothesis 1	Digital games don't have impact on motivation and engagement of students

Table 3: Research Questions

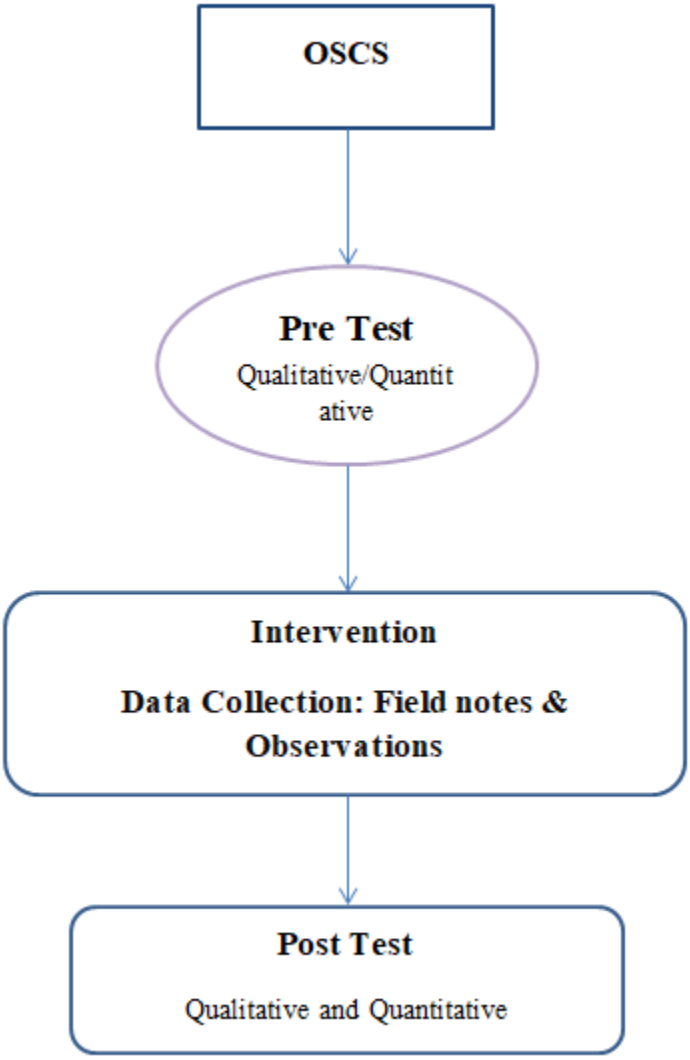

Figure 8: Intervention (OSCS)

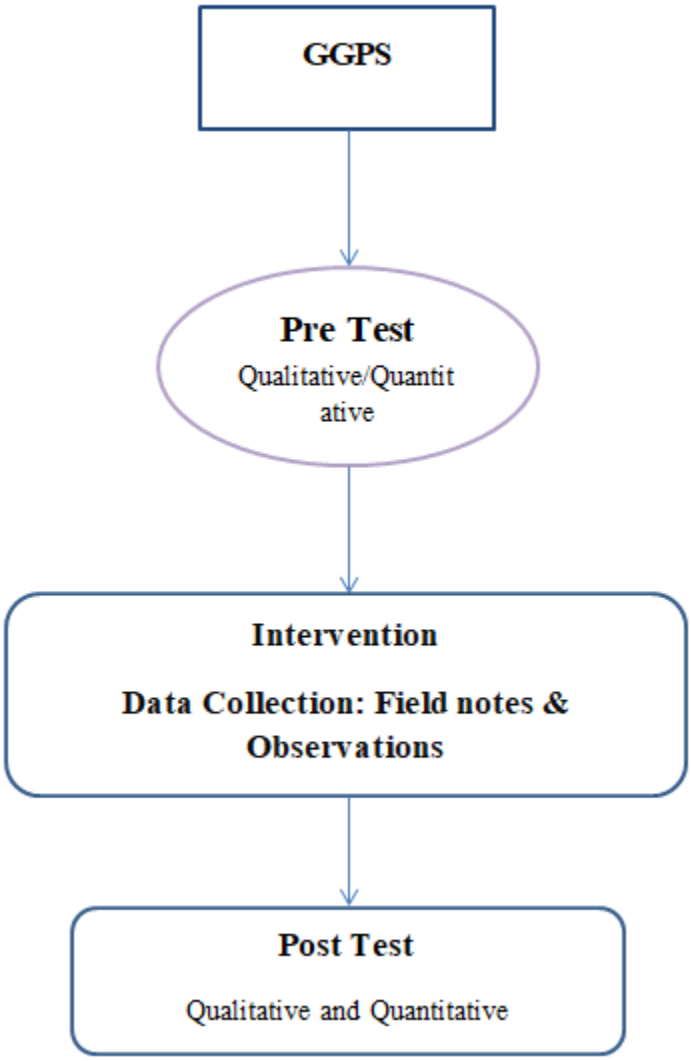

Figure 9: Intervention (GGPS)

4.14 Research Participants

Research was conducted in two different schools from different areas. First it was carried out in Out of School Children School (OSCS) located in I-10 Islamabad. Second was Government Girls Primary School Wasankay. Wasankay is a small village in district Sialkot. Total participants in this study were 44. 20 were from Government girls primary school Wasankay and rest 24 were from Out of School Children School (OSCS). They all were students of grade 3 and 4.

4.15 Research Setting and Intervention

Intervention was carried for six days continuous. Pretest was taken on first day and next four days students played with game. Two days were assigned for addition and two days for multiplication. After the gap of two days post-test was taken on the sixth day of intervention. Detailed table about intervention is given below:

Intervention		
Day 1	Pre Test	
Day 2	Addition game was deployed	Motivation and engagement was observed
Day 3	Multiplication game was deployed	Motivation and engagement was observed
Day 4	Addition game was deployed	Motivation and engagement was observed
Day 5	Multiplication game was deployed	Motivation and engagement was observed
Day 6	Post Test	

Table 4: Intervention

4.16 Pre Test

Main objective was of the research was to enhance the capability of student's in mathematics. So, it was necessary to find their current level of understanding of mathematics procedures. Pretest was given to students and they were asked to solve the questions. Pretest was conducted in same fashion in both schools. Same set of questions was given to both groups under same time frame. Question paper was divided in two categories, one was addition and one was multiplication.

4.17 Intervention

Intervention was carried out for four days. Tw days were dedicated for each part of game. Students were introduced to play addition game on first day of intervention and on second day multiplication were introduced. On third day again addition was played by students and on fourth day multiplication was played again. Motivation and engagement was observed throughout those four days. The common mistakes during gameplay were noted also.

4.18 Post Test

Post-test was similar to the pretest because the main objective was to analyze the understanding of students about mathematical procedures. So, each student was given ten questions again. Pattern of questions was similar to the pretest, five questions were of addition and rest five was of multiplication. Common mistakes were noted during the post-test and interview with teachers were conducted on that day to find about their perspective of this intervention and how they feel about usage of digital games in the classroom setting.

Chapter 5: Data Analysis and Results

The main purpose of this research study was to measure the improvement of student's understanding about the procedure of mathematics and their ability to solve mathematical problems. Along with this research was focused on the impact of using digital games on engagement and motivation of students. Research approach used in this study was mixed method. Both quantitative and qualitative approaches were used in this research study. That's why the analysis of this research is divided in two parts. First we will analyze the quantitative part of the study and then qualitative part. There were 44 participants in this research from two different schools both were treated in same manner and same way. The data collection was done through tests (pretest and posttest), observations and random interviews. In this chapter all data analysis in explained in detail and every graph is explained.

5.1 Data Collection

Study was conducted in two schools. So, data collection was conducted on different times but the process of data collection was identical in both places to avoid any ambiguity in results. Students were made sure about that these results are not going to be marked and failing will result in some kind of punishment. This was necessary to lift the burden of test from students. So they can focus and enjoy the test. The tests were quantitative part of the study. Total there were 10 questions in the test. 5 questions were about addition and 5 questions were about multiplication. Each question assigned a one mark to easily analyze the results.

Qualitative part of the data collection was carried out through mainly by observations and field notes. In observations the things which were taken care was the attention when they were playing the game and the eagerness to play more and learn more. Questions asked by students were noted down and were responded in polite manner. Comments made by students were also noted down about the game and the whole process of research. In the end there was a formal discussion with teachers about how they feel about usage of digital games as pedagogy in their classrooms. What benefits they see and what were the points they noted during the intervention.

5.2 Data Analysis (Quantitative)

The quantitative part of the study was concerned with students' progress in mathematics. The tool used for analysis is MS Excel 2010. All graphs are created in MS Excel. One school was from urban area and one was from rural area. So, the quantitative analysis is further divided in two categories which are rural and urban.

