Impact of an Interactive Educational Desktop Application of Science on Student Engagement

Author

Amna Khan

NUST201463063MSEECS61414S

Supervisor

Dr. Muhammad Muddassir Malik

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

APRIL, 2016

Impact of an Interactive Educational Desktop Application of Science on Student Engagement

Author

Amna Khan

NUST201463063MSEECS61414S

A thesis submitted in partial fulfillment of the requirements for the degree of

MS Innovative Technologies in Education

Thesis Supervisor:

Dr. Muhammad Muddassir Malik

Thesis Supervisor's Signature:_______________________________________

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

APRIL, 2016

Approval

Certified that *Ms. Amna Khan* Regno *NUST201463063MSEECS61414S* student of MSITE-*1* have submitted the final draft copy of his/her thesis titled *Impact of an Interactive Educational Desktop Application of Science on Student Engagement*

Arrange her final defence presentation as per the SOP.

Advisor: Dr. Muhammad Muddassir Malik

Signature:___________________________

Date: ___________________________

Committee Member1:Ms. Farzana Ahmad

Signature____________________________

Date:________________________________

Committee Member2: Dr. Sohail Iqbal

Signature ____________________________

Date: ________________________________

Committee Member3: Mr. Jaudat Mamoon

Signature ____________________________

Date: ________________________________

Dedication

Dedicated to my parents, whose support and cooperation led me to this glorious achievement

Certificate of Originality

I hereby declare that the research paper titled "***Impact of an Interactive Educational Desktop Application of Science on Student Engagement***" is my own work and 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 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 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: Amna Khan

Signature: _______________

Acknowledgements

All praises to almighty ALLAH whose blessings enabled me to complete this thesis.

I would like to thank my supervisor Dr. Muddassir Malik for his valuable input and support. I would also like to thank Ms. Farzana Ahmad for guiding me and giving me time and a valuable support at different stages of this research work.

Finally, thanks to my friends and family for supporting me in this research work.

Table of Contents

List of abbreviations

CF	Consistent Focus
CAI	Computer Aided Instruction
CAL	Computer Assisted Learning
DGBL	Digital Game Based Learning
FGD	Focus Group Discussion
F&E	Fun and Excitement
GBL	Game Based Learning
ICT	Information and Communication Technologies
OECD	Organization for Economic and Cultural Development
PBL	Positive Body Language
SC	Student Confidence
TPACK	Technological Pedagogical Content Knowledge

List of tables

List of figures

Abstract

The primary reason for dropping out of school is associated with student disengagement in classrooms. Almost 25 million girls and boys aged 5 to 16 are out of school in Pakistan and this percentage further elevates as the education level increases. Integrating technology in education not only enhances student engagement, but also boosts academic achievement. However, Science revolves around the abstract concepts that are hard to comprehend by most of the students. Instead of teaching science concepts through conventional instruction, educational technologies are embedded in Science education to make learning more fun and engaging. To boost student engagement and learning performance, an educational app on Science was developed targeting 8^{th} grade students.

This study is quasi experimental with convenience sampling of the participants. This study includes four phases. In phase 1, an educational app on Science was developed targeting misconceptions regarding patterns of reactivity. In phase 2, pre test based on content knowledge was conducted. In phase 3, intervention started which lasted 3 weeks. In phase 4, post test similar to pre-test was conducted followed by focus group discussions. The outcome was analysed and it was revealed that the learning app on science "patterns of reactivity" has a significant effect on student engagement. Moreover, this app promoted significant gender disparity among students. Contrary to these outcomes, this app does not result in significant gain in the learning outcomes of experimental groups. However, no significant difference was found in the student achievement between control and experiment groups.

To gain insights and study the trends of various engagement factors, qualitative analysis was collated with quantitative data collection methods. This study contributes significantly to the existing literature in terms of student engagement and gender difference. Apart from this, the present study could be an alternative solution for the children who do not attend the schools especially in Pakistan due to certain reasons. Moreover, this study suggests future researchers to minimize the gender gap and further, deduce a solution that promotes low cost but a quality education enhancing retention and eradicating illiteracy particularly in the context of Pakistan.

Keywords: *Student Engagement, Game Based Learning, Learning Performance, Science Education, Gender Difference, Educational Technologies, Digital Games, GBL*

1 Introduction

It is hard to neglect the significance of Information and Communications Technology (ICT) in high school education due to recent trends and widening scope of technology. Lots of interest has developed in using the idea of integrating educational technology in schools, recently. The benefit of using a computer or digital technologies in an educational context is their ability to enhance learners' engagement, which contributes to better learning achievement.

1.1 Problem Statement

According to a survey conducted by Annual Status Education Report (ASER) in 2014, 21% of children (aged 6-16) in Pakistan were reported to be out-of-school, which has almost remained the same as compared to the previous year i.e., 21%. Among these 21% children, 15% children have never been to a school while 6% children have dropped out of school for various reasons (ASER 2014). One of the main reasons for dropping out of the schools is disengagement in the classroom (Finn 1989). This notion is further supported by Ulmanen et al. (2014) who discovered that the chances of disengaged students to drop out of schools are greater. Moreover, dropping out of the school has remained the serious concern in Pakistan (AlifAilaan 2015).

Almost 25 million girls and boys aged 5 to 16 are out of school in Pakistan and this percentage further elevates as the education level increases (AlifAilaan 2015). Moreover, it has been found out that almost 85% children are out of school by the time they reach higher-secondary schools (AlifAilaan 2015). The education of girls, especially in Pakistan is essential since more than half i.e., 55% of all out of school children are females (AlifAilaan 2015).Moreover, the reasons of not attending schools as reported by the parents are associated with location of school, cost of schooling, early age marriage, and parents, themselves, unwilling to send their children to school (AlifAilaan 2015).

Some studies reported that 40-60% of students are disengaged by the time they reach high school (Marks 2000). According to the investigation reviewed by Pietarinen et al. (2014), the proportion of reduced affective gain among students in schools of Organization for Economic and Cultural Development (OECD) countries is 25% and the proportion of regular absenteeism of students from these schools is 20% .Furthermore, reduced engagement levels resulted in low achievement among students, negative attitude and dropping out of school (Pietarinen Ibid 2014).Engaged students have two characteristics common in them a) performing better in the studies, and b) getting good grades in state administered tests (Pietarinen ibid 2014, Ladd and Dinella 2009, Schunk and Pajares 2005). Moreover, student engagement demonstrated the direct correspondence with achievement contrary to dropping out of school (Fredricks et al. 2004). However, learning can be made fun for such students, who are in danger of dropping out of schools, simply by enhancing their learning motivation through games (Toussaint and Brown 2015). The acceptance of edutainment (blend of education and entertainment) and games is higher among preschool and early school kids, but it is harder for teachers to motivate and engage the middle and high school kids than younger children in school studies due to lack of teachers and parents' interests in games and edutainment (Brom et al. 2011). However, engaged students find learning meaningful, earn better grades and are determined while facing problems throughout their education as compared to disengaged students who suffer from their studies (Ulmanenibid 2014). Moreover, students engaged in school learning activities were found to be engaged throughout their school life (Ulmanen Ibid 2014). In addition to this, engaged students are inclined towards investing more time and exerting much effort in their education throughout their education and such students are more inclined to be efficient and persistent in problem solving hence, boosting engagement in school learning activities and preventing them from negative states leading to anxiety (Ulmanen ibid 2014).

Apart from this, students start losing interest in conventional instruction of Science because it requires rote learning of facts which is the drawback of such instruction (Li and Tsai 2013). Moreover, lack of teaching aid and styles used in science class and the difficult language of science made it difficult for students to comprehend the complicated theoretical concepts (Woldeamanuel et al. 2014). In a similar way, for students to be successful in high school science, they are required to master the important experimental ideas and skills in order to comprehend the most difficult and in depth scientific concepts taught by their instructors (Mo et al. 2013). Therefore, Mo ibid (2013) considered 8^{th} grade as an essential and critical point for interest development and positive attitude of the students in science education.

It is hard for most of the secondary and college students to get the gist of science and these students keep on struggling with themselves to learn Chemistry throughout their education and many among them fail to do so (Woldeamanuel ibid 2014). According to Woldeamanuel Ibid

(2014) and Kamisah and Nur (2013), students still have misconceptions comprehending the basic concepts of chemistry. Such misconceptions held by the students never change through their education. However, the students seem interested in considering the pedagogical (the way of teaching) demands of teaching and learning and proposed that collaborative work, student centered learning environment, use of educational technology, students' motivation, and conceptual understanding might accomplish better comprehension of Scientific concept (Woldeamanuel Ibid 2014). In his study, Tatar Ibid (2013) found that the educational technology helped students learn about their misconceptions, correct them and learn the unlearned concepts relevant to the subject.

A survey was conducted on students of 9th grade prior to the intervention of the present study which revealed that 60% of the students regarded Chemistry as a difficult subject to comprehend, whereas 30% of the students found Physics difficult and remaining 10% of the students found Biology difficult to comprehend. In conclusion, the students faced difficulty comprehending chemical formulas and reactions since such concepts made them lose their interest in subject matter.

1.2 Synopsis of relevant literature

Several researchers (Zafar et al. 2014, Terri 2014, Keengwe and Hussein 2014, Li and Tsai ibid 2013, Tatar ibid 2013, Klisch et al 2012) have recommended the integration of educational technologies in schools including digital ames, Game Based Learning (GBL),and animations as a part of the curriculum in several domains such as mathematics, science, and arts.

The implications of games on student learning and engagement have been identified by 129 reports (Lester et al 2014). New Media Consortium's Horizon Report restated that GBL is a primary innovation that carries great potential to have a huge impact on education. According to Lester Ibid (2014), computer games in learning science, motivate individual learners by offering them with great challenges, instant feedback and adapting according to their demands and interests.

1.3 Desirability of research

Though, extensive research has been carried out on the implication of educational technologies, and GBL on learners' engagement and their learning performance. Still, several authors (Dorji et al 2015, Chang et al 2014) have recommended that there is a need of more research studies that can address the interaction between learning methodologies and genders on learning achievement and develop the strategies to enhance game engagement among genders of both types.

It has become important to address the out of school children and drop out issues in Pakistan and promote girls' education equality. Moreover, there is a need to provide low cost and easily accessible and quality education targeting children from varying socioeconomic status in Pakistan especially girls.

1.4 Purpose

The purpose of the present study is to evaluate the impact of an interactive educational application of Science "Patterns of Reactivity", designed and developed for 8th grade students on their learning performance, and engagement. This study also identifies the relationship between learning approaches (receiving Science traditional instruction and an educational app instruction) and gender differences. The present study sought to formulate the following null hypotheses;

H_{01}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on student engagement.

H_{02}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on learning outcomes.

H_{03}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on gender differences.

1.5 Engagement in Science

In general, Newmann et al. (1992) defined engagement as "psychological investment in and effort directed towards learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (p-12) and "engagement refers to the quality of a child's or youth's connection or involvement with the endeavor of schooling and, hence, with the people, activities, goals, values, and place that comprise it" (Skinner et al. 2009, p3). This research study is focused on emotional engagement concerned with emotions, student interestwork and behavioral engagement is concerned with positive body language, attention, and confidence while initiating and completing activities in the Science class (Mo et al. 2013, Jones 2009).

1.6 Synopsis of research method

This study followed the approach of equivalent sample pre and post-tests quasi experimental research design using certainquantitative and a qualitative data collection methods (Cohen et al. 2007). Student engagement was observed towards the work during the experimental process. Learning Achievement Test was conducted before and after carrying the experimental process followed by focus group discussion. In this study, the two learning methods were compared (educational app based Science instruction versus non-learning app based Science instruction also known as conventional instruction) based on their effectiveness. To smooth out the variable, the study assumed that all students at the school under study were from a varied socioeconomic background. They had a very similar prior knowledge of science concepts and skills and were equally capable before randomly allocating them to the treatment and control groups.

Though, gamification has been embedded in designing the learning activities of Science based app , but serious gaming, video games based learning, pedagogical agents (avatars or characters speaking or communicating with the students) and virtual reality are beyond the scope of this study. Constructivist learning theory promoting individual learning is discussed in this study; however, social constructivist learning theory is beyond the scope of this study. However, this app was not pilot tested prior to intervention. This study promises to offer a valuable impact on Pakistan with increased retention rate. This study delivers a reliable, low cost and easily accessible solution to the individual and classroom students. This research study mold the overall report in six chapters, including this introductory chapter. The second chapter starts by laying out the theoretical underpinning of the research, and looks at how trends of game based learning in ICT has changed over time, what pedagogical aspects and instructional design elements should be considered while developing procedures for engaging students in Science learning. The third chapter is concerned with the quasi experimental research framework and in-depth data collection methods used for this study. The fourth chapter analyses the results of the various methods employed in data collection followed by focus group analysis. The fifth chapter discusses the consequences of the findings of the present research study. Chapter six draws a conclusion by giving a brief summary of the findings. Chapter seven recommends or suggests the area for further research.

2 Literature Review

2.1 Background

Science classrooms play a major role in enhancing students' participation and performance (Lester ibid 2014). Despite this, such classes neglect the curiosity of children about the natural world when they enter in school (Lester ibid 2014). However, Lester ibid (2014) has suggested that any nation can advance only if the individual's interest is developed in scientific proficiency, achieved by minimizing the rote learning of facts and focusing on the scope of content that actively engages the learner in critical thinking and deep learning of core scientific concepts and ideas. Many high school students lack the skills of self directed learning and cannot learn without any assistance, guidance or coaching (Toussaint and Brown 2015). In fact, students prefer using technology and games in their studies and take interest in learning. This sort of learning replaces conventional teaching methods (Toussaint and Brown ibid 2015).

According to Tatli and Ayas (2013), it is equally challenging and difficult for students to construct abstract concepts in chemistry as teachers do not help them in constructing difficult concepts in their minds, such as a chemical change unit. The abstract concepts in chemistry are one of the main hurdles having a bad impact on student achievement (Tatli and Ayas Ibid 2013).As a consequence, this obstacle can be overcome through technology based alternatives in chemistry (Tatli and Ayas Ibid 2013).Since past studies reported that considering the vitality of lab work in chemistry courses: a) confusion and hesitation in conducting experiments, b) an enormous amount of effort and time needed to perform experiments, and c) safety concerns arise while embedding lab work in conventional chemistry courses (Tatli and Ayas Ibid 2013). However, technology boosts the conventional instruction instead of replacing it (Terri 2014). Qualities such as motivation and emotions are the prime means of achievement in science (Mo et al. 2013). Tatar et al. 2013 has developed educational software for electricity in his study and the main focus of this software was on addressing students' misconceptions and comprehension of learning concepts. In general, Tatar ibid (2013) and Mo ibid (2013) suggest that misconceptions held by the students can only be addressed through proper teaching methods and materials as the future career of eighth grade students revolve around it. Moreover, Tatar ibid (2013) points out that effective educational software has the potential to enhance students' learning and boost positive affective skills, thus eliminating the misconceptions held by the students. This view is supported by Keengwe and Hussein (2014) who stated that the use of computer technology can increase the learning efficiency and motivation. Since, it has already been proven that learning gets up to 40% faster through educational technology due to its tendency to enhance time-on-task of the students (Keengwe and Hussein ibid 2014). Games in its student-centered model of design contrast from the formal teacher-centered and content-driven education (Jan et al. 2015). According to Domínguez et al. (2013), apart from promoting knowledge based on facts, educational games also encourage higher order thinking. Enjoyment and fun are essentials when adapting new tools as the learner is more at ease and eager to learn and motivate (Prensky 2001). Huang and Saman (2013) investigated that motivation and engagement are generally considered essentials to encourage a particular conductor task completion. According to Byun and Loh 2015, Finn and Zimmer 2012, Orthner et al. 2010; there is a less likelihood of engaged students to drop out of school. Huang and Saman ibid (2013) has also discussed the purpose behind the low performance of students and dropping out of school and further stated that boredom or absence of engagement leads to absenteeism which makes the students less eager to return to school.

According to Huang and Saman ibid (2013), gamification has turned into a prominent strategy to encourage practices, and boost further engagement and motivation in today's computerized era. Presently, this practice is being implemented in educational programs offering instructor's assistance with finding balance between accomplishing their targets and considering the demands and interests of the students (Huang and Saman ibid 2013). Schools are usually blamed for the academic accomplishment of the students, instructors should offer students with opportunities to accomplish their learning achievement by identifying activities for them and understanding the way they learn (Parsons et al. 2014).

2.2 Student Engagement

Recently, student engagement has gained a lot of attention (Parsons ibid 2014). Though, students are required to be actively engaged in order to earn better grades, but engagement keeps on declining as students advance through elementary to middle school, therefore, educators need to consider and encourage engagement at all grade levels (Parsons ibid 2014).According to Parsons ibid (2014), it is hard to isolate student engagement from their environment. Students feel energetic, actively take part in discussions, and show a positive attitude towards their work when highly engaged whereas students feel bored and not interested about learning tasks when disengaged (Parsons ibid 2014).

2.2.1 Emotional and Behavioral engagement

Engagement variables such as *emotional engagement* concerned with the emotional aspects, affect, interest, motivation to engage in a task, feelings, enjoyment, happiness, enthusiasm, support, and perceptions towards the educational environment (Hsieh et al. 2015, Pietarinen et al. 2014, Parsons Ibid, 2014, Mo Ibid, 2013, Hampden-Thompson and Bennett 2013, Tatar ibid 2013, Mitchell and Carbone 2011) and *behavioral engagement* concerned with time on task, involvement in tasks, effort exertion, persistence, confidence, exhibiting positive body language and mental effort (attention and concentration) (Hsieh Ibid, 2015, Pietarinen Ibid 2014, Parsons Ibid 2014, Mo Ibid 2013, Mitchell and Carbone Ibid 2011, Skinner Ibid 2009, Jones 2009) are used in this study.

According to Mo ibid (2013), the positive attitude of students in learning science led to better science achievement thus promoting emotional engagement in the US and other countries. This notion is further supported by Tatar Ibid (2013) who revealed that the computer assisted instruction method influences the positive attitude of the students towards science prompting the extensive use of computer animations in science education. In his study of identifying the impact of embedding animations and videos in instruction, Tatar ibid, 2013 concluded that students were actively engaged while learning concepts interactively using educational software.

2.3 Gamification

In general, gamification can be defined as “the application of game-like mechanics to non-game entities to encourage a specific behavior” (TeachThought Staff 2015). Marczewski (2012) argued that in gamification, game elements are implemented in the real world to further influence behavior, boost motivation and engagement. Gamification can also be defined as “a form of service packaging where a core service is enhanced by a rule-based service system that provides feedback and interaction mechanisms to the user with an aim to facilitate and support the user’s overall value creation” (Huotari and Hamari 2011, p-3). Kapp (2012, p-10) defines it as “using game based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems”. Leaning (2015, p-159) defines it as “a process applied to an existing service or experience which will result in a different (and hopefully enhanced) experience for users”.

In fact, gamification is not GBL and does not demand students to play games, with toys, use gadgets, and set up extensive frameworks of experience points, and badges (TeachThought Staff

Ibid 2015). Gamification for commercial purposes has been integrated into social platforms as a way to create confined relationships between the platform, thus implying its use in education as an instrument to boost student engagement and to encourage desirable behavior on them (Domíngue ibid 2013). According to Reiners et al. (2015), game design elements are utilized to transform the non gaming context into gamification that increases engagement and achieve specific learning outcomes, moreover, embedding gamification principles in education lead to improved outcomes, active learning and enhanced engagement in conventional classrooms. According to Barata et al. (2013), a new technique called gamification is used to keep students engaged and motivated in learning context. In order to fulfill this purpose, the gamification is being used to integrate game elements and mechanics to non-gaming context. According to Huang and Saman ibid, 2013, Gamification is described as the process of implementing game elements of the real world or activities by extracting fun and attractive game elements apart from engaging and motivating individuals and groups to prompt certain behaviors and influence outcomes. Gamification is not dependent on knowledge or skills, rather it has a direct impact on engagement and motivation and indirectly results in promoting knowledge and skills and therefore, prompts students to act; for instance, the skills will enhance if students are motivated to practice computer programming and knowledge will foster if students are motivated to memorize (Huang and Saman Ibid 2013). According to Leaning ibid (2015), significant amount of research has been conducted on the use of gamification in instruction and finding the ways to boost engagement with a core subject matter in a gamified activity. Furthermore, the game leads to enhanced engagement and participation in a learning activity (Leaning ibid 2015). The aim of gamification is to enhance learning engagement and motivation in education by introducing game elements such as level, badges and leader boards, though; gamification into education has gained limited attention by researchers (Paisley 2013). However, much research on adolescents and game play or the application of games into technology based classes has been taken into consideration and much literature on using games in learning has already been reviewed by the reviewers (Paisley 2013). Moreover, gamification has the potential to further boost engagement and motivation in the classroom (Paisley Ibid 2013). Game mechanics used in non gaming context have demonstrated the motivational aspects of individuals to achieve certain goals solve social problems and perform a task or activity in a systematic manner (Paisley Ibid 2013). A study on gamification of eLearning course conducted in University of Colorado resulted in significant gain of 14% among the students who received instruction via gamification approach than those students who received instruction via conventional approach thus deeming gamification as an effective learning tool (Medved 2014). Gamification converts the whole learning process into a game by taking into account the game mechanics, such as, achievement badges, points, leader boards, progress bars, levels, and quests and game play elements and their application to existing educational courses and content to further boost learning motivation and engagement (Medved Ibid 2014).

2.4 Educational Technologies (Digital Games Based Learning and Gamifiaction)

In general, Hung et al. (2014) considered Digital Game-based Learning (DGBL) as computer games used and developed for educational purposes that actively engage students in critical thinking or acquiring learning whenever confronted with the challenges in the game. Learning through games is simply called game based learning (TeachThoughtStaff 2015). Game based learning (GBL) is not about obsessing over video games, it even does not require video games, nor the students play the game, which in this case is a video GBL, rather GBL is the use of the basic design of most games to learn (TeachThought Staff 2015).

In addition to this, GBL trigger learning engagement, motivation and enjoyment thus boosting the retention, recall of information and prompting the social and cognitive skills development (Terri Ibid 2014).

TeachThought Staff (2015) has contrasted between the two terms, gamification and game based learning. According to them (TeachThought Staff 2015), gamification is about “encouragement mechanics and the system that boosts them while GBL is about the game and the academic or game’s content that increases cognitive gains” (TeachThought Staff 2015).Both approaches lead to become expert in content learning but these approaches are not solely utilized in classrooms. This is the reason; students will probably like those tools (TeachThought Staff 2015). This notion is further supported by Medved ibid (2014) who differentiated both, gamification and GBL, and described that “gamification is taking a learning process and applying game principles to it, GBL is taking a game and using it for learning.” Moreover, the objective of GBL is to teach a certain skill or a learning goal instead acting like a ‘pedagogical system’ (Medved ibid 2014). However, pedagogical and learning needs should be considered in real education setting to make GBL more efficient (Terri ibid, 2014). Furthermore, research has demonstrated that GBL approach is better compared to traditional instruction because it enhances the student learning performance (Terri ibid 2014).

2.5 Impact of Digital Game Based Learning and educational technology

According to Brom et al. (2011), cognitive and affective elements are the primary focus of computer GBL with regard to Bloom's taxonomy of learning goals. The educational computer games not only increase the motivation of learners but also create inherent motivation through fantasy, control, test, interest, and rivalry and/or collaboration (Brom ibid 2011). The context in which GBL takes place for upper elementary science instruction has undergone designing, development and iterations to further refine it for as long as four years (Lester ibid 2014). In general, Tatar ibid (2013) has proven the effectiveness of CAL in instruction by enabling the learning of abstract concepts easily. Digital games are attractive because they offer students with engaged and joyful learning experience; and encouraging their learning interest, motivation and engagement (Li and Tsai 2013). According to Chu and Hung (2015), there is a likelihood of digital games to become an educational trend as games make their applications worth able in education by demonstrating elements of instruction, entertainment besides practicing and discovery of new skills, boosting self esteem, and evolving attitudes. However, several researchers investigated 68 studies on DGBL and further explored that out of 68, 22 (32%) studies demonstrated significant differences and resulted in better performance opposed to 38 (56%) studies, which carry no significance (Chu and Hung Ibid 2015).

Studies proposed increase in learning and enhancement of teaching experience through the use of games amid the learning procedure (Yousef et al. 2014). Moreover, critical thinking, retention, creativity, and cooperation are developed and ideas are further strengthened due to the educational games as they can contribute emphatically to the learning environment (Yousef ibid 2014). This notion is further supported by Zafar et al (2014) who stated that compared to traditional instruction, educational computer games offer more creative and beneficial environment to the children.

In general, CAL refers to the formation of computer technology along with a blend of self learning principles that not only boost the learning motivation and instruction process, but also adapts according to the learners' speed (Tatar Ibid 2013). Furthermore, CAL affects students cognitive and affective skills by promoting science achievement and self efficacy, and by helping them in the development of learning concepts, attitude towards science and assisting them in career planning (Tatar Ibid 2013).Apart from this, computer animations boost the learning motivation by drawing students' attention towards the subject (Tatar Ibid 2013). Moreover, Tatar Ibid (2013) analysed that computer animation helps in comprehension of learning concepts by enhancing interest, curiosity and positive attitudes of the students towards the subject. Previous literature on gaming revealed that students reported themselves more motivated and interested in gaming activities and learned better as compared to the conventional instruction approach (Brom Ibid 2011). However, their cognitive performance measured immediately after the experimental process was found to be less effective compared to other kinds of instruction (Brom Ibid 2011). In addition to this, a previous study by Li and Tsai Ibid (2013) investigated that Science digital educational games offer a promising approach to learning and concluded that the use of computer games with language, history, physical education, and mathematics boosts learning and enhances motivation, attitude towards these domains.

2.5.1 Game Based learning in science classrooms

According to Lester Ibid (2014), few studies on randomized controlled trials and quasi-experimental approach directed at students revealed that the GBL environments in the context of the classroom were successful and primarily focused on the classification of learning outcomes or effectiveness (Li and Tsai Ibid 2013). In this regard, lots of research has been conducted on the positive use of DGBL in schools (Terri Ibid 2014). In addition to enhancing the learning accomplishments of students and their attitudes towards learning science, DGBL methodology is considered useful in Science education (Chu & Hung Ibid 2015).

According to Jan Ibid (2015), a survey conducted by the Joan Ganz Cooney Center in 2011 revealed that among 505 US instructors of mostly of 5th grade, only 18% of them utilized games in their classroom on a routine basis whereas 32% of them utilized games 2-4 days per week (Jan Ibid 2015).Moreover, 70% of these teachers agreed that the use of games enhanced learning motivation and engagement with content or curriculum in classrooms (Jan Ibid 2015). It has also been revealed that games emerge as a well known method for teaching and learning in Asian countries such as, Singapore (Jan Ibid 2015).

2.5.2 GBL and student learning outcomes

According to Harris (2011), student learning refers to a curricular or intended learning contrary to the learning via taking part in a class activity or via physical presence in the classroom. A study conducted by a researcher concluded that usage of computer games in learning yields better cognitive gains and positive attitudes of students compared to conventional instruction (Li and Tsai Ibid 2013). In addition to this, Cheng-Yu et al (2014) reported that educational computer games resulted in an enhanced academic performance, motivation, and satisfaction of the students probably adding to a more intriguing learning environment. In short, education computer games contribute to an increased motivation of the students by enhancing their learning interest (Cheng-Yu ibid 2014).

Previous studies revealed that the learning performance and contentment of students were enhanced through digitization of educational games (Cheng-Yu ibid 2014). Apart from this, Lester ibid (2014) investigated the integration of GBL in Science classrooms over augmented timeframes with an instructor driven implementation opposed to researcher driven implementation. The outcome supported the developing patterns in game play in which high school students using a gaming approach outperformed non-gaming students and the findings supported the thought that GBL affected positively content knowledge on a science topic and critical thinking skills and enhanced student engagement (Lester Ibid 2014). This notion is further supported by Hung Ibid (2014) who mentioned that educational computer games can lead to enhanced learning performance, attainment and accomplishment because of their capability of boosting learning motivation of the students. Therefore, it has been found by Hung Ibid (2014) that for enhancing accomplishment and learning motivation of students, DGBL could be a decent approach.

Moreover, Zafar Ibid (2014) supported the findings of previously mentioned authors and concluded that the educational games have the potential to help students boost their learning and achievement. Recently, Chu and Hung Ibid (2015) explored that educational games make students learn and acquire knowledge happily by permitting them to play with the games, and boast their learning interest. Moreover, Chu and Hung ibid (2015) deemed GBL as a learning assistant, and a motivation and an interest booster to learners hence, proving that the application of digital games to learning boost interest, motivation and accomplishment among learners.

Many research studies on the implementation of educational computer games have been conducted and these studies demonstrated that the computer games resulted in improved learning accomplishment (Chu and Hung Ibid 2015). In the context of fun-filled learning, educational games boost learning by promoting and motivating students as proposed by Dorji et al. (2015).

In general, educational computer games along with computer assisted learning and teaching positively affect the learning interest, academic, and learning performance of the students in science (Hung ibid 2014; Lester ibid 2014; Zafar ibid 2014; Kushwaha et al. 2014; Tatar ibid 2013).

2.5.3 GBL and student engagement

Student engagement has been thought to be an imperative variable for effective learning in multimedia learning environments including DGBL. According to Byun and Loh Ibid (2015), much research has been conducted on DGBL and its potential to engage learners while very few have focused on the actual engagement of learners in an interactive context of DGBL. Moreover, it has been revealed that out of an aggregate of 256 DGBL studies reviewed, only 8 empirical studies were about impact of game playing on learner's engagement, which adds up to simple 3% (Byun and Loh Ibid 2015).It has become critical for students to enhance engagement in science and such students are being offered with great opportunities to boost learning achievement in science (Mo Ibid 2013). The impact of engagement was found to be both stronger and weaker for different science classes (Mo Ibid 2013). However, student interest and self efficacy of students in science are highly correlated with science achievement (Mo Ibid 2013). Recently, Chu and Hung (2015) reviewed several studies and concluded that the activities in the context of online GBL have engaged learners significantly and motivated them from inside.

Cheng-Yu ibid (2014) has studied the elements that make the game more engaging by permitting students to tap and drag objects on user screen for movement and allowing them feel the flow of the challenging games such as prompting the students engaged in gamified activity. In his study, Chang et al. (2014) reported the contrast in game engagement levels by learner's demographics, previous skills, and the measure of game play in mathematics performance. In general, Chang ibid (2014) discovered the critical impact of the gender interaction and measure of game play on the game engagement. Chang Ibid (2014) considered the time frame in a game, as an important factor of game engagement. Moreover, Chang ibid (2014) revealed that the students who tended to play game longer displayed higher game engagement compared to students who played for a short duration of time as the latter one led to frustration because of taking longer than usual to adapt to the rules of the game. However, Chang Ibid (2014) suggested that researchers should not let students play games for a longer period of time as these results in boredom among students. Yousef Ibid (2014) reviewed a study of gamification theory that was adopted as a test case program and this study revealed that the starting results of gamification in Kaplan University demonstrated 155% more student engagement. In addition to this, success and higher engagement are associated with each other as engagement leads to greater achievement, likelihood of graduation and satisfaction among students. Moreover, Yousef Ibid (2014) has also discussed the process of motivating learners by making them feel secure, comfortable, relaxed, and valued. Furthermore, fun and excitement are stimulated by the game concept that will further prompt to positive input and engagement (Yousef Ibid 2014). As mentioned by Yousef Ibid (2014), game(s) segments are integrated in GBL to prompt engagement and participation during the learning process of a student. However, it is primarily about fun and engagement and an interactive edutainment into a newly evolving and exciting medium (Yousef Ibid 2014). This notion is further supported by Terri ibid (2014) who wrote that GBL not only boosts learners to motivate, and enjoy learning along the way, but also encourages learning from their mistakes by offering them chances to compete, engage themselves, and give instant rewards. According to Zafar Ibid (2014), an association exists between the usage of technology and enjoyment since; the later one is the primary objective in gaming. Therefore, GBL motivates and engages learners thus keeping them absorbed in learning for hours (Terri Ibid 2014).