5.2.1 Quantitative Analysis (Urban)

Questionnaire used in this research was divided in two categories addition and multiplication. Analysis of both will be done separately and then overall progress will be analyzed. First analysis of addition is given below.

5.2.1.1 Pretest

First only the marks of pretest were predicted on the graph and then posttest and later both were compared together for better understanding.

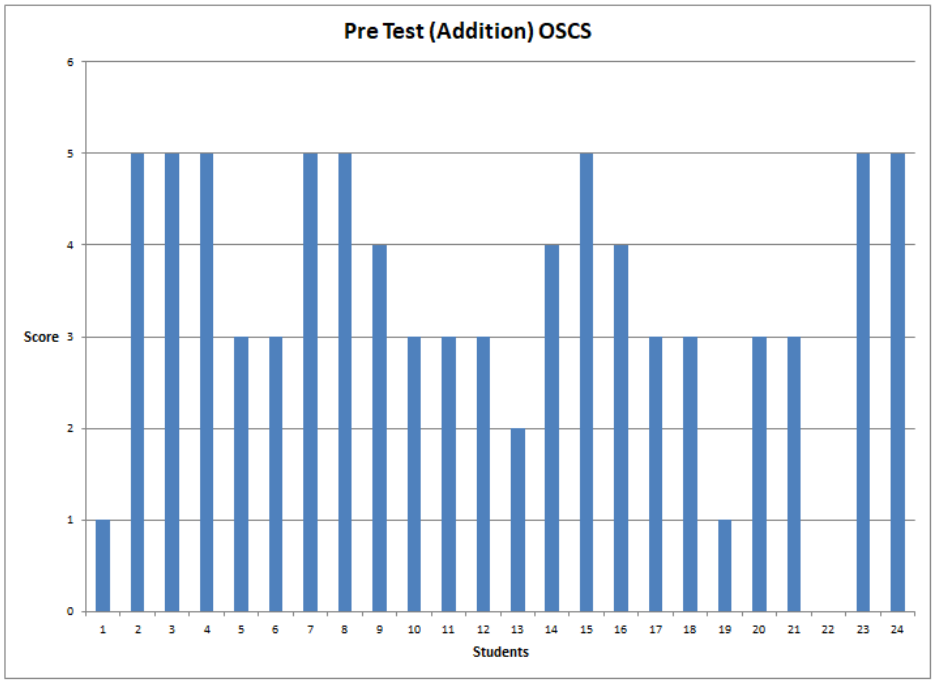

Figure 10: Pretest addition (OSCS)

This graph represents the initial score of students from urban area school. The school chosen was OUT of School Children School (OSCS). This shows that 6 students were able to secure full marks in the pretest, one student scored 0 and two students secure 1 mark in the pretest. Average score for addition was 3.45 in pretest.

The next we analyze the multiplication section of OSCS. The graph below is of marks obtained by students in multiplication section.

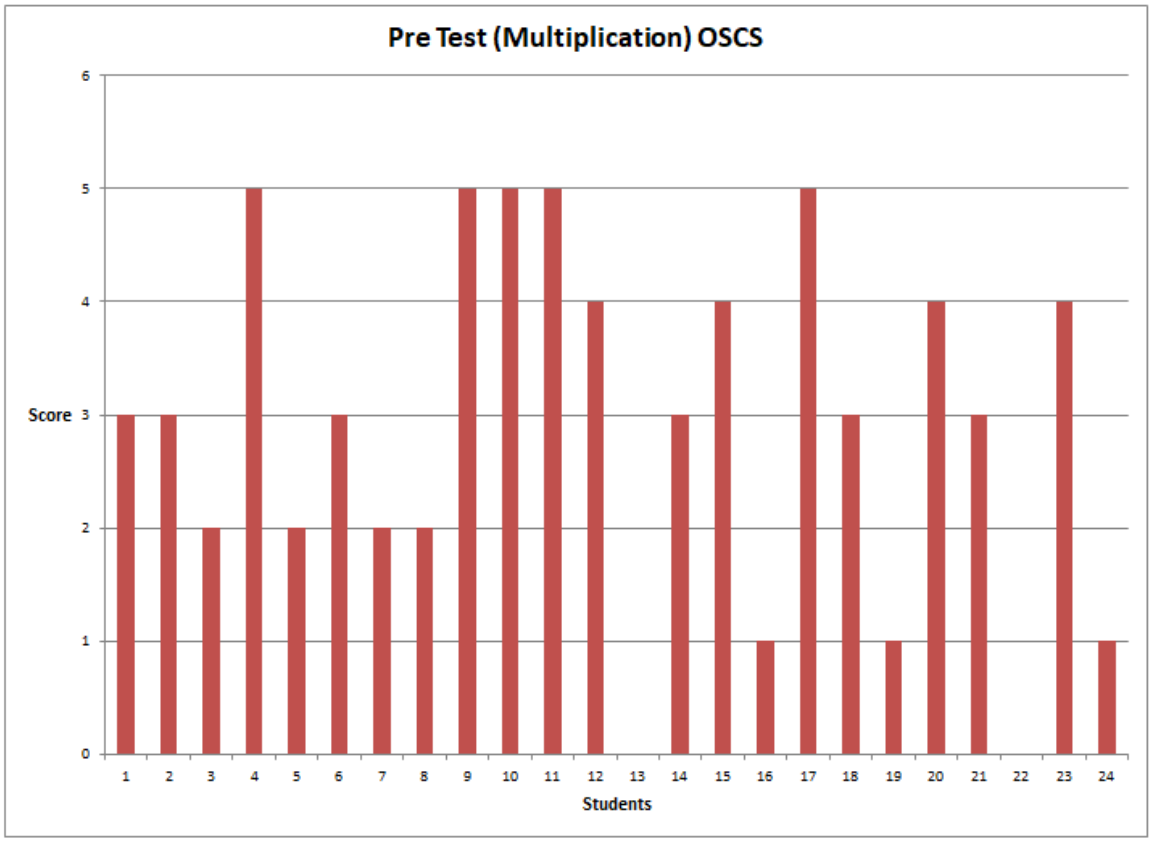

Figure 11: Pretest multiplication (OSCS)

Only four students were able to secure full marks in multiplication while two students failed to solve a single question during pretest. One student scored 0 in both addition and multiplication. The average score in multiplication was 2.91 during pretest. Students performed poor in multiplication as compared to the addition section in pretest.

5.2.1.2 Posttest

In this section we will plot the graphs of posttest of both addition and multiplication. The graph below shows the performance of students of OSCS in addition during posttest.

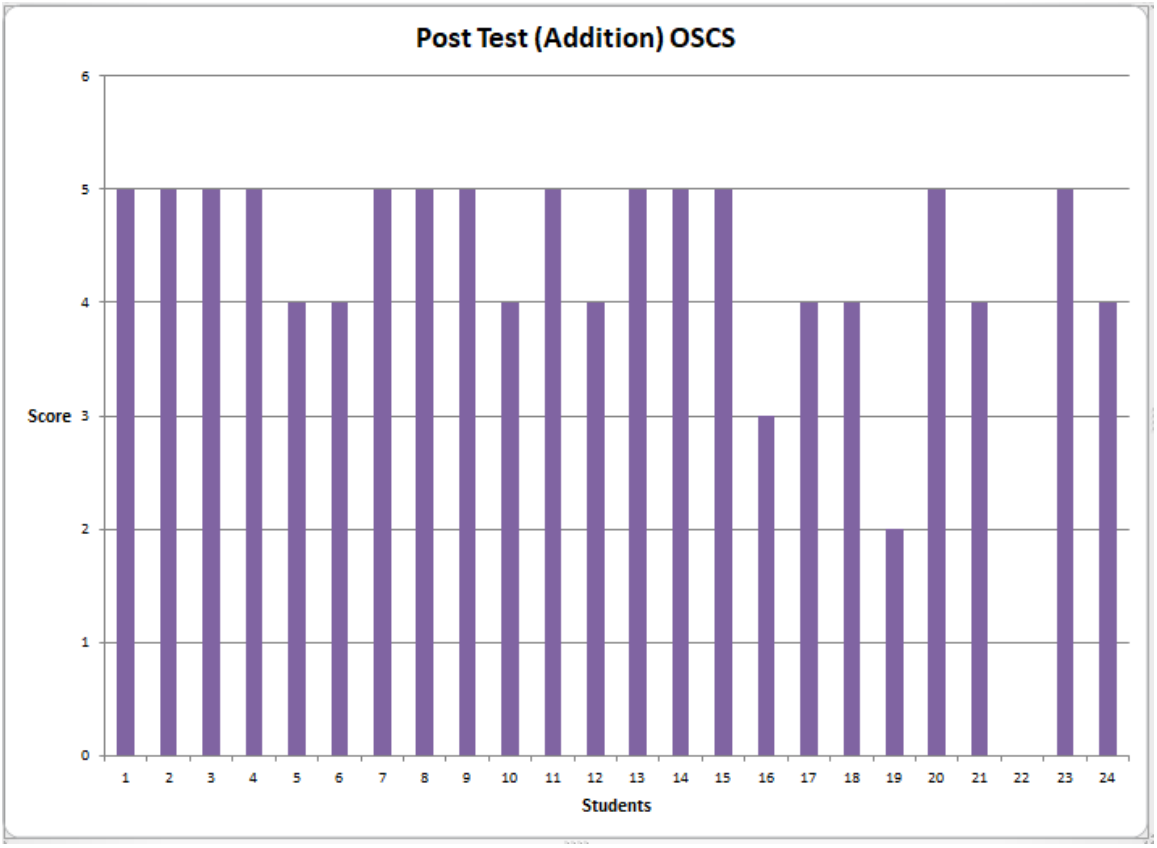

Figure 12: Posttest addition (OSCS)