In general, educational computer games and technologies have positively influenced the learning engagement, and the cognitive and affective skills of the students in Science computer animations (Hung Ibid 2014, Lester Ibid 2014, Tatar Ibid 2013).

2.5.4 Engagement and Learning

Many studies in the past have been conducted on educational games which demonstrated that the learning and motivation are affected by the engagement as games have the potential to engage learners (Abdul Jabbar and Felicia2010). According to Li and Tsai Ibid (2013), learning is a natural process that occurs while playing games therefore, effective principles and approaches are embedded in games facilitating positive learning outcomes and offering players with engaged learning experience. Terri Ibid (2014) further added to the game and found that digital games encourage motivation, engagement, and student learning. As mentioned by Kushwaha ibid (2014), students' engagement in learning is promoted by embedding interactivity in computer technology which enhances student achievement and encourages student motivation. Furthermore, such games benefit learners in introducing computer proficiency; science and innovation; preparation; enhanced visual, spatial, verbal, and iconic skills; expanded capacity to focus; and reaction time (Terri Ibid 2014). In general, student engagement and learning outcomes are the prime means of intrinsic motivation (Yousef Ibid 2014). According to Shaari (2014), apart from mere energy to achieving a milestone, engagement demonstrates the psychologically invested or cognitively involved students during work. Moreover, the students who are more involved would perform better in academics in university life as involvement is an essential predictor of academic achievement (Shaari 2014). This notion is further supported by Parsons Ibid (2014) who stated that educators struggle hard to design an engaging experience for learners as engagement is associated directly with learning achievement besides predicting learning, grades, scores, retention, and graduation of the students.

2.5.5 GBL and Gender Difference

Several researchers considered gender differences in GBL and recommended that gender sensitivity is deemed important towards educational games (Hsieh Ibid 2015). Gender difference has a significant role in digital game based learning approach when it comes to affecting learning achievement (Dorji Ibid 2015). Further, investigations have demonstrated that no gender differences exist in learning achievement and motivation (Hsieh Ibid 2015). Few authors investigated whether such differences exist in game development skills demonstrated by students. Klisch Ibid (2012) and Chang Ibid (2014) revealed that the learning of girls from the games was significantly more rather than the boys. Moreover girls had a higher game engagement compared to males (Chang ibid 2014, Klisch ibid 2012). However, according to Dorji Ibid, 2015, past studies showed that the learning performance of males was significantly better compared to their female counterparts in DGBL methodology. Nevertheless, studies conducted by Lester Ibid (2014) and Dorji Ibid (2015) found no significant gender differences in learning achievement of GBL. Though, Dorji Ibid (2015) further investigated the equal learning gains between males and females in digital games and revealed that a learning gap between both genders can be reduced by encouraging learners to explore and construct knowledge instead of memorising answers.

2.6 Pedagogical aspects of GBL

Learning and teaching processes of science are based on constructivist learning theory (Tatar Ibid 2013). Learners construct new information by using their own experiences, views and emotions while staying active in the learning process (Tatar Ibid 2013). Students need to learn and look for profound implications and understanding of the learning process which operate at high levels of cognition (Mitchell and Carbone 2011). Usually, students operate at levels above the comprehension level of Blooms taxonomy and at a relational response in Bigg's Solo taxonomy (Mitchell and Carbone Ibid 2011). Tatli and Ayas Ibid (2013) found from several studies that students demonstrated high achievement score, frequent participation, and deeper attention in chemistry lab instruction involving constructivist learning approach.

Several studies have already been conducted that utilized a framework of student engagement to further study learning outcomes and experience, but a significant number of these studies neglected metacognition as a part of quality learning (Mitchell and Carbone Ibid 2011). In general, metacognition implies that students are paying consideration to their own learning besides controlling their own learning behavior which further implies that the learner knows about the motivation behind the task and further explores the meaning associated with it as tasks impact learning and engagement (Mitchell and Carbone Ibid 2011). According to Abdul Jabbar and Felicia Ibid (2010), Bloom's taxonomy i.e., remembering, understanding, and application; is an accepted approach for designing curriculum for learning purposes. Furthermore, several reviewers considered the usefulness of digital games on "spatial cognition, visual processing, attention, perceptual motor skills, and critical thinking skills and found positive effects, including changes in everyday habits such as eating habits" (Li and Tsai Ibid 2013).

According to Li and Tsai Ibid (2013), digital games tend to offer both affective and cognitive learning experience to the individuals for science learning to take place compared to other instructional approaches. Moreover, adding affective environment in the context of digital games can offer students safe opportunities and fun-filled experiences to discover science, flexibility to investigate the problems in science, to construct and further explore science knowledge (Li and Tsai Ibid 2013).

According to Mastang et al. (2013), visual learning is considered the most important style of learning as students learn through sight and this process takes place via visual information which is essential in learning scientific concepts. One of the best approaches towards science learning is by presenting visualizations via animations (Mastang Ibid 2013). In animation, many image moves by following a movement sequence contrary to conventional teaching approach where static image is presented to the students and teachers find it hard to explain it to their students (Mastang Ibid 2013). Apart from this, animation boost the retention of the students, thus making it stay for a long time in memory compared to static images (Mastang Ibid 2013). According to Hampden-Thompson & Bennett (2013), learning and engagement enhance when curriculum deals with present day issues, makes instruction style less didactic, promotes a student –centered learning, and exerts an effort to make science less challenging for the students. Students feel encouraged and motivated to further make science as their future career when classroom activities promote active, hands-on experience, independence and self directed learning, peer learning, collaboration with foreign students, and the learning that is not bound to one lesson termed as engagement points.. Moreover, Toussaint and Brown Ibid (2015) argued that engaged learners have the skills to learn independently as previously stated by Hampden-Thompson & Bennett ibid (2013) without external support such as guidance or coaching skills which still, many high school graduates lack.

Previous studies reported that although, embedding technology in constructivist or student centered learning environment has been quite a success but, still many instructors do not have any idea of integrating technology into their curriculum successfully (Sandholtz et al. 1997). Moreover, the reason behind failing to implement technology is that instructors may not be prepared due to lack of skills in technology use and pedagogy related to technology (Sandholtz et al. 1997).Mostly educational software designed to enhance learning outcomes of students paid very little attention to the teaching dimension which led to the difficulty of embedding it into practice by such teachers (Hinostroza and Miller 2001). According to Huang and Saman ibid (2013), Michael Wu, Chief Scientist of Lithium Technologies highlighted that teachers often commit mistakes of gamifying an outcome instead of a behavior for instance, instead of gamifying better grades, one can gamify the whole process of students earning better grades therefore, instructors ought to take note of this that gamification works best when learning program is based on pure educational content and/or when significance of information is not obvious to the learners. In addition to this, the particular application of gamification or technology in curriculums leads to better teaching job (Huang and Saman Ibid 2013).

Nevertheless, it does not mean it ought to be a swap for a thorough educational program or usual instruction (Huang and SamanIbid 2013). As the use of computers, internet and communication technologies have become common, it is easy for individuals to access games as games do not cost much and keep all players engaged and are fun for all age groups (elearning and Learning Management System LMS blog by GCube 2014). Furthermore, utilizing all of the aforementioned attributes in games designed for entertainment purposes will not only keep players engaged, have fun playing, but players will continue returning for additional as long as games are attractive to its players, they can be effective (Ibid). However, the world of educational and learning games has already been discovered and motivation and engagement are the major goals in learning games and these games not only engage learners, but also permit them to master knowledge and skills which are the ultimate goals of the learning games and essential in the workplace too (Ibid). The author (Ibid) has considered the outcome, such as the transfer of knowledge or skills gained, in the gaming experience as the ultimate goal. Though, GBL technologies appear to enhance learning outcomes, but the instructors confront resistance to the adoption of this technology (Hamari and Nousiainen Ibid 2015). The resistance has been generally credited to inadequate resources regarding time and innovation and in addition, educators' lack of competence and self-efficacy as for attainable methods for utilizing GBL technologies (Hamari and Nousiainen Ibid 2015). It is further connected to the view that games are regularly connected with play and entertainment while they are not compatible enough with teaching and their support is neglected, particularly by the individuals who have no gaming background and may in this manner be less open to trying different things with GBL (Hamari and Nousiainen Ibid 2015). However, teachers resist the use of technology in classrooms and consider it as a challenging task (Chai et al. 2013). Moreover, such instructors are not prepared to integrate technology specific to the subject in their instructions leading to the lack of strong theoretical framework (Chai ibid 2013). To address this, frame work such as Technology Pedagogy and Content Knowledge (TPACK) is used to guide the instructors in the use of technology (Chai ibid 2013). TPACK offers "synthesized form of knowledge for the purpose of integrating ICT/educational technology into Classroom teaching and learning" (Chai ibid 2013, p-32). The three constituents including Content, Pedagogical and Technological Knowledge, are blended and integrated together to give rise to TPACK framework (Chai ibid 2013).Several researchers in their study blended this TPACK framework with several other approaches to devise a new pedagogical method that can facilitate teachers. According to Morris (2015), the present focus of GBL is on the influence of games in exploring and offering new chances of constructivist learning to school going children. The author (Morris 2015) deduced a teacher facilitated pedagogical approach, namely VISOLE (Virtual Interactive Student-Oriented Environment) that integrated constructivist online GBL in formal education.

Instructor's play a major role in boosting learning and motivation through the use of GBL in classrooms and further escalate the willingness to use games in the classroom and expressing a positive attitude towards them (Foster and Shah 2015). In addition to this, Foster and Shah ibid (2015) enlisted the various factors affecting the adoption of GBL in K-12 schools. Some of them includeda) school bell-schedules limiting the use of lengthy and complicated games, b) low quality technological frameworks, c) restrictions creating hindrance in the integration of GBL, d) limited use of games at schools due to some acceptable user policies, and e) lack of GBL models to facilitate teachers. Therefore, a model based on pedagogy is required to implement games in K-12 schools. The purpose of these games is to guide teachers and help students in learning and assessment. Hence, Foster and Shah (2015) proposed the GaNA model that offered teachers with adaptive framework and focused on pedagogy and content of games in the context of classrooms and used games for learning and teaching. Previous studies produced positive results in boosting instructor’s capability to embed ICT in the instructions (Chai ibid 2013). However, more development is required through integration of technology for studying students’ learning conception (Chai ibid 2013).

2.7 Instructional Design Elements

Prensky (2001) described the elements of digital game. A digital game has a clear vision, consistent focus on the players’ experiences, strong structure, highly adaptable, easy to learn and hard to master, stay within flow state, and users with useful interface; offers frequent reward, low and less penalties, and mutual assistance; and let the players explore, discover, and save the progress (Prensky 2001, p-23). Therefore, a game should be challenging enough to keep the interest of the learners intact and enhance their learning and engagement thus leading to further excitement (Klisch et al. 2012). In his study of measuring the effect of the game “Uncommon scents” based on drug education, Klisch Ibid (2012) found that students who were absent might be at a loss because this game might have benefitted the most and they were thought to be more engaged. Although, GBL offers much promise in science education still, there is a need to conduct research that proves the effectiveness of new learning technologies along with the awareness of enhanced learning design (Li and Tsai Ibid 2013). Li and Tsai Ibid (2013) further studied the game elements that boost the engagement and investigated that few important game elements such as objectives, challenges and interactivity can add engagement and fun to the digital games.

Moreover, Yousef Ibid (2014) added more game elements to promote certain factors and stated that games offer fun, entertainment, competition, and excitement and need tolerance and determination to play them. Apart from offering fun, feedback is the vital aspect of the game since players move forward by achieving certain goals and with adaptable and continuous practice scores/rewards (Yousef Ibid 2014). Yousef Ibid (2014) has shared the experience of transforming passive and boring structure of game by further explaining that the games can change the passive and boring learning experience to active and engaging learning by implementing the framework of the games in the lesson such as rules, challenges, problems, goals, solutions, outcome, and point framework. In addition to this, games and difficulty levels should be tailored and considered according to the ability of the students otherwise this will lead to boredom or anxiety among them (Yousef Ibid 2014).

A recent study conducted by Hseih Ibid (2015) wrote that to motivate students to take part in activities, fantasy should be integrated into games. To enhance learning engagement; games should offer adequate challenges, instant and clear response, and playable experiences to the students (Hseih Ibid 2015). In addition to this, the objectives of the game can be tailored according to the needs of the students so as to make them attractive and encourage them to attend and engage in the tasks in GBL (Hseih Ibid 2015). In fact, interactivity with digital application leads to enhanced cognitive and affective experience of the learners (Hseih Ibid 2015).

Through feedback, learning takes place in a game and learner is offered a reward for mastering skill or knowledge, or in case of failure, the learner is offered with a word and has to attempt again or seek help until a learner can do it (Prensky Ibid 2001). It is essential in games to offer players with a feedback to make it more appealing (Huang and Saman Ibid, 2013). It is often complex because depending on the amount of feedback provided, a player can get frustrated too. Therefore, the game should adapt to the needs of the player which means that level of challenges faced by the player should go up or down automatically depending on what the player does

(Prensky 2001). This notion is further related and supported by Dominguez Ibid (2013) who investigated that the effect on the emotional area revolves around the idea of concept and failure in the game. Moreover, when players accomplish tasks, they expect some positive emotions as the result of overcoming obstacles and this can be done by offering them with reward systems such as points, trophies or item on successful completion of the task that gives instant recognition of success to the players, whereas, players feel anxiety when they fail but if the degree of anxiety is unacceptable and undesirable, it may transform to frustration (Domínguez Ibid 2013). In order to avoid that, the sequence of tasks is designed to adapt to the skill level of player and on failure, these tasks give low penalties to foster experimentation and task repetition (Domínguez Ibid 2013). The player can be driven to a flow state which is highly motivated only if the level of difficulty is balanced correctly in the games (Domínguez Ibid 2013, Prensky Ibid 2001).

In the past, much research has been conducted on the evaluation of educational software interface design. However, studies that evaluated the activities in software supporting children's learning needs are rare in number (Shiratuddin and Landoni 2002). Content presentation is considered essential while designing educational software to achieve certain sets of learning procedure (Shiratuddin and Landoni Ibid 2002). It is also important to take precise steps while designing the way the learning content is structured, presented and organised (Shiratuddin and Landoni Ibid 2002). Besides this, the user's involvement plays eminent roles in the activities design to promote the success of pedagogic design (Shiratuddin and Landoni Ibid 2002).

A Delphi method used by Williams et al. (2004) in his study investigated whether the requirement of educators are being fulfilled by the present day educational software and the changes that should be incorporated to make it more effective where content and purpose was additionally a noteworthy concern. For this purpose, Williams ibid (2004) considered the summative and formative evaluation in order to evaluate the educational software where former one measures the student's learning outcomes and the later one measure the accurateness of elements required to design instruction including the content, and interface and the extent to which computer is mediated and its use in classrooms. However, without formative assessment, which is a foundation of instructional frameworks plan, the suitability of a piece of learning software for specific students is questionable (Williams ibid 2004). Nevertheless, teachers are totally dependent on the commercial software publishers to produce quality educational software and assume that these products are well designed, developed, and evaluated prior to their marketing which is not necessarily the scenario (Williams Ibid 2004). Moreover, publishers are not willing to talk about the instructional design and evaluation procedure of their educational software as they do not follow a particular set of procedures for evaluating the software and before marketing, few teachers or students evaluate their educational software (Williams Ibid 2004). Technology is being utilized in inquiring about and solving the problems, a communication tool among learners, and is a prime element of learning and curriculum instead of acting as a segregated tool. Therefore, the educational software is socially, cognitively and pedagogically appropriate for the students foremost and is purely designed to actively engage learners in the process of self reflection and inquiry (Williams Ibid 2004). William Ibid (2004) found that 17% of the participants in his study represented that “educational software should be easier to use, self-explanatory and more intuitive”. According to Williams Ibid (2004), segments of assessment and monitoring should be considered for meeting the needs of the software. Moreover, such software should offer teachers with several options, and adapt to the needs of various students by offering them different skill levels and the major consensus areas such as, software cost, its usability and the aim and content of the software. Participants raised several instructional design issues that further improved the educational software and grouped them into three major categories which included content, interactivity and usability (Williams Ibid 2004). Furthermore, Prensky Ibid (2001) listed the characteristics of a game which included a) fun(offers enjoyment and pleasure), b) play (offers intense and passionate involvement),c) interactivity(offers doing), d) adaptivity(offers flow), e) rules(offers structure), f) goals(offers motivation), g) outcomes and feedback(offers learning), g) win states(offers ego gratification), h) conflict/competition/challenge/opposition(offers adrenaline), and i) problem solving(sparks creativity).

Challenged and engaging games need players to strategize, plan, synthesize, analyse, and evaluate (Dickey 2015). Dickey (2015) discussed three ways to target aesthetics in game design: a) art design, b) interactive design, and d) games as art. Dickey (2015) reviewed taxonomy where learning types were mapped to various learning styles. Learning outcomes are aligned to various categories of game which further aligns to the learning types based on Bloom’s taxonomy and all games have some goals and are bound to the rule and game mechanics are the prime element of making rules in a game (Dickey 2015). However, the success of an educational program is dependent on considering the students benefitting from it and the environment in which program is being delivered while aiming at designing a program that permit the learners to achieve the goals of the programs where target audience and context are analysed to help consider the factors like age group, learning abilities, current skill set, group size of the students, environment, skill sequences, and time frame (Huang and Saman Ibid, 2013). According to Huang and Saman Ibid (2013), there are three goals associated with an educational software; it can either be behavioral (where students are required to concentrate in class, complete their assignments faster, and minimize distractions in class etc), general instruction goals(where student is required to complete an assignment, test/quiz/exam or a project etc) or specific learning goals(students are required to comprehend a learning concept, perform a task or complete a learning program) or blend of them. In this study, only first and the last goals are associated with an educational app. As mentioned earlier, integration of game elements in non-gaming context is called gamification and these game mechanics/elements can be points, badges, labels, or time limitations and competition and sense of achievement among students (Huang and Saman Ibid 2013). A particular type of game elements utilized can prompt to various reactions from students and inappropriate use of gamification may backfire on instructors (Huang and Saman Ibid 2013). Several steps are involved in gamification of education to efficiently apply gamification elements in the learning process and achieve various learning objectives (Huang and Saman Ibid 2013). The context will determine the pain points after the clarification of learning goal and the analysis will be easier with the whole program breaking down into stages or milestones (Huang and Saman Ibid 2013). The currency (points, time, money, etc.) based tracking mechanism (measure students' progress in the learning program), and rules are essential to develop levels and offer feedback on the students' progress and self or social elements are applied where applicable (Huang and Saman Ibid 2013). After following these steps, instructor will run the game through a trial, compare the results with the defined objectives and then adjust the elements accordingly(Huang and Saman Ibid 2013).However, the efficient and accurate implementation of gamification of an education program relies solely on the proper and correct implementation of these steps (Huang and Saman Ibid 2013).

Digital Game Based Learning (DGBL) takes place often through audio and visual stimuli as this form the basis of communication, and learning materials to the learners (Byun and Loh 2015). Moreover, DGBL is considered most engaging among all multimedia learning environment

(Byun and Loh 2015). Furthermore, an engaged student usually spends more time interacting with the content presented in DGBL environments as compared to the less engaged ones (Byun and Loh 2015). The learners will automatically take in more information while interacting and spending more time with the content presented (Byun and Loh Ibid 2015). As found by Byun and Loh Ibid (2015) recently, research revealed that very little is known regarding what game elements in digital games engage individuals in play learning (Byun and Loh Ibid 2015). According to the authors, audio and visual elements have the potential to directly affect the mood and emotions of learners during learning process which, in a sense, carries impact on engagement in DGBL environment (Byun and Loh Ibid 2015). Digital game enforces sensory stimuli upon its users and audial stimuli help involve learners and keep them behaviorally engaged (Byun and Loh Ibid 2015). Moreover, researchers found that the proper utilization of sound and feedback in DGBL environment carries an impact on player's engagement besides visual elements such as high quality screen design, color, action and animation (Byun and Loh Ibid 2015).

2.8 Gaps in existing studies

In his study of science based digital games, Kilisch Ibid (2012) found significant gender differences. In order to make educational games effective among both genders, Kilisch Ibid (2012) recommended that the factors such as understanding games and their reliability should be considered while developing future games as these factors promoted gender disparity. Moreover, there is a need to fill the gap between student learning and their assessed outcomes i.e., games should provide students with enhanced scientific knowledge and problem solving skills instead of limiting themselves to the rote learning of facts (Li and Tsai Ibid 2013). Zafar Ibid (2014) discussed that more research needs to be conducted on the effectiveness of computer games on education considering different context, environment, levels and tools. It has been reported that computer games are successful in supporting students in learning different strategies, making them stay attentive in classroom and establishing connections with the scenarios in class (Zafar Ibid 2014).

Further discussion on the impact of DGBL on learning performance and transformation of learning, and knowledge needs to be considered (Chu & Hung Ibid 2015). Dorji Ibid (2015) stated in his study that gender difference and learning performance in DGBL approach are associated with each other and both are critical to each other and there is a need to address this interaction as well.

2.9 Summary

Learning motivation and engagement leads to better performance or achievement in science education and increases the retention rate in school. However, traditional science education results in boredom among students leading to negative behaviors and emotions, disaffection and misconceptions held by them which remains unchanged throughout their education. Moreover, students reported that in science, it was difficult for them to comprehend abstract concepts in chemistry. Therefore, digital game based learning or gamifiying the learning activity in the non-gaming environment can further enhance learning, affective engagement and positive behavior of the students. Instructional game design elements and pedagogy are essentials to involve and engage students and instructors in the learning procedure and this has been discussed in detail in this section. However, few gaps exist in the previous research which will be addressed in this study.

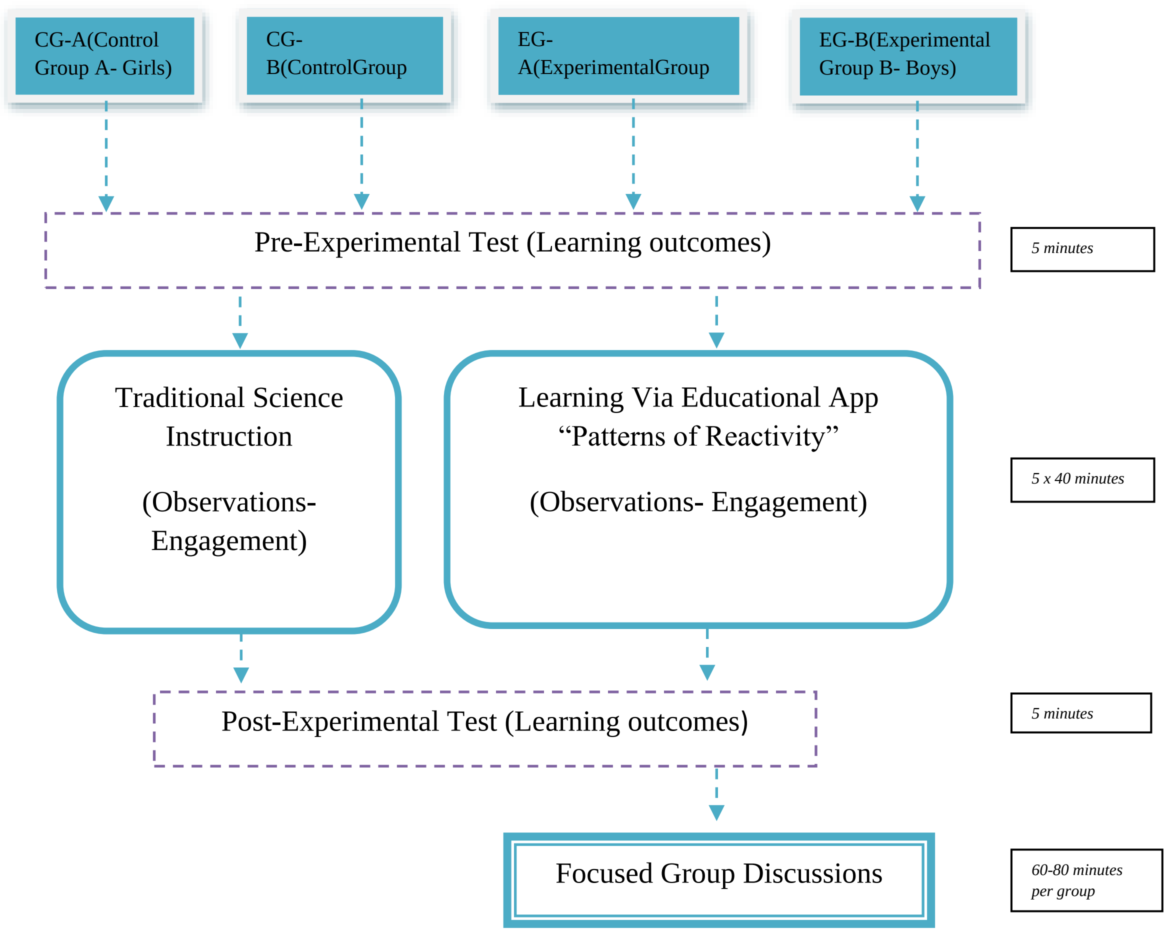
3 Methodology

This chapter aims to describe the methods and materials used to conduct the Quasi Experimental research. The present study investigated the impact of an interactive educational desktop application of Science "patterns of reactivity" on student engagement in 8^{th} grade classrooms. This chapter also aims to describe the research design, research setting and participants, educational app, and instruments designed, developed and used, data collection and divides the experimental process of this study in three phases of intervention i.e., pre-intervention, during intervention and post-intervention and discusses each of them in detail.

3.1 Research Framework and Design

The present study utilized a Quasi Experimental research framework. This method was employed to contrast or compare different groups. Four comparison groups were used in this study. Two comparison groups received traditional science instruction while the remaining two comparison groups received educational application instruction. However, in this study convenience sampling was adopted in the selection of schools because the school was easily accessible in terms of computer technology and for experimentation (Dissertation.laerd.com 2015). This is a small scale study (in terms of cost and time) conducted on convenience sampling technique (Dissertation.laerd.com 2015). It is easy to collect useful data and information through various methods using convenience sampling (Dissertation.laerd.com 2015). Otherwise, random sampling requires a list of the population, which is impossible when resources are insufficient or hard to get permission from higher authorities or administration from school understudy (Dissertation.laerd.com 2015). However, the participants have been randomly allocated to the experimental and control groups. The random assignment ensures the high chances of equivalence between the experimental and control groups (Cohen ibid 2007). The reasons of random assignment were the class settings and its internal validity (Socialresearchmethods.net 2015). The class settings were different in the school understudy and classes were segregated based on genders. Therefore, a class of 54 male students was further randomly divided into two groups i.e., experimental and control. Similarly, a class of 46 female students was randomly assigned to the two groups (control and experimental) for this study. Moreover, random assignment relates to the internal validity of the study (Campbell 1966, Cohen Ibid 2007).

Figure 3.1 The Experimental Design of the present research study



3.2 Research Questions and Hypothesis

The present study is followed by three research questions:

RQ_1: Does the treatment group (receiving Science app "PATTERNS OF REACTIVY" instruction) differ from the control group (receiving conventional Science instruction) in terms of student engagement for secondary school students of 8th class in Pakistan? The corresponding null hypothesis is:

$H_{01:}$ Learning through an interactive Science app PATTERNS OF REACTIVITY has no significant difference on student engagement.

RQ_2: Does the treatment group (receiving Science app PATTERNS OF REACTIVY instruction) differ from the control group (receiving conventional Science instruction) in terms of subject knowledge for secondary school students of 8^{th} class in Pakistan? The corresponding null hypothesis is:

H_{02}: Learning through an interactive Science app PATTERNS OF REACTIVITY has no significant difference on learning outcomes.

RQ_3: Does the treatment group (receiving Science app PATTERNS OF REACTIVY instruction) differ from the control group (receiving conventional Science instruction) in terms of gender difference for secondary school students of 8^{th} class in Pakistan? The corresponding null hypothesis is:

H_{03}: Learning through an interactive Science app PATTERNS OF REACTIVITY has no significant impact on gender differences.

3.3 Participants and Setting

100 South Asian participants (including both genders) of 8^{th} grade between the ages of 12 and 15 belonging to different socioeconomic status enrolled at a low cost private school in an urban area of Islamabad Capital Territory, Pakistan took part in this study during the period Aug-Sep, 2015.

Of these students, four comparison groups were formulated based on Science instruction received. The first group was about 27 male students who received a Science educational app instruction. The second group was of 23 female students who received a similar instruction, Science based educational app instruction. The third group was about 27 male students who received conventional Science instruction and the fourth group was of 23 female students who received conventional science instruction. All students were randomly assigned to these four groups.

The teacher involved in traditional Science instruction differed as well. These differences included teaching style, personality, and teaching experience (10-16 years of teaching experience). However, the teacher who taught using an educational app as an instruction had no teaching experience in the past, for which the study could not control.

3.4 App Development Phase

Prior to the development of an educational application, a general survey was conducted from 9^{th} graders at the school understudy. The survey asked the students what science chapter they found difficulty in 8th class and reported the reason behind it. The majority of students answered “patterns of reactivity” based on Chemistry. The reason behind finding Chemistry hard to comprehend was the misconceptions held by the students previously in this domain (Woldeamanuel ibid 2014 and Kamisah and Nur ibid 2013). Moreover, some of the basic chemistry topics revolve around the abstract concepts which are hard to comprehend by most of the students as reviewed in Chapter 2 (Tatli and Ayas 2013). In this study, C# and Unity 2D version 4.3 were adopted as a tool to design and develop an educational app, PATTERNS OF REACTIVITY. Unity 2D is a cross-platform tool. Users can run this app in Windows OS supporting RAM of 1GB and graphics driver of Shader Model version 2.0 or greater. The development phase spanned over one and a half months.

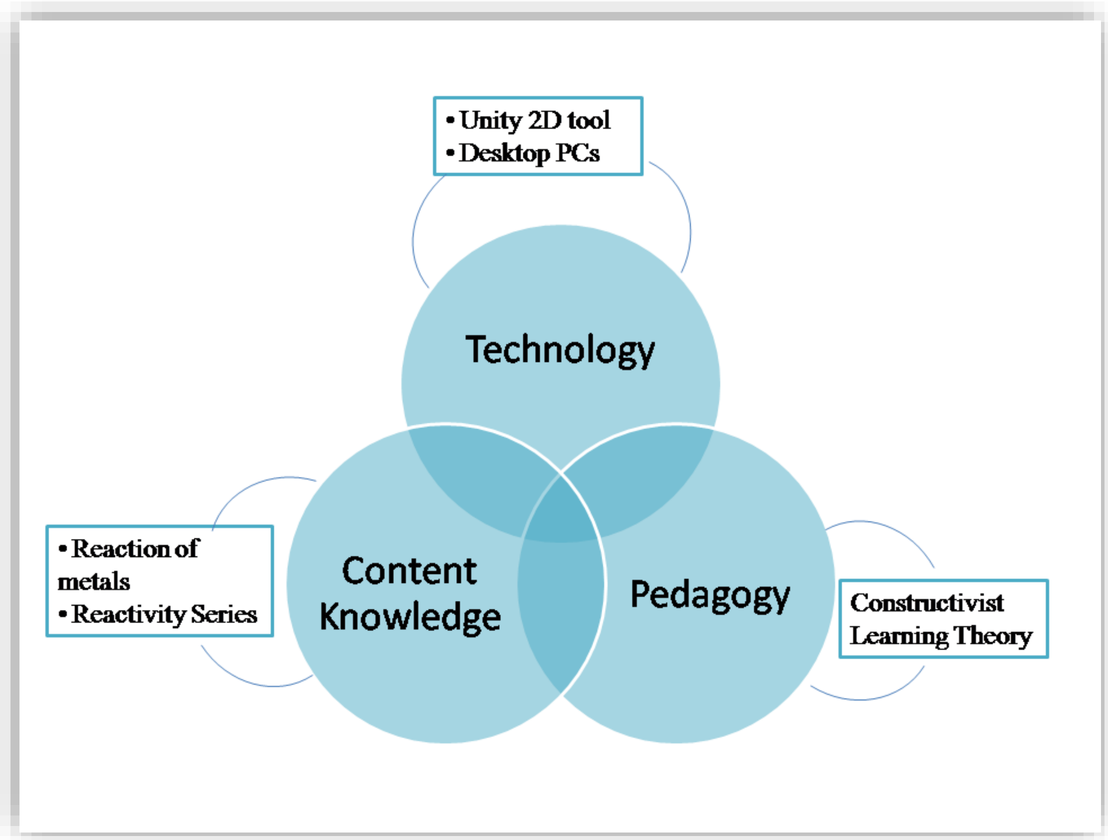
3.4.1 Learning Objectives and Outcomes

The learning app was designed and developed on Chemistry based lesson “Patterns of reactivity” in a Science subject for Secondary Classes 3 (Coppock 2007). Chapter 5, Patterns of reactivity aims to “1) show that although metals react in a similar way with oxygen, water, and acids some react more than others, and 2) establish and use a reactivity series of metals”. The associated learning outcomes with the objectives were to “ a) identify and describe similarities in chemical reactions between metals and oxygen, water and acids, b) recognizes differences in the reactivity of different metals, and c) use differences in the reactivity of metals to explain some everyday uses and occurrence of metals” (Coppock 2007).