This graph shows the performance of students in addition section of posttest. Thirteen students secured full marks in addition during posttest. But still one student was not able to solve a single question of addition during posttest. But overall there was a significant gain in the results during the posttest in addition section. The overall average score of the students increases from 3.45 to the 4.25. There was increment of almost 1 in the result.

The below graph shows the performance of students during posttest in multiplication section.

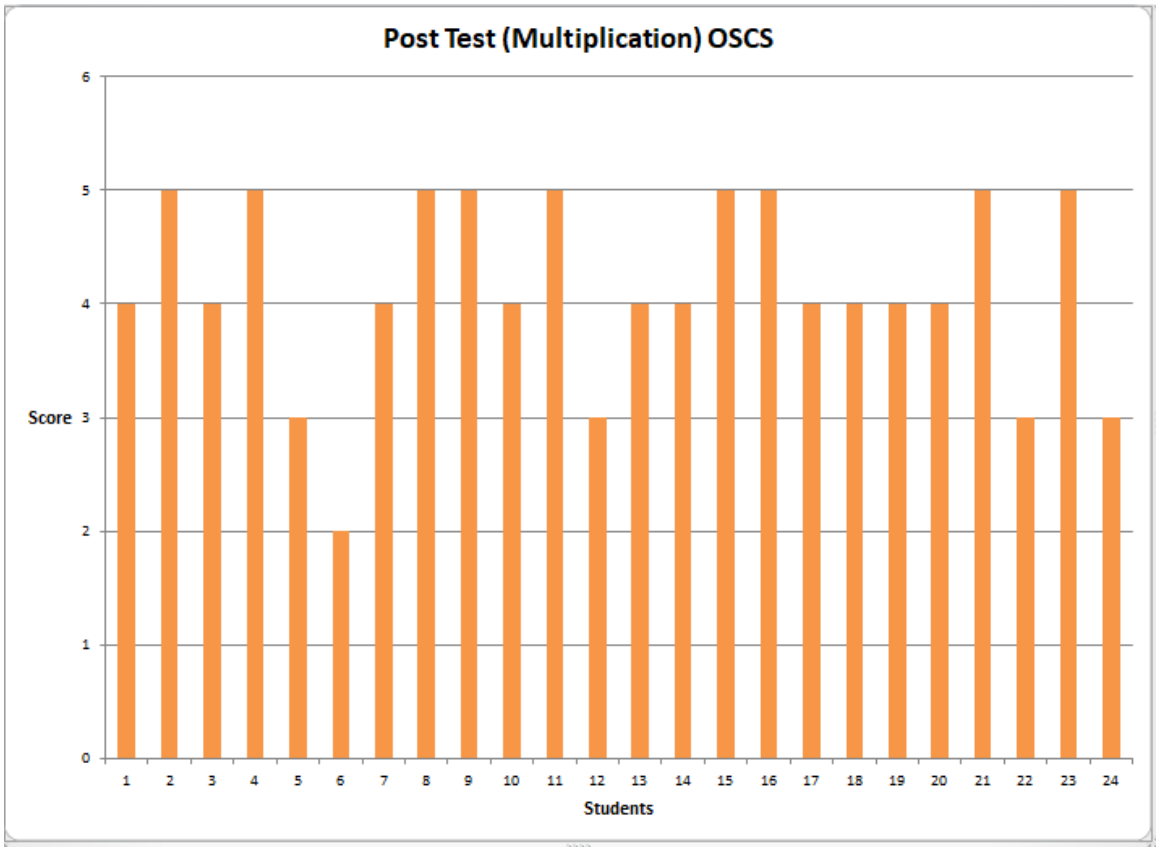

Figure 13: Posttest multiplication (OSCS)

It is evident from the graph that student's performance was better in posttest as compared to the performance in pretest. 9 students were able to secure full marks in posttest as compared to 4 students during pretest. No student scored 0 in posttest as compared to two students in pretest. There was a significant improvement in student's ability to solve multiplication as evident by the graphs above.

5.2.1.3 Pre & Post Test Comparison

In this section both results will be shown together so, that we analyze the result better. In x-axis there will be students' assigned number and on y-axis the scores will be projected by students. First comparison will be of addition then multiplication and on last result of both will be shown together on the scale of 10. The graph below shows the result of students of addition in both pretest and posttest.

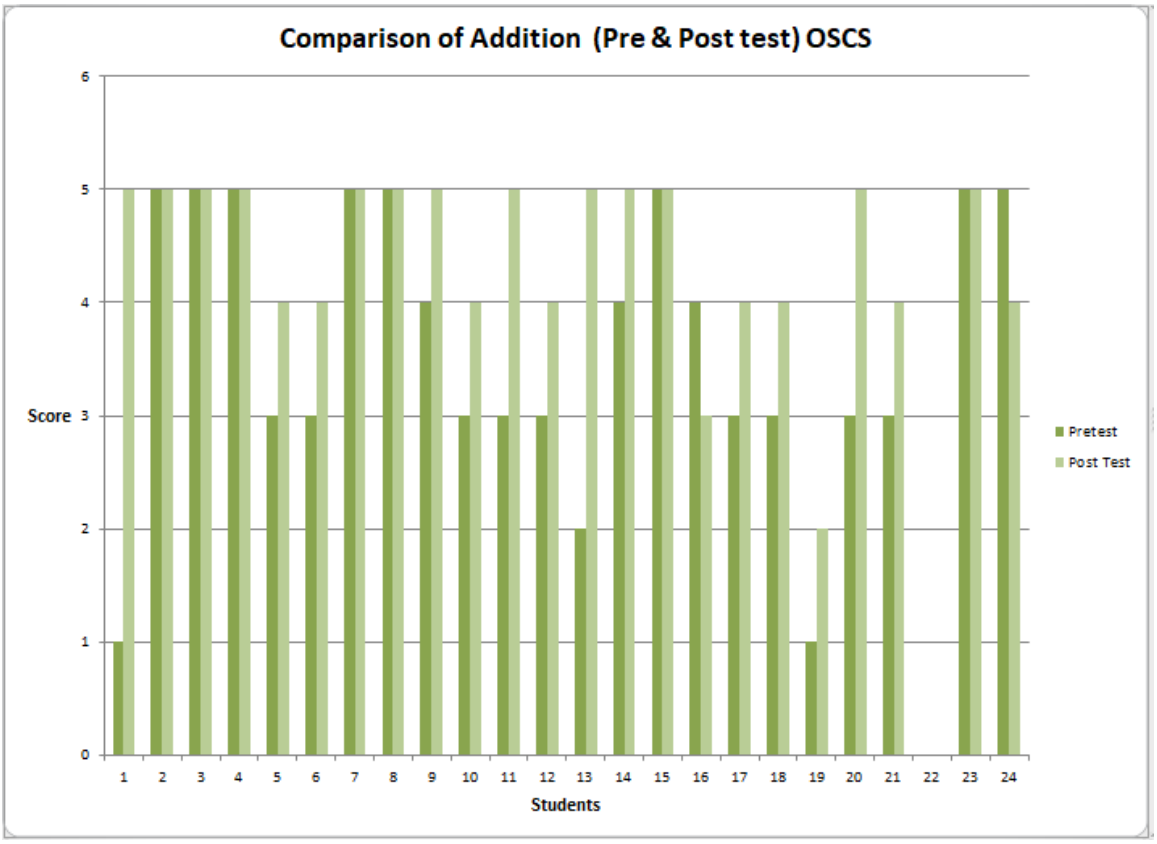

Figure 14: Pre & Post test addition (OSCS)

The graph shows the improvement among students. Dark green shade is indicating pretest while the light color is indicating posttest. The students who secured full marks in pretest were able to secure full marks except one student who secured 4 marks out of 5. One student scored 0 in both pretest and posttest. While other shows significant improvement in marks. Each question was assigned one mark. So, the overall result is from 5 for each section of addition and multiplication.