3.4.2 Design and development

TPACK frame work was utilized for the design and development of this learning app. This app was designed and developed for individual use and thus, this app did not promote collaborative or peer learning. Moreover, the learning through this app was self-directed and self-paced. TPACK framework blended the content knowledge, technology and pedagogy to promote students’ learning conceptions in Science as depicted in figure 3.2. Individual constructivist learning theory was utilized as the pedagogical approach in delivering the learning outcomes. Based on the learning outcomes and goals of the lesson, patterns of reactivity, three learning activities were designed and embedded in an app.

Figure 3.2TPACK Design Framework used in app development



3.4.2.1 Activity 1

It is hard for the students to memorize static images presented in the course or textbook. To address this issue, videos and animations were embedded in the app to foster student's retention. Videos were based on reactions of 13 different metals with Hydrochloric acid, water, and air. However, these videos were taken from different you tube channels of various users mentioned under credits section of an app. Moreover, the videos of few non-reactive metals were not available on the internet, therefore, for such reactions, Adobe Photoshop tool was adopted to create sprite sheet animations. In addition to this, audio, interactivity i.e., drag and drop functionality, extra information on metals, help, quiz, feedback, and videos were embedded as design elements in this learning activity. Figure 3.4 illustrates the flow of this activity based on reaction of metals.

3.4.2.2 Activity 2

This activity was based on exploring the metals and their appropriate placement in an order of reactivity. Moreover, this activity prompts the user to place the metals in the racks in correct order of reactivity. In case of incorrect placement, the object or item retains its original position. However, on correct placement, a positive feedback appears on the screen of the user (as illustrated in figure 3.5). In addition to this, feedback, audio, goal defined at the top of the user screen, interactivity i.e., drag and drop functionality, extra information on pop up, and help were embedded as design elements in this learning activity.

3.4.2.3 Activity 3

This activity was based on constructing reactivity series. The aim of this activity was to offer users with self directed learning. This activity was gamified by adding several game elements to SHOOTING THE BALLOON. Table 3.1 indicates the game elements embedded in this activity. Lives, scores, progress tracking system, feedback, challenges (completing the level with in limited time frame), two levels, audio, goal, interactivity, and help were embedded as game elements in SHOOTING THE BALLOON game. Figure 3.6 illustrates the detailed flow of this game.

Table 3.1 Gameelements of SHOOTING THE BALLOON activity of an educational app

Game Elements	Application
Levels	Addition of four metal balloons in level 1. The addition of 6 metals balloons in level 2.
Progress tracking system	Elements placement in rack after correct metal balloon shooting.
Reward System	Scores. Increments on shooting correct metal balloons.
Feedback	Life loss on shooting wrong balloon.
Challenge	Completion of task within limited time frame.

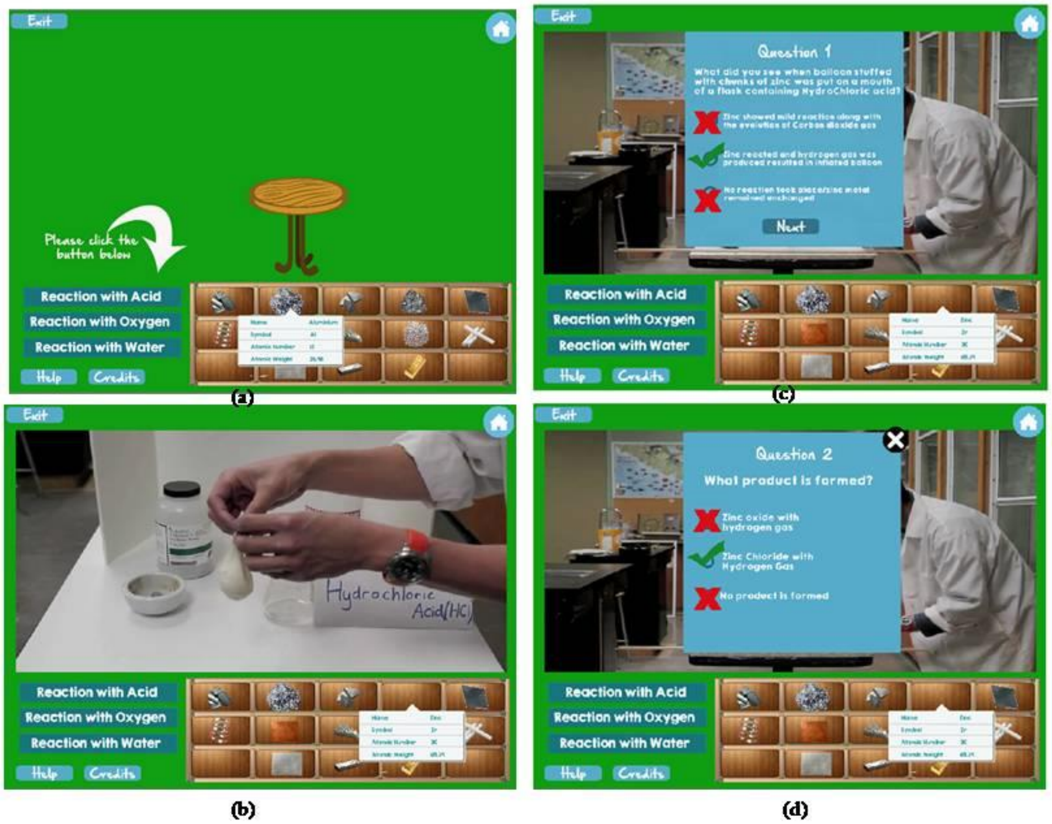


Figure 3.3 Flow of first learning activity based on reaction of metals in an educational app PATTERNS OF REACTIVITY. (a) Prompting user to click one of the three buttons at the bottom left corner of the user screen (b) Prompting the user to drag and drop desired metal on the table place above the rack to play the video of desired reaction. User can mouse over any metal to see the extra information on popup. (c) After video stops playing, a quiz pops up where the user is required to answer the multiple choice question with 3 responses (d) Second question will pop up with 3 responses. The app gives the feedback on the user action.

Figure 3.4 Flow of second learning activity in an app PATTERNS OF REACTIVITY based on order of reactivity. (a) Prompting the user to drag and drop items from a bedroom scenario and place them in the racks in correct order of reactivity. In case of correct placement of metals, positive feedback pops up on the user screen. (b) Prompting user to click the question mark icon to open a pop up with general information on item and its composition**.**

Figure 3.5 The game SHOOTING THE BALLOON based on reactivity series in an app PATTERNS OF REACTIVITY. (a) On correct shooting of the metal balloon, the score increments. (b) On incorrect shooting of metal balloon, one life of a user is lost showing a message on user screen, “you lost one life”.

3.4.3 Hardware Requirements

Portability is the advantage of this app since it can run on any electronic devices may it be yours or android or Windows etc. However, for this study specifically, the app is built for desktop PC users since it targeted school going students. Another advantage of this app is that the installation of any software is not required for this app to run since it can execute by running the .exe file saved on personal computers. However, the constraint associated with the .exe file is the malicious malware attackcorruptingthe.exe file. For this purpose, fresh copy of Windows can be installed or anti-malware can be used to protect the system. Design and development of this educational app took approximately one and a half months. This is a non-commercial and a low cost solution app designed and developed to increase retention rates. It is easily accessible to all individuals and group of students in school or out of school (no accessibility issues).

3.5 Usability Testing

Prior to intervention, the app was used by few accessible users. Though the application was not piloted in any of the schools, but the feedback provided by few people, including science teacher helped to further refine the learning application. Few took long to getting accustomed to the rules of the game based on reactivity series. While few others had difficulty following instructions of all the sections covered in this app. At first, users had to look for instructions manually by clicking on the button (Help) as depicted in figure 3.6. Later on, this functionality was enhanced by placing instructions/help screen before navigating to the main screen of a learning activity. For further up gradation, hints were automatically generated to instruct the user drag and drop metals on the beaker/burner placed in metals' reaction section as illustrated in figure 3.7.

Figure 3.6 Showing first learning activity of an app without any guided instructions on user screen

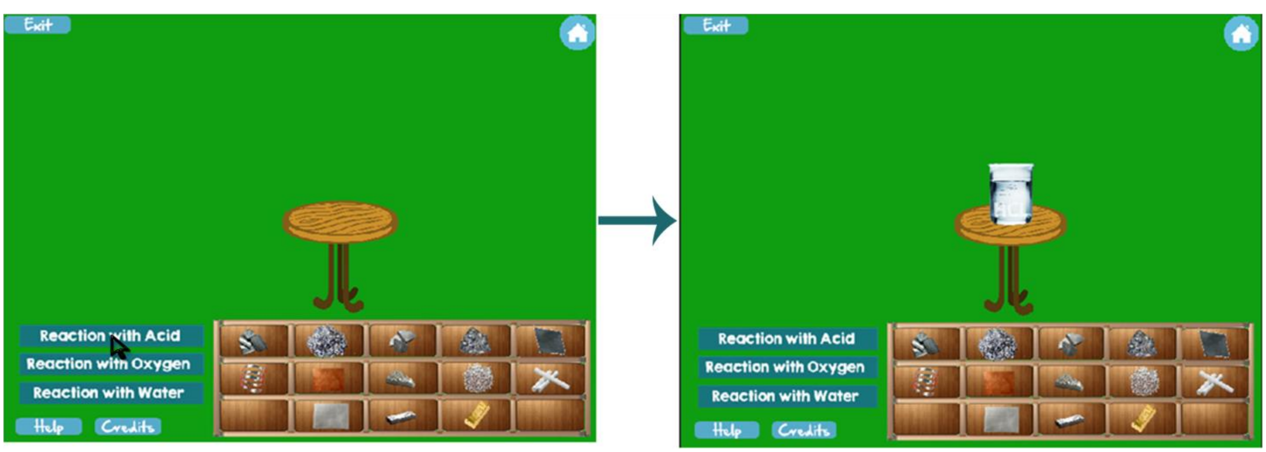
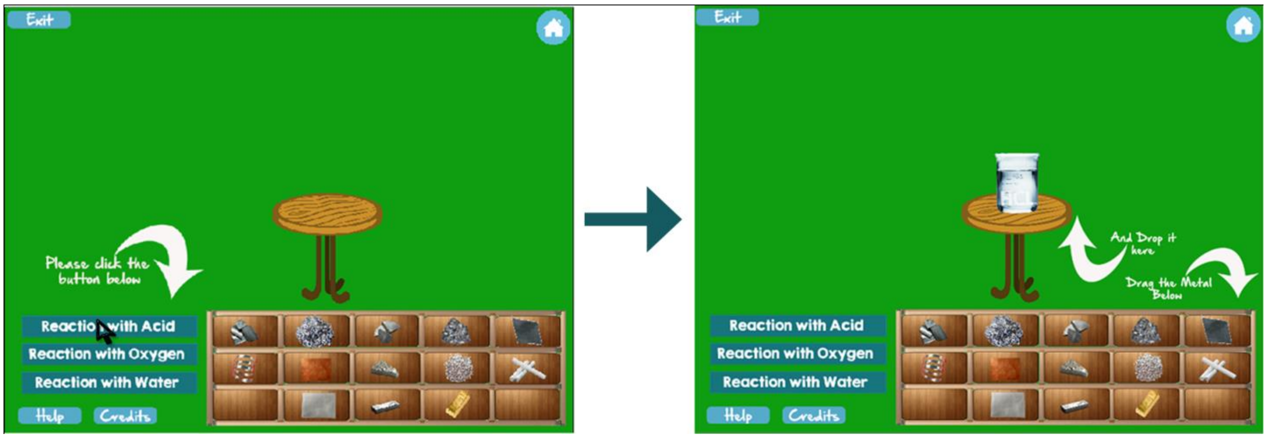


Figure 3.7 Use of clear and guided instructions in the first learning activity of an app on the user screen



3.6 Data Collection Tools

The quantitative and qualitative data were gathered through questionnaires, observations and focused group discussion. Various methods such as observations, and questionnaires were utilized in this study to ensure the effectiveness of learning app “Patterns of Reactivity” and its contribution towards affective students’ learning (Hsieh et al. 2015).

3.6.1 A student reported content knowledge or learning outcomes test

The learning outcomes scale included 10 items that assessed the learning outcomes or basic information of Patterns of Reactivity accessible to the students within PATTERNS OF REACTIVITY app. The test items were mapped against the defined learning outcomes of the patterns of reactivity in Science curriculum. All items were presented as true or false, fill in the blanks, multiple –choice questions with three responses, and descriptive answers. The items were validated by a science teacher. This test was taken immediately before and after the intervention and the test lasted approximately 5-10 minutes. The reason behind conducting the pre-test was to assess the mental ability and current knowledge acquired by the participants of both control and treatment groups and a proof that the knowledge or mental capability was similar for both groups. The post test was conducted after the experimental process that further helped in analysing the knowledge gained by receiving various Science instructions and measuring the difference between the groups (separate pre test comparisons of both groups and separate post tests comparison of both groups) and within the groups (pre test and post test comparisons). The minimum overall score of this tool was 0 and the maximum being 10. True or false were coded 0 or 1, correct option in multiple choice questions was coded as 1 and incorrect options were coded as 0. The correct filled blank was coded 1 and incorrectly as 0. However, the descriptive answers were coded as 1, 0.5 or 0 depending on the accuracy of the answer. This tool contains independent and dependent variables which were evaluated during the analysis. The independent grouping variable “engagement groups” included two levels: a) control (taught using traditional approach) b) treatment (taught using educational app). The independent variable gender included two levels: a) male b) female. The dependent variables included were learning achievement scores of the students before and after an experimental process.

3.6.2 Student engagement walk-through checklist

Student engagement walk-through checklist was used to observe the participants involved in this study during the intervention in Science classroom and lab. This checklist was adopted from Richard D. Jones. Furthermore, this checklist investigated the extent to which students demonstrated engagement patterns or behaviours during receiving traditional Science and educational app instructions. The teacher’s peers conducted classroom walk-through by using the checklist to gauge the level of observed student engagement from “very low” (1) to “very high” (5). The direct observations of the students were based on these criteria: “a) positive body language b) consistent focus c) verbal participation d) student confidence and e) fun and excitement”(Appendix E). This walk-through checklist was implemented in a study conducted in Singapore and offered some evidence for validity (Ganeshini 2011).

Moreover, the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) observation tool was used as an instrument to record the behaviour of the students as a snapshot for 10 minutes cycle (Alimoglu et al. 2014). There were three 10 minutes cycles to observe the students in the lab and in classroom during 30 minutes period. During each 10 minutes cycle, the behavior of 23-27 students was observed on the above mentioned criteria (Appendix D). In addition to this, an aggregate of 216 10-min observations were carried out (C= 41, E = 31).In GBL environment, gathering data through observations is a highly suitable method to understand the engaged behaviour patterns of students (Hsieh ibid 2015). This further helped us in determining the relationship between the students’ learning and gaming process (Hsieh ibid 2015)**.** However, the instrument was highly reliable and the values of Cronbach’s alpha revealed that the internal consistency of this tool was high during five instructional sessions (Day1: 0.881, Day2: 0.811, Day3: 0.899, Day4: 0.872, Day5: 0.844). The observers were trained prior to conducting the observations in Science classroom. However, professional trainers or observers were not employed in this study. Moreover, an observation tool STROBE was utilized with 158-177 students in a medical school and provided some proof for validity of the engagement scores (Alimoglu Ibid 2014).

The school teachers reported the perceived observations of the students. The independent grouping variable “engagement groups” included two levels: a) control (taught using traditional approach) b) treatment (taught using educational software). The independent variable gender included two variables: a) male b) female. The dependent variables were observed engagement level of the students on above mentioned factors during an experimental process.

3.6.3 Focused groups discussion

The focused group method was utilized to triangulate it with various other methods (questionnaires, observations). The focused group was conducted to collect detailed views of the participants. The discussion was designed to be semi-structured whereas the response from the participants was unstructured. Following the questionnaires, six male students and six female students came forward to participate in the discussion where two groups were formed, one for males and other for females. The sessions lasted 63 minutes and 95 minutes for males and females, respectively. Based on the focus group guide, the participants were asked a series of basic questions intended to promote further discussion regarding a) qualities of the learning app, b) learning goals, c) finding their misconceptions and addressing them through an app, d) concentration/attention, e) effort exertion, f) focus and g) engagement level during work as mentioned in Appendix F. The discussion was videotaped and participants were free to speak in their native language.

3.7 Pre-Intervention Phase

During this phase, students were randomly allocated to the four groups i.e., two groups were non-app groups called the control groups and the remaining two were app groups called the experimental groups. However, it should be noted that the male and female experimental groups were treated separately in computer lab. The pre-test based on learning outcomes was taken from the students prior to the intervention where the basic information relevant to the patterns of reactivity was accessed.

Reduced number of respondents

Before the intervention, the original sample size was 100 (50 for treatment and 50 for control groups). Among those 100 participants, 87% of them gave the pre and post tests based on learning outcomes. However, the size of the sample was reduced to 72(31 for treatment and 41 for control groups) out of 100 for observations reported by the teachers during the intervention due to factors such as student absenteeism.

3.8 Intervention Phase

During intervention, the experimental groups received instruction in a computer lab while interacting with an educational Science app and the control groups received usual or traditional Science instruction from their usual teacher in their classrooms. However, the instructor who taught experimental groups was not a teacher by profession and had no experience in this field. The intervention spanned over 3 weeks. This intervention took place in the months of August and September, 2015. Moreover, these set of learning goals were delivered in five classes, each lasted approximately 30 minutes (5 x 30 minutes). A gap of two days occurred between the first and second sessions. However, the desktop computers in a school lab were rare in number where 2-3 students shared a single computer.

During this phase, students learned about and explored the reaction of metals, and constructed the reactivity series (as indicated in table 3.3) following a lesson plan (Appendix G). Moreover, the students of treatment groups were offered further support during work by providing them with a worksheet, “reaction of metals with acid, water and oxygen”, for jotting down the observations made during the activities (Appendix C).This led to their exercise of self directed learning. The scaffolds such as, worksheets helped the students in learning “patterns of reactivity” via an educational app (Puntambekar and Kolodner 2004). Furthermore, the purpose of the worksheet was to aid students in making their own observations individually during work which helped them in constructing reactivity series.

During the intervention, the teacher’s peers observed the behavior of the individuals of control and treatment groups. The observations were recorded on a piece of paper provided to the observers. Furthermore, verbal participation is measured as students expressing thoughtful ideas and asking questions relevant to learning apart from reflecting on problems (Jones 2009). However, in this study, the app was developed for an individual use where the students participated less in verbal communications and focused more on work. Therefore, the observers did not measure this factor accurately since the tasks were not assigned to the students in groups where they learned collaboratively in the present study. Hence, the item that measured the verbal participation was discarded from the observation tool.

Table 3.2 Learning objectives achieved during an intervention while receiving instruction of education Science app

Class periods (40 minutes per period)	Learning Objectives
Class Period 1	Reaction of metals with acid
Class Period 2	Reaction of metals with acid and oxygen
Class Period 3	Reaction of metals with oxygen and water
Class Period 4	Reactions of metals with water and introduces to reactivity series
Class Period 5	Game based on the reactivity series

3.9 Post-Intervention Phase

After the intervention, the post-test based on the set of learning outcomes, learned or achieved during intervention, was taken from the control and treatment groups. The FGD were taken separately from boys and girls and the sessions lasted approximately 63 minutes and 95 minutes, respectively. The post test aims to investigate and analyse the students' performance after receiving Science educational app instruction with pre-tests and making comparisons between groups. Following by post-test, Focus Group Discussion (FGD) were taken separately from boys and girls and the sessions lasted approximately 63 minutes and 95 minutes, respectively. Later on, various methods such as questionnaires, observations and focus groups were analysed in the Results section.

3.10 Limitations

The app PATTERNS OF REACTIVITY was not piloted in any of the schools before starting intervention. Moreover, the size of the respondents was reduced during intervention due to student absenteeism.

3.11 Summary

The pre and post test equivalent sample quasi experimental framework was adopted to conduct experimentation in a low cost private school in urban area of Pakistan. The tools used to gather data were observations, content knowledge tests, and FGD. This experimentation lasted three weeks. The app and lesson based on Science PATTERNS OF REACTIVITY was designed during app development phase. This experimentation was divided into three phases. During pre-intervention phase, students were randomly assigned to the control and experimental groups. Moreover, the pre test based on content knowledge was taken from these groups. During intervention phase, experimentation took place where students received instruction through educational app while the other group was controlled. During post-intervention phase, post-test similar to pre-test was conducted followed by focus groups discussion.

4 Results

4.1 Introduction

The present study aims to measure the impact of an interactive educational application PATTERNS OF REACTIVITY based on Science on student engagement, achievement and gender difference. This educational app was designed and developed specifically for 8thgrade students. Student engagement, achievement and gender difference were measured through a questionnaire, walk-through checklist, and FGD. The present study sought to formulate the following null hypothesis:

H_{01}: Learning through an interactive Science app “PATTERNS OF REACTIVITY” has no significant effect on student engagement.

H_{02}: Learning through an interactive Science app “PATTERNS OF REACTIVITY” has no significant effect on learning outcomes.

H_{03}: Learning through an interactive Science app “PATTERNS OF REACTIVITY” has no significant effect on gender differences.

Keeping in mind the null hypotheses, independent grouping variables (control, treatment; male, female) and dependent variables (student engagement, learning outcomes) were identified and measured already discussed in section 3 of this report. In the chapter 3 (of methodology), several tools/instruments (student engagement walk through checklist, learning achievement test and FGD) were used for data collection that were analysed and reported in this chapter.

4.2 Quantitative Data Analysis

The collected data on learning outcomes and observed engagement level of the students were analysed using SPSS tool.

4.2.1 Comparison of Student Engagement

4.2.1.1 Introduction

An analysis was conducted to observe students’ engagement with an educational app “patterns of reactivity” in Science classroom and investigated its effect on them in comparison to the conventional instructional approach. This section of the study reported the results of the impact of an educational app on observers reported engagement level of the students.

Prior to conducting the analysis on collected data, the assumptions of Independent Samples t-test and One Way ANOVA with Repeated Measures were examined (Statistics.laerd.com 2015). Normality test's assumption was executed to check whether the data was normally distributed between control and treatment groups.

4.2.1.2 Sample characteristics

A Shapiro-Wilk's test($p<.05$)(Shapiro &Wilk1965; Razali&Wah2011) along with a visual analysis of their histograms, normal, Q-Q plots and box plots revealed that the observed student's engagement scores were not normally distributed on day 1 with a skewness of 1.148(SE =.369) and a kurtosis of 2.005(SE = .724) for the control group and a skewness of -.303(SE =.421) and a kurtosis of -.882(SE =.821) for treatment group(Cramer 1998,Crammer & Howitt 2004, Doane & Seward 2011), on day 3with a skewness of .373(SE = .369), and a kurtosis of -.810 (SE=.724) for the control group and a skewness of -.337(SE = .421) and a kurtosis of -1.448(SE = .821) for treatment group(Cramer 1998, Crammer &Howitt 2004, Doane & Seward 2011), on day 4with a skewness of -.928(SE =.369), and a kurtosis of .846(SE = .724) for the control group and a skewness of -.053(SE= .421) and a kurtosis of -.290(SE = .821) for treatment group(Cramer 1998, Crammer & Howitt 2004, Doane & Seward 2011) and on day 5with a skewness of -.928(SE = .369), and a kurtosis of .846(SE = .724) for the control group and a skewness of 1.061(SE = .421) and a kurtosis of -.408(SE = .821) for treatment group(Cramer 1998, Crammer &Howitt 2004, Doane& Seward 2011).

A Shapiro-Wilk's test($p>.05$)(Shapiro &Wilk 1965, Razali &Wah 2011) along with visual analysis of their histograms, normal, Q-Q plots and box plots revealed that the observed student's engagement scores were normally distributed on day 2 with a skewness of .298(SE =.369), and a kurtosis of -.237(SE =.724) for the control group and a skewness of -.571(SE =.421), and a kurtosis of -.522(SE= .821)for treatment group (Cramer 1998, Crammer &Howitt 2004, Doane & Seward 2011).

Since the observed engaged behavior scores were skewed for the independent grouping variables and also one of the assumptions (normality of data) of parametric test was violated, therefore non-parametric tests equivalent to Independent Samples t-test and One Way ANOVA with repeated measures were conducted for evaluating null hypotheses associated with observed student engagement.

4.2.1.3 Results and interpretation of observed student engagement with repeated measures with in treatment group

Friedman test was conducted to identify whether the means of the observed engagement level measured multiple times were equal to each other (Statistics.laerd.com 2015). Friedman Test indicated in table 4.1 revealed that there was a significant difference on each factor of the observed engagement level ($p = 0.000 < 0.05$), therefore, the associated null hypothesis; “there is no significant difference between the means of the observed engagement level measured multiple times within treatment group”; was rejected.

Table 4.1 Results of the Friedman test to compare the repeated measures on various factors of observed engagement level with in the treatment group

	Descriptive										**Friedman Test Statistics**	
Factors of Engagement	**Day 1**		**Day 2**		**Day 3**		**Day 4**		**Day 5**		$\chi 2$	***p***
	Mean	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**		
Positive Body Language	11.29	1.532	12.19	1.721	11.35	3.440	13.97	1.426	12.97	1.426	41.395	.000
Consistent Focus	12.81	1.957	13.77	1.230	10.23	4.039	12.48	1.288	12.87	1.586	34.727	.000
Student Confidence	11.74	2.323	12.84	2.339	10.77	3.658	11.97	1.560	12.61	1.838	15.284	.004
Fun and Excitement	11.87	2.141	11.65	1.889	11.58	3.538	13.26	2.265	14.03	1.426	24.349	.000

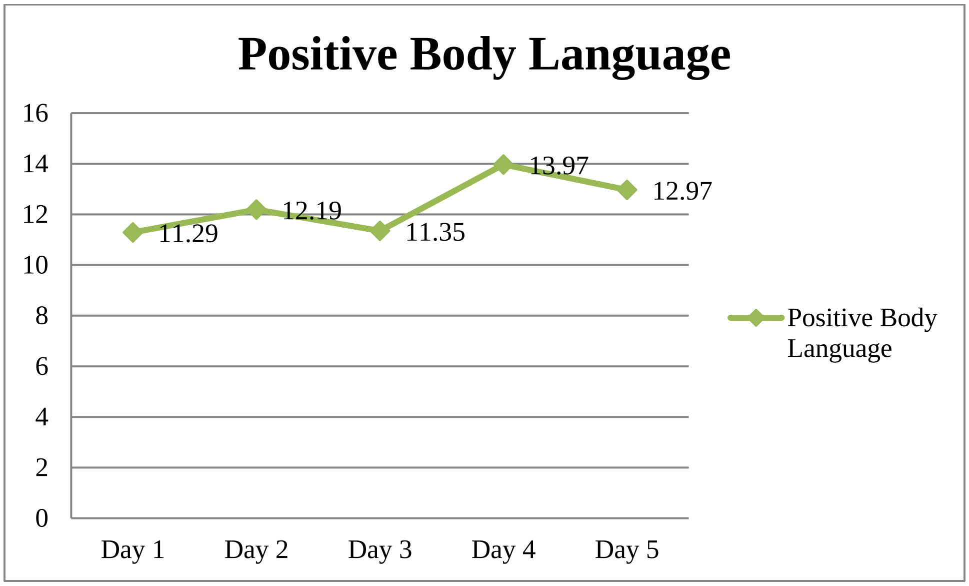
Note. $df = 4$, N=31 for all analyses.

To see the patterns of student engagement on each of the five factors, a line graph was plotted depicting the trend of repeated measures over time.

4.2.1.3.1 Positive Body Language

The trend in observed positive body language of the students rose mildly with time except it dropped off a bit on day 3 as seen in figure 4.1. However, students exhibited low positive body language on day 5 as compared to on day 4.

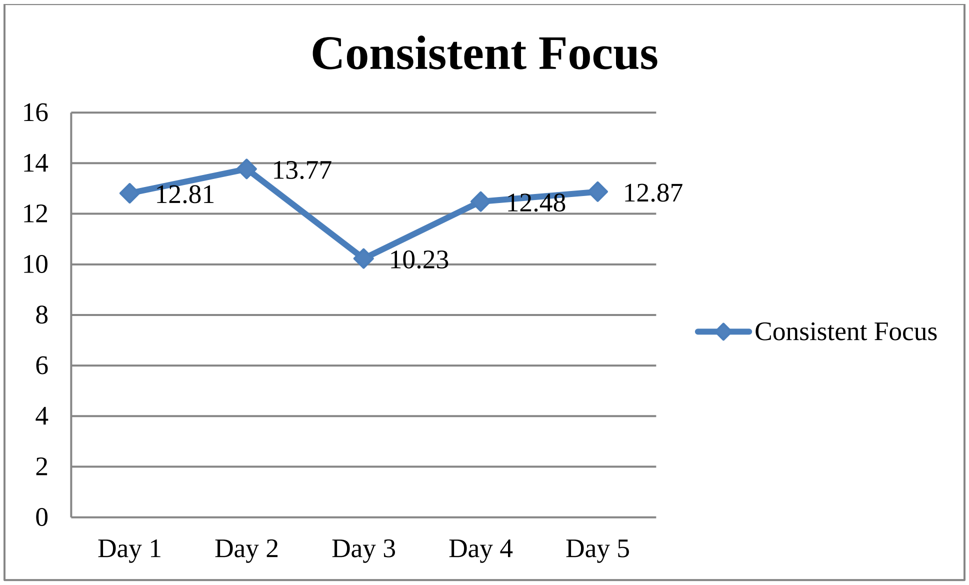
Figure 4.1 Line plot depicting the overall trend of the observed body language of the students measured multiple times within the treatment group



4.2.1.3.2 Consistent Focus

The trend in consistent focus of the students rose slowly except on day 3 where it declined sharply. However, it started to rise significantly from day 3 to day 4 as can be seen in figure 4.2. Though, the increase in consistent focus on days 4 and 5 was less as compared to on day 2.