In the same manner graph of multiplication was plotted from the data. The graph below shows the comparison between pretest and posttest of multiplication section.

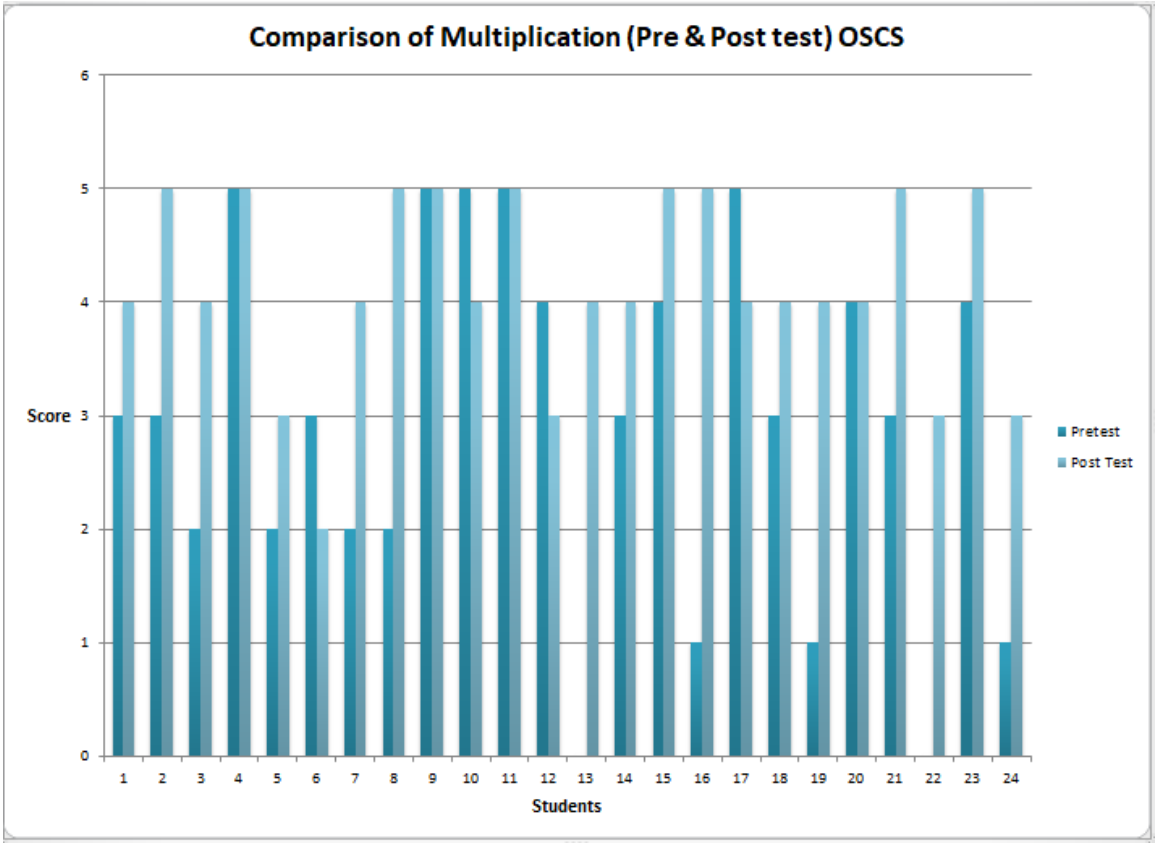

Figure 15: Pre & Post test multiplication (OSCS)

The graph clearly shows the increase in scores which means the students were able to solve more questions after the intervention. Those students who scored 0 in pretest were able to solve questions in posttest. Some students were not able to solve as many questions as they did in pretest. Average score of students saw an increase of more than 1 point.

The graph below will show the comparison between pretest and posttest overall. The overall graph will show how students performed after the intervention. The intervention was carried out for 6 days from which students played game for 4 days and two days were used for pretest and posttest. Students have shown significant improvement in term of score in test.

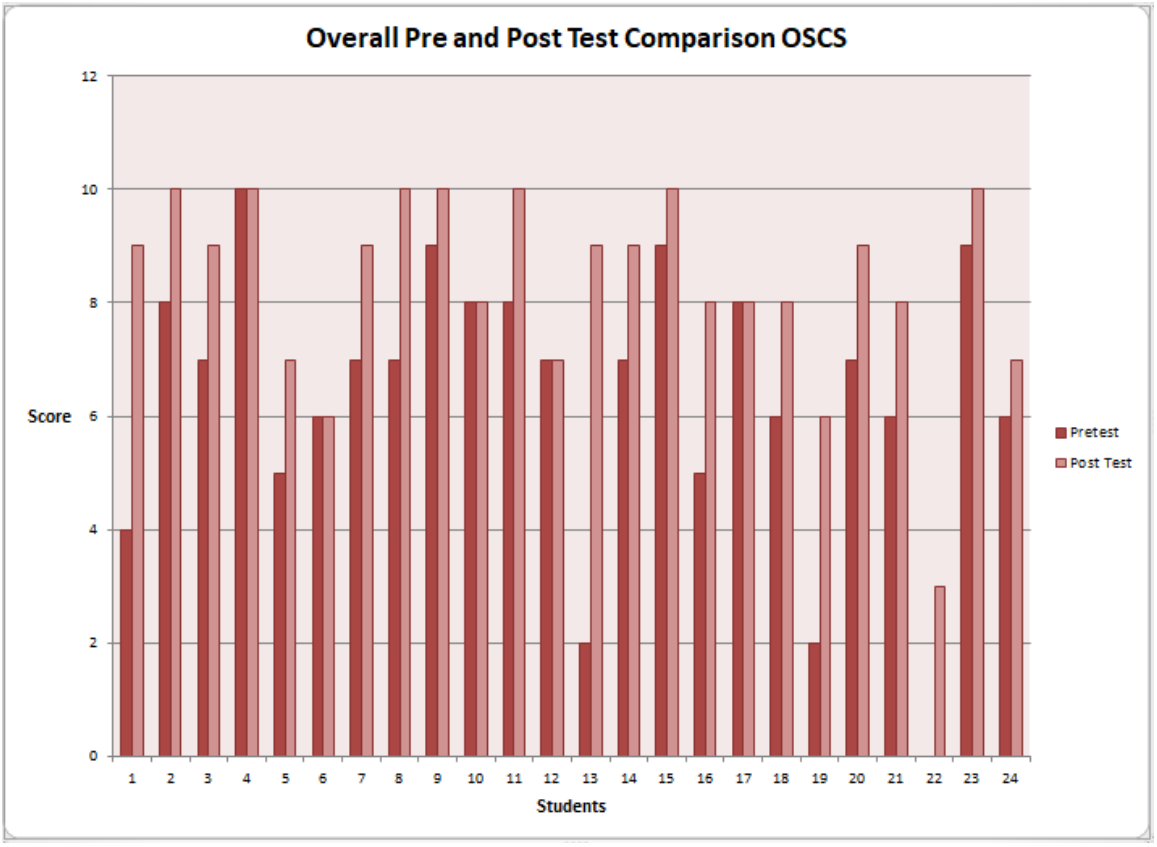

Figure 16: Pre and Post test comparison (OSCS)

This graph shows that there was no student whose overall score was below than the pretest. Some students scored the same score but majority of students showed the improvement. The overall average scored among students was 6.3 in pretest. But in posttest the average saw the increment of two pints and average score was 8.3 after posttest. This shows that the digital game and the whole intervention had an impact on the students of Out of School Children School (OSCS).

5.2.1.4 Data Analysis using SPPS

Statistical package for social sciences (SPSS) was also used to analyze the data. This software was used to make sure that our results are consistent and are same. T-test was applied on the data to analyze the data more deeply and accurately. The statistics were same as they were found in excel.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Pre_school1	24	6.3750	2.42832	.49568
Post_school2	24	8.3333	1.71100	.34926

Figure 17: t-Test using SPSS (OSCS)

Mean is exactly same as it was during analysis in excel. The standard deviation dropped by 0.7 approximately. The results show that there was a significant improvement.

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pre_school1	12.861	23	.000	6.37500	5.3496	7.4004
Post_school2	23.860	23	.000	8.33333	7.6108	9.0558

Figure 18: t-Test using SPSS (OSCS)

p values in the above data is less than 0.5 which mean our null hypothesis is rejected and the intervention had a significant impact on the learning abilities of the students.

5.2.2 Quantitative Analysis (Rural)

The second school of this research study was from rural area, Government Girls Public School (GGPS) Wasankay. In this section the data collected from GGPS will be analyzed. First we will compare pretest scores of both sections of questionnaire and then we will compare posttest of both sections and on last we will compare overall progress of students.

5.2.2.1 Pretest

The graph below shows the data collected during pretest in GGPS of addition section. There were 20 participants from GGPS in this study. The criteria of score was same and total score in one section was 5.

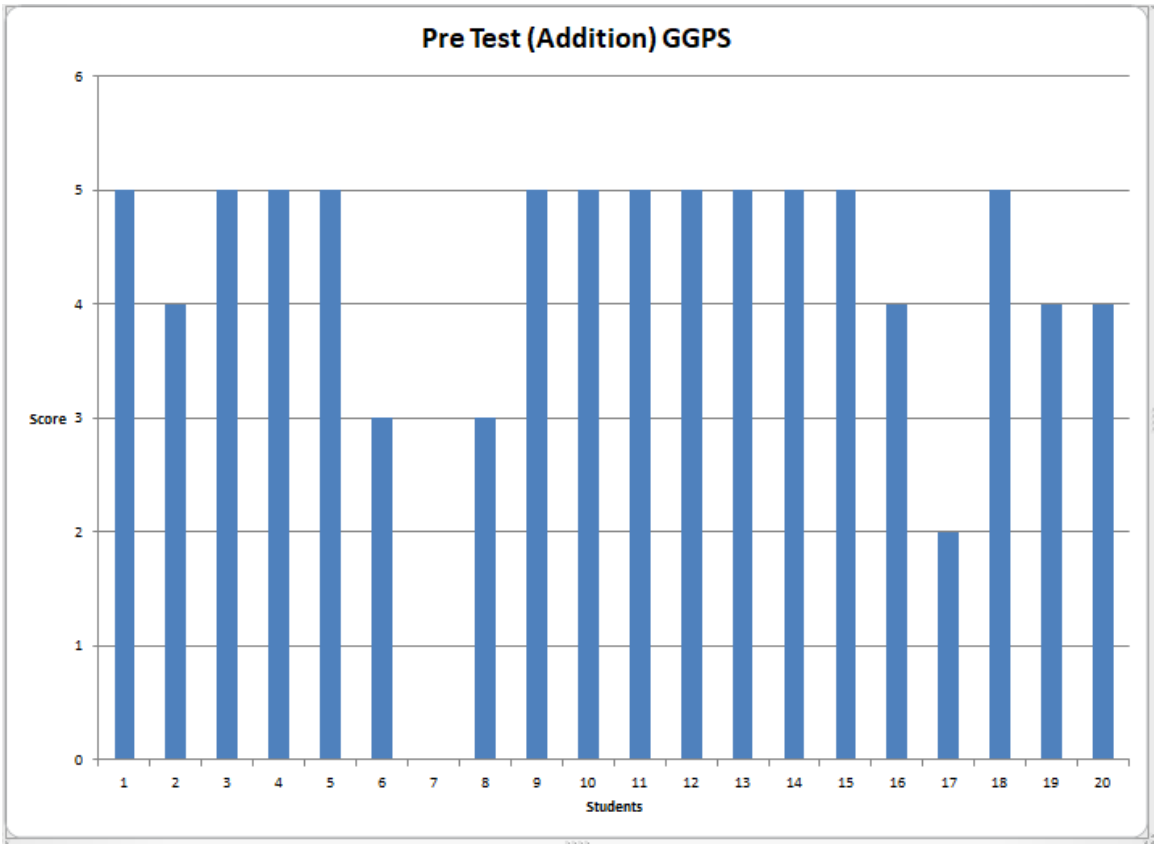

Figure 19: Pretest addition (GGPS)

It is evident from the above graph that majority of students scored maximum marks. Out of 20 students, 12 scored maximum marks and only student scored 0. The average score in addition was 4.2 during pretest.

In multiplication during pretest students performed not as much as they did in addition. The data collected from GGPS shows the sign that students were weak in multiplication compared to the performance in addition. The graph below shows the data of students' performance in multiplication section of pretest.

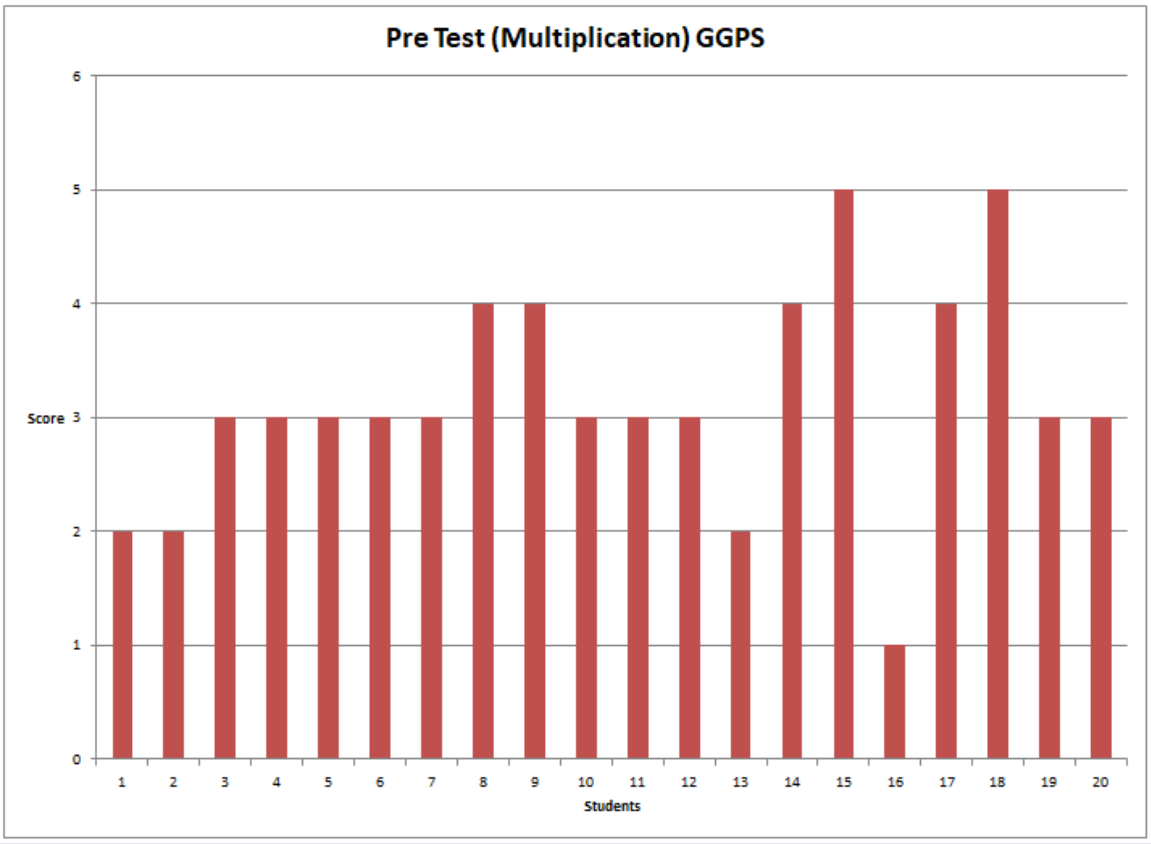

Figure 20: Pretest multiplication (GGPS)

The graph shows that only two students were able to score maximum marks as compared to addition where 12 students scored maximum marks. The lowest mark in this section was 1 and 3 students got 2 marks/score in this section. The average score for multiplication part in pretest was 3.15.

5.2.2.2 Posttest

The data of posttest that was collected from GGPS was analyzed using MS Excel. First we will analyze the data of addition section and then the data of multiplication section. The graph below is from data of addition.