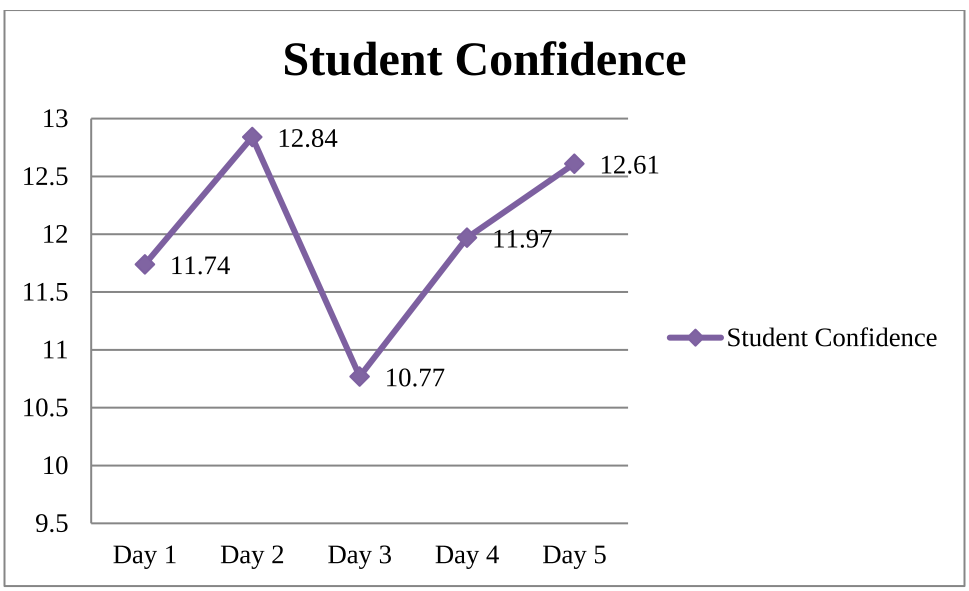
Figure 4.2 Line plot depicting the overall trend of the observed consistent focus of the students measured multiple times within the treatment group



4.2.1.3.3 Student Confidence

The observed student confidence rose sharply till day 2 as depicted in figure 4.3. However, it declined sharply from day 2 to day 3 and started to rise again from day 3 to day 5.

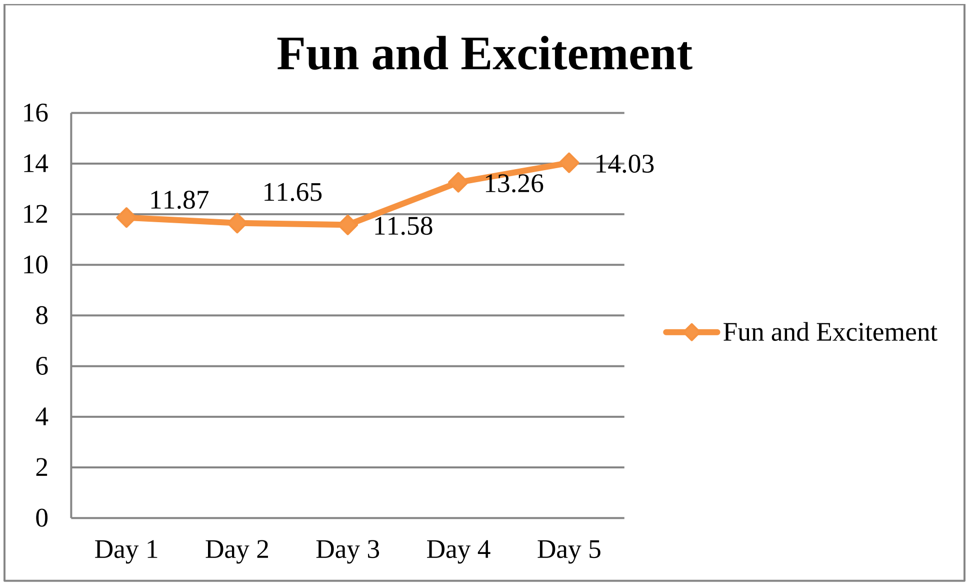
Figure 4.3 Line plot depicting the overall trend of the observed student confidence of the students measured multiple times within the treatment group



4.2.1.3.4 Fun and Excitement

The observed fun and excitement of students declined mildly till day 3 and it rose slowly from day 3 till day 5 as depicted in figure 4.4.

Figure 4.4 Line plot depicting the overall trend of the observed fun and excitement of the students measured multiple times within the treatment group



4.2.1.4 Results and interpretation of observed engagement level on various factors between control and treatment groups

Since, the data was skewed for one of the variables; the non-parametric test was used to compare the difference in means for the observed engagement level of the students on various factors such as, positive body language (PBL), consistent focus (CF), student confidence (SC), fun and excitement (F&E) between control and treatment groups. Four null hypotheses included were a) there is no significant difference in the means of observed positive body language between control and treatment groups, b) there is no significant difference in the means of observed consistent focus between control and treatment group, c) there is no significant difference in the means of observed student confidence between control and treatment groups, d) there is no significant difference in the means of observed fun and excitement between control and treatment groups.

The Mann Whitney U test as indicated by table 4.2 showed that the observed positive body language of the students for the treatment groups on day 1(U =465, p = .049< 0.05), day2 (U = 389, p = .005 < 0.05), day 3(U = 447, p = .031< 0.05), and day 4(U = 324, p =.000< 0.05) were statistically significantly higher than the observed positive body language for the control groups. However, table 4.2 indicated that the Mann Whitney U test did not show any statistically significant difference between control and treatment groups' observed positive body language on day 5(U = 593, p =.612> 0.05).

Table 4.2 Results of the Mann Whitney U test to compare the Groups' observed positive body language score

Positive Body Language		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	41	32.3	465	.049*
	Treatment	31	42		
Day 2	**Control**	41	30.4	389	.005**
	Treatment	31	44.4		
Day 3	**Control**	41	31.9	447	.031*
	Treatment	31	42.5		
Day 4	**Control**	41	28.9	324	.000***
	Treatment	31	46.5		
Day 5	**Control**	41	35.4	593	.612
	Treatment	31	37.8		

Note. * =*p< .05*, ** =*p<.01*, *** =*p<.001*.

Since, the observed positive body language of the students in treatment group was significantly high on first four days of the intervention as compared to the control group therefore, the associated null hypothesis with this analysis was rejected(Statistics.laerd.com 2015). Moreover, the Mann Whitney U test as indicated by table 4.3 showed that the observed consistent focus of the students for the treatment groups on day 1(U =182, p = .000< 0.05), and day2 (U = 139.5, p = .000 < 0.05) were statistically significantly higher than the observed positive body language for the control groups. However, table 4.3 indicated that the Mann Whitney U test did not show any statistically significant difference between control and treatment groups' observed consistent focus on day 3(U =549, p = .323 > 0.05), day 4(U = 616, p = .815 >0.05) and day 5(U = 514, p =.148 > 0.05).

Table 4.3 Results of the Mann Whitney U test to compare the Groups' observed consistent focus score

Consistent Focus		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	41	25.4	182	.000***
	Treatment	31	51.1		
Day 2	**Control**	41	24.4	139	.000***
	Treatment	31	52.5		
Day 3	**Control**	41	34.3	549	.323
	Treatment	31	39.2		
Day 4	**Control**	41	36	616	.815
	Treatment	31	37.1		
Day 5	**Control**	41	33.5	514	.148
	Treatment	31	40.4		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed consistent focus of the students in treatment groups was significantly high on at least two days i.e., day 1 and day 2 as compared to the control groups, therefore the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015).

In addition to this, the Mann Whitney U test as indicated by table 4.4showed that the observed student confidence of the students for the treatment groups on day 1(U =210, p = .000< 0.05), day2 (U = 213.5, p = .000 < 0.05) and day 5(U = 463, p = .045 < 0.05) were statistically significantly higher than the observed student confidence for the control groups. However, table 4.4 indicated that the Mann Whitney U test did not show any statistically significant difference between control and treatment groups' observed student confidence on day 3(U =466.5, p = .53 > 0.05) and day 4(U = 565.5, p = .414 >0.05).

Table 4.4 Results of the Mann Whitney U test to compare the Groups' observed student confidence score

Student Confidence		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	41	26.1	210	.000***
	Treatment	31	50.2		
Day 2	**Control**	41	26.2	214	.000***
	Treatment	31	50.1		
Day 3	**Control**	41	32.3	467	.053
	Treatment	31	41.9		
Day 4	**Control**	41	34.7	566	.414
	Treatment	31	38.7		
Day 5	**Control**	41	32.2	463	.045*
	Treatment	31	42		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed student confidence of the students in the treatment groups was significantly high on three days i.e., day 1, day 2 and day 5 as compared to the control groups, therefore the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015).

Moreover, the Mann Whitney U test as indicated by table 4.5 showed that the observed fun and excitement of the students for the treatment groups on day 1($U = 68.5$, $p = .000 < 0.05$), day2 ($U = 73.5$, $p = .000 < 0.05$) , day 3($U = 236$, $p = .000 < 0.05$), day 4 ($U = 215$, $p = 0.000 < 0.05$) and day 5($U = 110$, $p = .000 < 0.05$) were statistically significantly higher than the observed fun and excitement for control group.

Table 4.5 Results of the Mann Whitney U test to compare the Groups' observed fun and excitement score

Fun and Excitement		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	41	22.6	68.5	.000***
	Treatment	31	54.7		
Day 2	**Control**	41	22.7	73.5	.000***
	Treatment	31	54.6		
Day 3	**Control**	41	26.7	236	.000***

	Treatment	31	49.3		
Day 4	**Control**	41	26.2	215	.000***
	Treatment	31	50.06		
Day 5	**Control**	41	23.68	110	.000***
	Treatment	31	53.4		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed fun and excitement of the students in the treatment groups was significantly high on all five days of an intervention as compared to the control groups therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015).

4.2.1.5 Results and interpretation of observed engagement level of female students on various factors based on groups

Since, the data was skewed for one of the variables; the non-parametric test (Mann Whitney U test) was used to compare the difference in the means of the observed engagement level for the female students on various factors such as, positive body language, consistent focus, student confidence, and fun and excitement between control and treatment groups. Four null hypotheses included were a) there is no significant difference in the means of observed positive body language of female students between control and treatment groups, b) there is no significant difference in the means of observed consistent focus of female students between control and treatment groups , c) there is no significant difference in the means of observed student confidence of female students between control and treatment groups , and d) there is no significant difference in the means of observed fun and excitement of female students between control and treatment groups.

The Mann Whitney U test as indicated by table 4.6 showed that the observed positive body language of the female students for treatment group on day 3($U = 62.5$, $p = .001 < 0.05$), day 4 ($U = 0$, $p = .000 < 0.05$) and day 5($U = 100$, $p = .044 < 0.05$) were statistically significantly higher than the female students' observed positive body language for the control group. However, table 4.6 indicated that the Mann Whitney U test did not show any statistically significant difference between the control and treatment groups' observed positive body language for the female students on day 1 ($U = 135.5$, $p =.392 > 0.05$), and day 2 ($U = 122$, $p = .197 > 0.05$).

Table 4.6 Results of the Mann Whitney U test to compare the observed positive body language scores of the females between control and treatment groups

Positive Body Language		*N*	Mean Rank	*U*	*p*
Day 1	**Control**	18	19.9	136	.39
	Treatment	18	17.0		
Day 2	**Control**	18	16.2	122	.19
	Treatment	18	20.7		
Day 3	**Control**	18	12.9	62.5	.001**
	Treatment	18	24.0		
Day 4	**Control**	18	9.50	0.000	.000***
	Treatment	18	27.5		
Day 5	**Control**	18	15.0	100	.044*
	Treatment	18	21.9		

Note. * =*p< .05*, ** =*p<.01*, *** =*p<.001*.

Since, the observed positive body language for the female students in the treatment group was significantly higher on first, second and third days as compared to the control group therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015). Moreover, the Mann Whitney U test as indicated by table 4.7 showed that the observed confidence of the female students for the treatment group on day 1(U = 40, p = .000< 0.05), day 2 (U = 9.5, p = .000< 0.05) , day 3(U = 90, p =.020 < 0.05), day 4 (U = 102, p = .048 < 0.05) and day 5(U = 75, p = .004 < 0.05) were statistically significantly higher than the female students' observed confidence for the control group.

Table 4.7 Results of the Mann Whitney U test to compare the observed student confidence scores of the females between control and treatment groups

Student Confidence		*N*	Mean Rank	*U*	*p*
Day 1	**Control**	18	11.7	40	.000***
	Treatment	18	25.2		
Day 2	**Control**	18	10.0	9.50	.000***
	Treatment	18	26.9		
Day 3	**Control**	18	14.4	90	.020*
	Treatment	18	22.5		

Day 4	Control	18	15.1	102	.048*
	Treatment	18	21.8		
Day 5	Control	18	13.6	75	.004**
	Treatment	18	23.3		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed confidence for the female students in the treatment group was significantly higher on all five days of an intervention as compared to the control group therefore, the associated null hypothesis was rejected (Statistics.laerd.com 2015). Moreover, the Mann Whitney U test as indicated by table 4.8 showed that the observed consistent focus of the female students for treatment group on day 1(U = 80, p = .009< 0.05), day 2 (U = 36, p = .000< 0.05), and day 5(U = 100, p = .042 < 0.05) were statistically significantly higher than the girl's observed consistent focus for the control group. However, the Mann Whitney U test revealed that observed consistent focus did not show any significant difference on day 3(U = 101, p =.050< 0.05) and day 4(U = 120, p = .162 > 0.05) between the girls of both engagement groups.

Table 4.8 Results of the Mann Whitney U test to compare the observed consistent focus scores of the females between control and treatment groups

Consistent Focus		*N*	Mean Rank	*U*	*p*
Day 1	Control	18	13.9	80	.009**
	Treatment	18	23.0		
Day 2	Control	18	11.4	35.5	.000***
	Treatment	18	25.5		
Day 3	Control	18	15.1	101	.050
	Treatment	18	21.8		
Day 4	Control	18	16.1	120	.162
	Treatment	18	20.8		
Day 5	Control	18	15.0	100	.042*
	Treatment	18	21.9		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed consistent focus for the female students in the treatment group was significantly higher on first, second, and fifth days of an intervention as compared to the control group therefore, the associated null hypothesis with this analysis was rejected(Statistics.laerd.com 2015). Furthermore, the Mann Whitney U test as indicated by table

4.9 showed that the observed fun and excitement of the female students for the treatment group on day 1(U = 4, p = .000< 0.05), day 2 (U = 0, p = .000< 0.05), day 3 (U = 0, p = .000< 0.05), day 4 (U = 0, p = .000< 0.05) and day 5 (U = 0, p = .000< 0.05) were statistically significantly higher than the girl's observed fun and excitement for the control group.

Table 4.9 Results of the Mann Whitney U test to compare the observed fun and excitement scores of the females between control and treatment groups

Fun and Excitement		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	18	9.7	4	.000***
	Treatment	18	27.2		
Day 2	**Control**	18	9.5	0.000	.000***
	Treatment	18	27.5		
Day 3	**Control**	18	9.5	0.000	.000***
	Treatment	18	27.5		
Day 4	**Control**	18	9.5	0.000	.000***
	Treatment	18	27.5		
Day 5	**Control**	18	9.5	0.000	.000***
	Treatment	18	27.5		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed fun and excitement of the female students in the treatment group was significantly higher on first, second, third and fifth days of the intervention as compared to the control group therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015).

4.2.1.6 Results and interpretation of observed engagement level of male students on various factors based on engagement groups

Since, the data was skewed for one of the variables; the non-parametric test (Mann Whitney U test) was used to compare the difference in means of the observed engagement level for the male students on various factors such as, positive body language, consistent focus, student confidence, and fun and excitement between control and treatment groups. Four null hypotheses included were a) there is no significant difference in the means of observed positive body language for the male students between control and treatment groups b) there is no significant difference in the means of observed consistent focus for the male students between control and treatment groups c) there is no significant difference in the means of observed student confidence for the male students between control and treatment groups d) there is no significant difference in the means of observed fun and excitement for the male students between control and treatment groups.

The Mann Whitney U test as indicated by table 4.10 showed that the observed positive body language of the male students for the treatment group on day 1(U =67, p = .005< 0.05) and day 2 (U = 91, p = .048 < 0.05) were statistically significantly higher than the observed positive body language for the control group. However, table 4.10 indicated that the Mann Whitney U test did not show statistically significant difference in the means of observed positive body language between the engagement groups of males on day 3(U = 133, p =.564 > 0.05), day 4 (U = 109 , p = .158 > 0.05) and day 5(U = 104, p =.110 > 0.05).