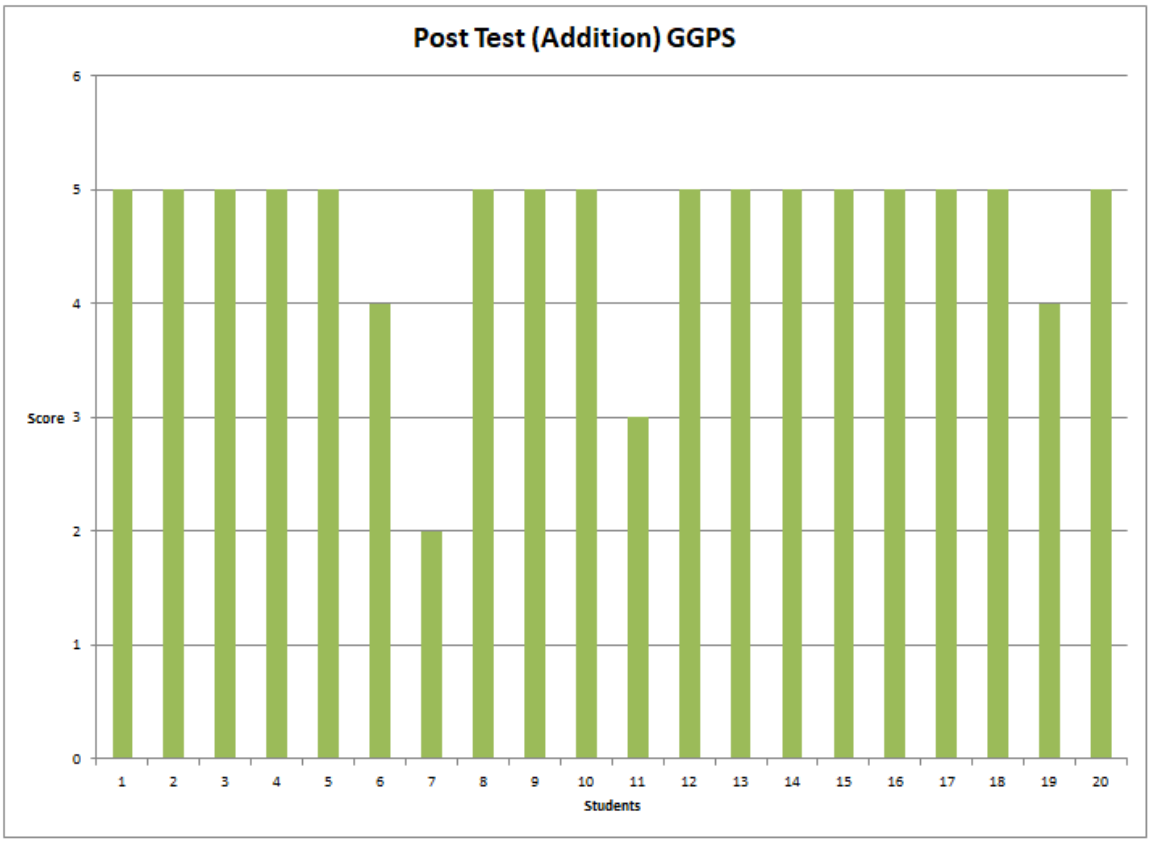

Figure 21: Posttest addition (GGPS)

The graph shows that the results have been improved. 16 students were able to score full marks during posttest. The lowest score in posttest was 2. The average score during posttest was 4.65 as compared to 4.2 during pretest. This shows a significant improvement among students. The students were able to solve more questions than they did in pretest.

The data of multiplication was plotted in same manner. The graph below is from the data of multiplication section.

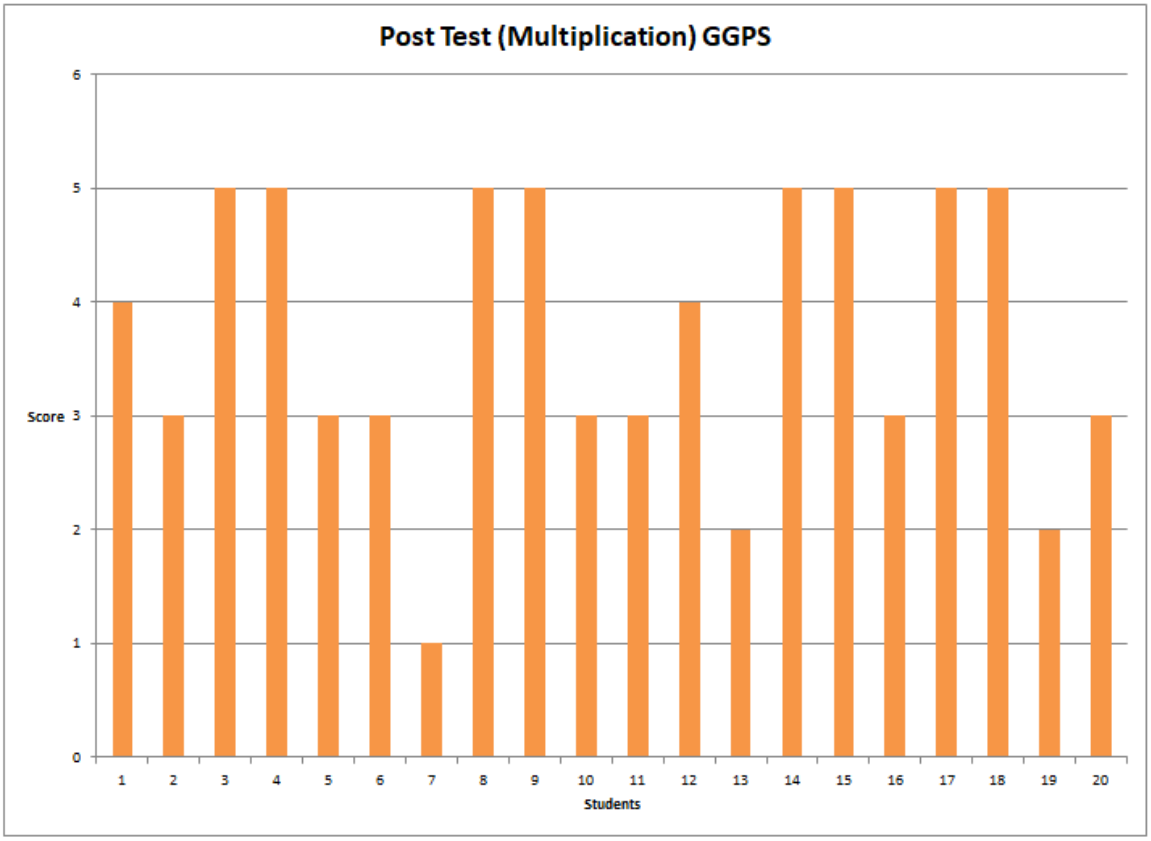

Figure 22: Posttest multiplication (GGPS)

The graph indicates that students were able to perform better after intervention. There was a rise in posttest in scores. Total 8 students were able to solve all questions and secure full marks as compared to two students during pretest. The overall average was high in posttest as compared to pretest. The average of posttest was 3.7 as compared to 3.15 in pretest.

5.2.2.3 Pre and Post Test Comparison

In this section both results will be compared side by side to get a clear picture of what the results are and how significant the intervention was. On x-axis there will be students and on y-axis there will be the score of all students respectively. The first graph will be of addition and both values will be shown.

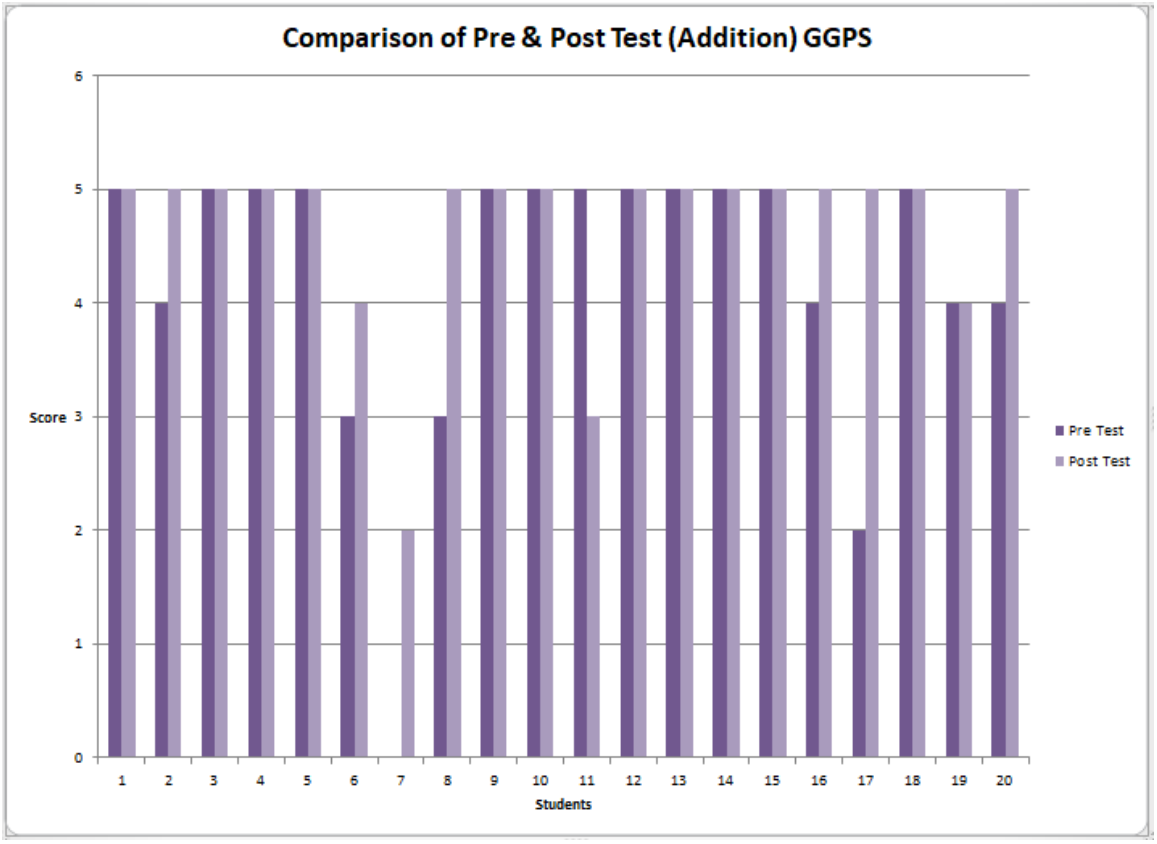

Figure 23: Pre & post test addition (GGPS)

The dark purple color represents the score of pretest and light purple color shows the results of posttest. Only one student out of 20 showed the decline in score and one student maintained the score of pretest. Rest all students showed an increase in score as compared to pretest. As discussed earlier the average score also saw the rise from 4.2 to 4.65. This shows that the intervention had a significant impact on students. They were able to perform better than the pretest.

The second graph is of multiplication. Multiplication is considered to be tough among students and it was evident too from the pretest. Student struggled in multiplication more relatively to the addition. The graph below shows the data of multiplication from pretest and posttest.

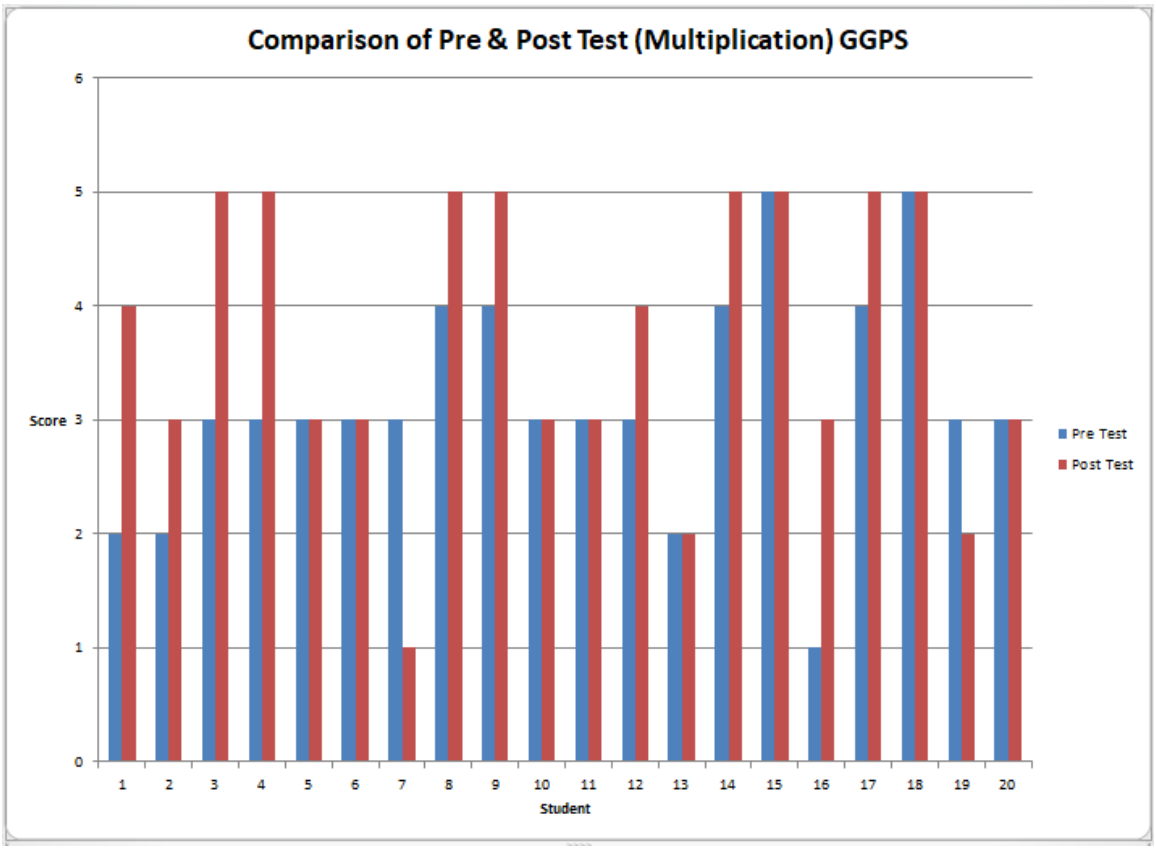

Figure 24: Pre & post test multiplication (GGPS)

The data in this graph shows the increment in scores of students' performance. Two students out of 20 were able to solve less solve less questions than pretest. Overall the number of students who scored full increases as compared to the pretest. As discussed in above section the overall average in multiplication was higher as compared to the pretest. The average in posttest was 3.7 as compared to 3.15 in pretest.

In last the overall graph of scores will be compared in order to analyze how students fared in this intervention. This will give us a bigger and clear picture and will help us analyze more clearly what the outcome of this intervention was. Total score in this graph was 10. Each question hold one score. We saw the increment in both addition and multiplication section of posttest.

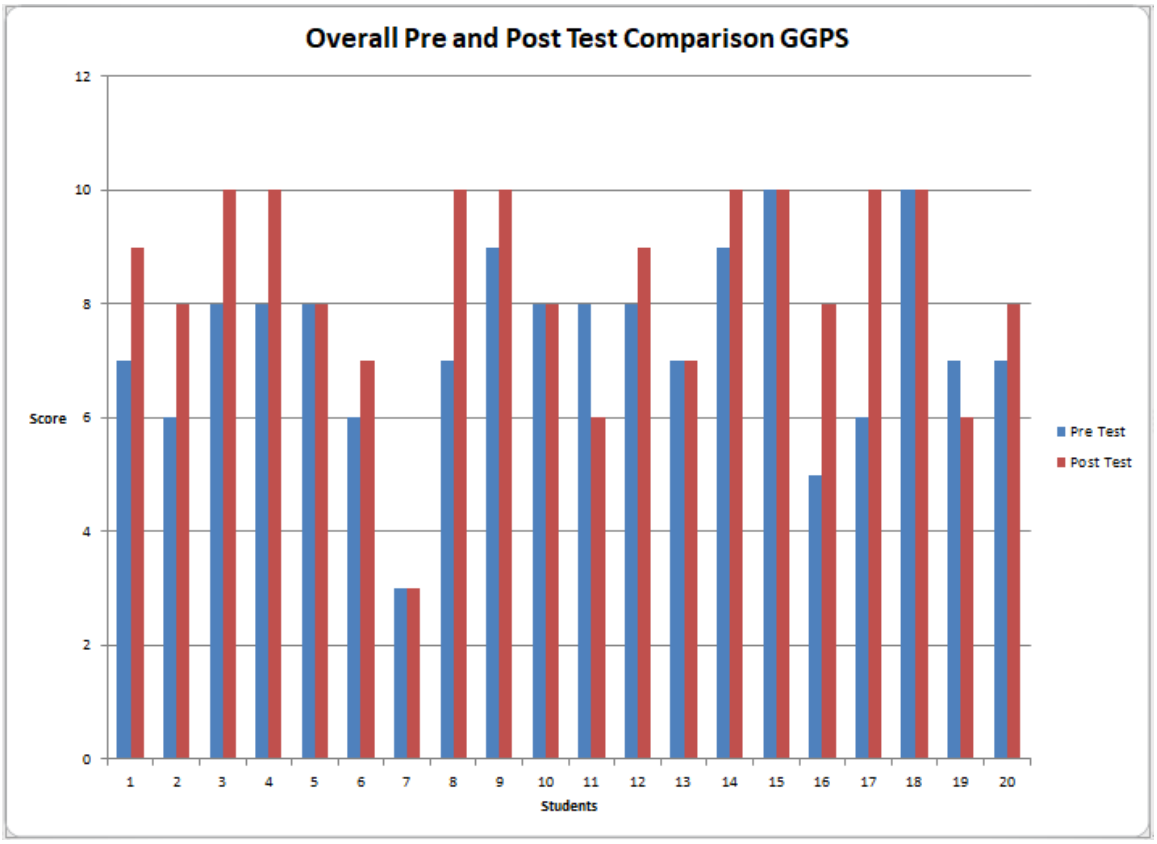

Figure 25: Pre and post test comparison (GGPS)

The blue color represents the pretest and red color represents the posttest. 2 students out of 20 were able to solve fewer questions as they did in pretest. But overall most students showed a sign of improvement. The overall average in pretest was 7.35 and after intervention the overall average saw the increment of 1 point and it stands at 8.35. This indicated that students' ability to solve questions was improved after the intervention. They showed improved performance in posttest.

5.2.2.4 Data Analysis using SPSS

SPSS was used to reconfirm our data analysis. Basic purpose was to find the p value and check the significance of the intervention from the data collected. Mean value was same as it was in Excel during analysis.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Pre_school2	20	7.3500	1.66307	.37187
Post_school2	20	8.3500	1.87153	.41849

Figure 26: t-Test using SPSS (GGPS)

Standard deviation increased during posttest as compared to the standard deviation in pretest. This shows that intervention carried out had an impact on the students' ability of solving mathematical questions.

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pre_school2	19.765	19	.000	7.35000	6.5717	8.1283
Post_school2	19.953	19	.000	8.35000	7.4741	9.2259

Figure 27: t-Test using SPSS (GGPS)

p-value is less than 0.5 which is 0.000, it implies that the intervention had a significant impact on the students. This is also evident by the comparison of average score of pretest and posttest. Average score was increased by 1 point which was very significant considering the total was of just 10 point.

5.3 Data Analysis (Qualitative)

Qualitative analysis was based on the observations, field notes and interviews with teacher. Participants in this study were from low socio economic background. They do not have access to tablets and other digital gadgets. Some participants did not how to use these tablets and play digital games. This was one of the major factors which enhanced their engagement and motivation during this study. The basic purpose of this research is

to check the level of engagement and motivation shown by students during this research study.

5.3.1 Engagement

Majority of students did not have the firsthand experience of using Tablet. Some students were not able to use properly at first. They did not know how to drag things in touchscreen devices. First few minutes were dedicated for those students who were having trouble in using tablet. Almost all students were excited to use tablet and play games. They were always looking forward for the session throughout the day as pointed by teacher during interviews. This was one of the main reasons that they showed higher engagement during this study. Engagement was measured by observing their behavior during the study. The things which were observed were their concentration, verbalizing thinking and seeking information and feedback.

They showed greater concentration, which was evident by the way they behaved during the intervention and were able to avoid distractions and some get annoyed when someone interfered in their game. They were constantly asking for help whenever they get stuck in the game. Although the game can be played infinite number of time and there was no limit of questions in the game. Because all questions were being generated randomly by the game within the set values taken from their book. Some students were so motivated to end the game that they spend all the time in solving questions.

The other main reason for the amount of engagement they showed was the change in classroom setting. They were doing something different what they used to do in their regular classes. It is human nature that when something new happens it excited them. Some students asked to continue this method in every class because in this way they were having fun while learning is happening at the same time.

5.3.2 Motivation

Motivation and engagement is linked together. Higher engagement will result in higher motivation and higher motivation will result in higher engagement. Motivation in classroom setting depends on the pedagogy, content and knowledge of teacher. If sound pedagogy coupled with engaging content is used in classroom

it will result in higher motivation among learners. In this study both the content and pedagogy was new for students and they liked this way of teaching. So, they were highly motivated during this intervention. This claim is also backed by the attendance of students during the intervention. The attendance of class was higher than regular days during the intervention. They were always asking for more time to play digital game on tablet. Once student even said, "*Ap hi agli class b le lain*" which means, "You should also take the next class".

5.3.3 Common Mistakes by students

During pretest there were some common mistakes by students. In addition most students were able to perform better than multiplication. Multiplication was newer topic for them as compared to addition and multiplication involves more step than addition. Some students did not know how to write questions. For example if the question is to add 84 and 4. They will write 4 under 8 and then add them both. They did not know that one's should be added in ones and tens in tens. If the above digits and lower digits were equal they were able to solve that question quite well. Some students had problem in those questions which involve the carry. They will just write carry on top and the after two digits one will be written in left most side of answer.

Mistakes in multiplication were much more than the mistakes in addition section. Most students were able to solve the question with single digits. For example if the question was to multiply 4 and 2. Most students have the answer right. But when there were two digits most students struggled in that part. They also struggled in those questions in which they have to take carry. They struggled in that part. That's why in game both these techniques were taught to students and they showed greater improvement in that part in posttest.

Chapter 6: Discussion

Main objectives of this was to find the impact of digital games in teaching mathematics and do digital games enhance the level of engagement and motivation by students. In this both hypothesis will be discussed in detail which were mentioned in chapter of methodology.

RQ 1: Do digital games have any impact in teaching mathematics concepts?

H_0: Use of digital games in teaching mathematics concepts have no impact on students.

The basic objective of this research was to improve the concepts of students about solving mathematic questions by teaching them mathematical procedure using digital games. In order to assess the outcome of this study pretest and posttest was conducted and analyzed. As the participants were of 3rd and 4th grade they already had learned about addition and multiplication in their classroom. But still students performed poorer in pretest. They did some common mistakes. They did not have the concepts of ones and tens. They did not know how to add the carry in answer and if digits are not equal in both parts they struggles to write properly. In multiplication sections students did have some issues and they were in pattern. Majority students were not able to solve the multiplication questions with carry and some added them instead of multiplication.
After intervention and playing digital game for four consecutive day results were outstanding. The average score in posttest was higher than the average pretest score. Mistakes while solving questions were less as compared to previous part. Almost every student was able to write ones under ones and tens under tens. They now knew that addition mean they have to add both digits and multiplication mean they have to multiply both numbers. They also knew to use carry in multiplication.
The above arguments and analysis have rejected the null hypothesis that digital games do not have any impact on students. Students' score saw an increase in average of each section by almost one point. Which means digital games, do have an impact on teaching mathematics concepts.

RQ 2: Does use of digital games have any impact on motivation and engagement of students?

H_0: Digital games do not have any impact on motivation and engagement of students.
Previous researches have shown that students find mathematics quite boring and dull. They do not have any interest in mathematics class. But in this study during intervention, students showed high level of engagement and motivation. They were avoiding distractions, they were asking questions, they were always present in class and the attendance was higher in those days than usual. They played game with excitement and fun. They were motivated enough that they will always ask for some more time to play game. Teachers also backed this claim by saying that students like this way of teaching and will love to be taught in this way.
Hence from the above statements our null hypothesis was rejected which was that digital games do not have any impact on engagement and motivation of students. While the data collected, showed an increased level of engagement and motivation by students.

Chapter 7: Conclusion and Recommendations

In this chapter we will conclude the study and its outcome and will give some general recommendation for future researchers to work on and improve the existing research.

7.1 Conclusion

This study has been conducted to assess the impact of digital games on teaching mathematical concepts to students and level of engagement and motivation achieved through using digital games. Background, purpose of the study, design and development phases, literature review, methodology, data collection and analysis has been discussed in previous chapters. After all the above mentioned steps, it has been established that, digital games do have an impact on enhancing the capabilities of students in solving mathematical problems. Participants showed high level of engagement and motivation during the intervention. Therefore both null hypotheses were rejected after the data analysis, which make this study successful.

In Pakistan use of digital games for teaching purpose is almost nonexistent. The schools that were covered in pre analysis and during research were not familiar with the concept of digital games for education. The available games on Google playstore are not that of quality and are not properly developed to teach students. So, there is a great need of working in this sector of developing mathematical games with proper instructional designing and pedagogies. The development and usage of digital games will not only enhance the results but will also keep the students engaged and motivated in learning mathematics.

7.2 Recommendations

In future digital game for teaching subtraction and division should be deployed to see whether the study has same impact or not. It should be applied in more number of students and should have certain updates. The thing which was lacking in this game was that students were not able to track their progress. The game can be played for infinite number of times. The next game should have proper stages to complete and student can end the game if not then it will give students a sense of satisfaction of that they are progressing.

The game should support multiple languages and students can select the language according to the need. Feedback and instant help should be available if any student feel stuck. The interactions within games should be recorded to know where students are struggling and where we need to improve the game. The other main issue was faced during the game was the permission to test the game in schools. Many schools did not allow carrying out intervention in their school despite showing them the official from university.

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