Table 4.10 Results of the Mann Whitney U test to compare the observed positive body language score of males between control and treatment groups

Positive Body Language		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	23	14.8	67	.005**
	Treatment	13	24.8		
Day 2	**Control**	23	15.9	91	.048*
	Treatment	13	23.0		
Day 3	**Control**	23	19.2	133	.564
	Treatment	13	17.1		
Day 4	**Control**	23	20.2	109	.158
	Treatment	13	15.3		
Day 5	**Control**	23	20.5	104	.110
	Treatment	13	14.9		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed positive body language of the male students in the treatment group was significantly higher on two days i.e., days 1 and 2 as compared to control group therefore, the associated null hypothesis with this analysis was rejected(Statistics.laerd.com 2015). Moreover, the Mann Whitney U test as indicated by table 4.11 showed that the observed consistent focus of the male students for treatment group on day 1(U = 5.5, p = .000< 0.05), and day2 (U = 2, p = .000 < 0.05) were statistically significantly higher than the observed consistent focus for control group. However, the Mann Whitney U test as indicated by table 4.11 showed that the observed consistent focus of the male students for control group on day 3(U = 82, p = .024< 0.05) were statistically significantly higher than the observed consistent focus for treatment group. Moreover, table 4.11 indicated that the Mann Whitney U test did not show any statistically significant difference between control and treatment groups' observed consistent focus of the male students on day 4(U = 109, p = .151 > 0.05) and day 5(U = 140, p =.740 > 0.05).

Table 4.11 Results of the Mann Whitney U test to compare the observed consistent focus scores of males between control and treatment groups

Consistent Focus		**N**	**Mean Rank**	***U***	***p***
Day 1	**Control**	23	12.2	5.5	.000***
	Treatment	13	29.5		
Day 2	**Control**	23	12.0	2	.000***
	Treatment	13	29.8		
Day 3	**Control**	23	21.4	82	.024*
	Treatment	13	13.2		
Day 4	**Control**	23	20.2	109	.151
	Treatment	13	15.3		
Day 5	**Control**	23	18.9	140	.740
	Treatment	13	17.7		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed consistent focus of the male students in the treatment group was significantly higher on at least two days i.e., day 1 and day 2 as compared to the control group therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015). Moreover, the Mann Whitney U test as indicated by table 4.12 showed that the observed confidence of the male students for treatment group on day 1(U = 70.5, p = .008< 0.05), and day 2 (U = 75.5, p = .012 < 0.05) were statistically significantly higher than the observed male students' confidence for control group. However, table 4.12 indicated that the Mann Whitney U test did not show any statistically significant difference between the control and treatment groups' observed confidence of the male students on day 3 (U = 119, p =.309 > 0.05), day 4 (U = 102, p = .108 > 0.05) and day 5(U = 131, p =.534 > 0.05).

Table 4.12 Results of the Mann Whitney U test to compare the observed student confidence scores of the males between control and treatment groups

Student Confidence		***N***	**Mean Rank**	***U***	***p***
Day 1	**Control**	23	15.07	70.5	.008**
	Treatment	13	24.58		
Day 2	**Control**	23	15.28	75.5	.012*
	Treatment	13	24.19		
Day 3	**Control**	23	19.83	119	.309
	Treatment	13	16.15		
Day 4	**Control**	23	20.57	102	.108
	Treatment	13	14.85		
Day 5	**Control**	23	19.30	131	.534
	Treatment	13	17.08		

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

Since, the observed consistent focus of the male students in the treatment group was significantly high on at least two days i.e., day 1 and day 2 as compared to the control group therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015). Furthermore, the Mann Whitney U test as indicated by table 4.13showed that the observed fun and excitement of the male students for the treatment group on day 1(U = 20.5, p = .000< 0.05), day 2 (U = 28, p = .000< 0.05) and day 5(U = 0, p = .000 < 0.05) were statistically significantly higher than the observed male students' fun and excitement for the control group. However, table 4.13 indicated that the Mann Whitney U test did not show any statistically significant difference between control and treatment groups' observed fun and excitement of the male students on day 3 (U = 133, p =.570 > 0.05), and day 4 (U = 97, p = .076 > 0.05).

Table 4.13 Results of the Mann Whitney U test to compare the observed fun and excitement scores of the males between control and treatment groups

Fun and Excitement	***N***	**Mean Rank**	***U***	***p***

Day 1	**Control**	23	12.8	20.5	.000***
	Treatment	13	28.4		
Day 2	**Control**	23	13.2	28	.000***
	Treatment	13	27.8		
Day 3	**Control**	23	17.7	133	.570
	Treatment	13	19.8		
Day 4	**Control**	23	20.7	97	.076
	Treatment	13	14.4		
Day 5	**Control**	23	12.0	0.000	.000***
	Treatment	13	30		

Note. * *=p< .05, ** =p<.01, *** =p<.001.*

Since, the observed fun and excitement of the male students in the treatment group was significantly high on at least two days i.e., day 1 and day 2 as compared to the control group therefore, the associated null hypothesis with this analysis was rejected (Statistics.laerd.com 2015).

4.2.2 Comparison of Learning Achievement

4.2.2.1 Introduction

An analysis was conducted to evaluate the performance of the students reported by them before and after an intervention i.e., learning using an educational app “patterns of reactivity” in Science classroom and comparing the performance of students in experimental group with the control group taught using conventional instruction approach. Normality test was executed prior to conducting the analysis. This section of the study reported the results of the impact of using educational app on student learning achievement. There were five null hypotheses a) there is no statistically significant difference on the mean ranks of achievement scores based on control and treatment groups, b) there is no statistically significant difference on the mean ranks of achievement scores based on gender within treatment group, c) there is no statistically significant difference on the mean ranks of achievement scores based on gender within control group, d) there is no statistically significant difference on the mean ranks of pre achievement test scores and post achievement test scores within Treatment group, and e) there is no statistically significant difference on the mean ranks of pre achievement test scores and post achievement test scores within Control group.

Prior to conducting the analysis on gathered data, the normality assumptions of Independent Samples t-test and Paired Samples t-test were examined (Statistics.laerd.com 2015).

4.2.2.2 Sample characteristics

A Shapiro-Wilk's test ($p<.05$)(Shapiro &Wilk 1965, Razali&Wah 2011) along with a visual analysis of their histograms, normal, Q-Q plots and box plots revealed that the pre-achievement test scores were not normally distributed, with a skewness of -.716 (SE=0.357)and a kurtosis of .693 (SE= 0.702) for the control group and a Shapiro-Wilk's test ($p>.05$)(Shapiro &Wilk1965, Razali&Wah 2011) with a skewness of -.108 (SE=0.361) and a kurtosis of -0.330 (SE=0.709) for the treatment group revealed that pre-achievement test scores were normally distributed(Cramer 1998, Cramer &Howitt 2004, Doane& Seward 2011).

A Shapiro-Wilk's test ($p>.05$)(Shapiro &Wilk 1965, Razali&Wah 2011) along with visual analysis of their histograms, normal, Q-Q plots and box plots revealed that the post-achievement test scores were normally distributed, with a skewness of -.339 (SE=0.357)and a kurtosis of .325 (SE= 0.702) for the control group and with a skewness of -.004 (SE=0.361) and a kurtosis of -0.436 (SE=0.709) for treatment group(Cramer 1998, Cramer &Howitt 2004, Doane& Seward 2011).

Since the pre achievement test scores were not normally distributed for one the independent grouping variables and also one of the assumptions (normality of data) of parametric test was violated, therefore non-parametric tests equivalent to Independent Samples t-test and Paired sample t-test were conducted for evaluating null hypotheses associated with students' learning outcomes.

4.2.2.3 Results and interpretation of students' learning achievement between control and treatment groups

Since the achievement scores were skewed for the control group, non-parametric test was chosen as the most appropriate test analysis. Mann Whitney U test was selected for evaluating the effect of educational app on students' learning achievement compared to conventional instruction approach in Science.

The Mann Whitney U test as indicated by table 4.14 showed that the pre-test scores $U=766, Z= -1.54, p=.12>.05$)and post-test scores($U= 912, Z = -.30, p =.77>.05$) based on learning outcomes of an app PATTERNS OF REACTIVITY for the control and treatment groups did not show any statistically significant difference .

Table 4.14 Results of the Mann Whitney U test to compare the Groups' pre and post achievement test scores

	Group	***N***	**Mean**	***U***	***Z***	***P***
Pre Test Scores	**Control**	44	48.1	766	-1.54	0.12
	Treatment	43	39.8			
Post Test Scores	**Control**	44	44.8	912	-0.3	0.77
	Treatment	43	43.2			

The analysis revealed that there was no significant difference in the pre and post-achievement test scores between the control and treatment groups. Therefore, the associated null hypothesis with this analysis was accepted. The results indicated that the overall learning performance of the students who learned Science using educational app “patterns of reactivity” was somewhat similar in comparison to the conventional instructional approach.

4.2.2.4 Results and interpretation of students’ learning achievement with in treatment group

To test the hypothesis, that the means of pre-achievement test (*M =5.02, SD=1.31*) and the means of post-achievement test (*M = 7.05, SD=1.44*) were equal with in the treatment group, a Wilcoxon signed test was performed. A Wilcoxon signed test indicated in table 4.15 showed that there was a statistical significant difference in the scores of pre-achievement test and post-achievement test with in the treatment group, *(Z =- 4.92, p=.000>.05).*

Table 4.15 Results of the Wilcoxon Signed Test to compare the Experimental Group’s pre and post-test scores based on content knowledge or learning outcomes

		N	**Mean Rank**	***Z***	***p***
Pre-test scores –Post-test scores	Negative Ranks	6	5.25	-4.92	.000***
	Positive Ranks	32	22.1		
	Ties	5			
	Total	43			

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

The result indicated that the associated null hypothesis with this analysis was rejected which means that the students who were taught with an educational app during intervention performed significantly better on learning outcomes test conducted after intervention than their pre-test scores.

4.2.2.5 Results and interpretation of students' learning achievement with in control group

To test the hypothesis, the mean ranks of pre-achievement test *(M = 5.40, SD = 1.29)* and post-achievement test scores*(M= 7.10, SD = 1.44)* were equal, Wilcoxon signed test was run for computing this analysis. The output in table 4.16 indicated that the post-achievement test scores were statistically significantly higher than the pre-achievement test scores of the students within control group *(Z =- 4.59, p=.000>.05).*

Table 4.16 Results of the Wilcoxon Signed Test to compare the Control Group's pre and post achievement test scores

		N	**Mean rank**	***Z***	***P***
Post Test - Pre Test	Negative Ranks	5	10.9	-4.59	0.000***
	Positive Ranks	33	20.8		
	Ties	6			
	Total	44			

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

The results indicated that the associated null hypothesis with this analysis was rejected which means that the students performed better after an being taught with conventional Science instructional approach process rather than their performance on pre test.

4.2.2.6 Results and interpretation of students' learning achievement based on Gender with in treatment group

To test the hypothesis that the mean of males' pre-achievement test *(M= 4.90, SD = 1.33)* and mean of females' pre achievement test *(M= 5.17, SD= 1.32)* were equal with in treatment group, and also mean of males' post-achievement test *(M= 6.30, SD = 1.27)* and mean of females' post-achievement test *(M= 7.92, SD= 1.12)* were equal with in the treatment group, a Mann Whitney u test was performed. Since the data was not normally distributed, so Mann Whitney u test was used to compare the pre achievement test score in males and females with in treatment group. Table 4.17 indicated that the Mann Whitney U test did not show statistically significant difference between males and females on pre-achievement test scores with in treatment group *(U = 194, Z = -.887, p = .375>.05).*However, the test indicated that the post achievement test scores for the females was statistically significantly higher than the post achievement test scores for males with in the treatment group (*U = 81, Z = -3.654, p = .000< .05).* Therefore, the associated null hypothesis with this analysis was rejected which means that girls gained significantly high scores on post test after intervention i.e., being taught with Science app rather than the boys.

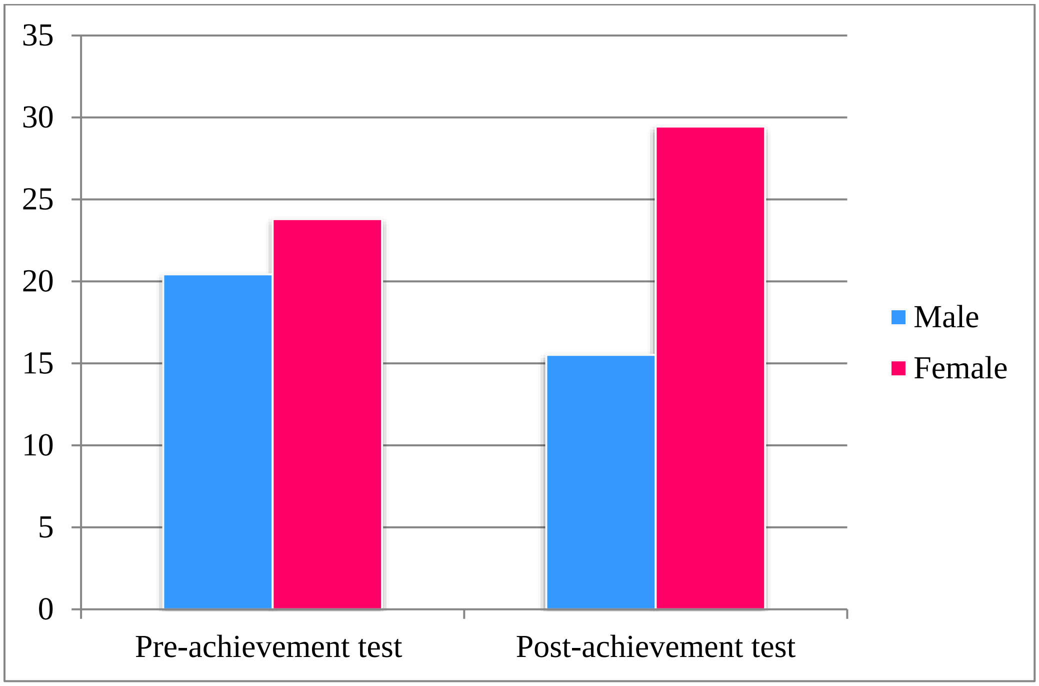
Table 4.17 Results of the Mann Whitney U test to compare the Genders' pre and post achievement test scores with in treatment group

	Groups	***N***	**Mean Rank**	***U***	***Z***	***p***
Pre- test scores	**Male**	23	20.4	194	-0.88	0.37
	Female	20	23.8			
Post-test scores	**Male**	23	15.5	81	-3.65	0.000***
	Female	20	29.4			

Note. ** =p< .05, ** =p<.01, *** =p<.001.*

As illustrated in figure 4.5, female students scored higher in learning outcomes test as compared to the males before and after the intervention. However, females scored better in post test conducted after receiving Science app instruction as compared to their pre-test.

Figure 4.5 Comparison of pre and post achievement test scores based on gender with in treatment group



The results revealed that males and females performed somewhat similar in pretest based on learning outcomes but after an experimental process, females outperformed males in test based on learning outcomes. In conclusion, the educational app had a positive impact on females' content knowledge than the male students.

4.2.2.7 Results and interpretation of students' learning achievement based on Gender with in control group

To test the hypotheses that males' pre-achievement test *(M= 5.30, SD = 1.428)* and females' pre-achievement test means *(M= 5.55, SD= 1.104)* were equal with in control group and males' post-achievement test *(M= 6.78, SD = 1.620)* and females' pre-achievement test means *(M= 7.52, SD= 1.086)* were equal with in control group, Mann Whitney U test was performed. Mann Whitney U test was performed to compare the pre achievement scores in males and females of control group. The results as indicated in table 4.18 showed that pre achievement test scores *(U = 226, Z = -.264, p = .792>.05)* and post achievement test scores *(U = 164, Z = -1.742, p =*

.081>.05) did not show statistically significant difference for males and females within the control group

Table 4.18 Results of the Mann Whitney U test to compare the Genders' pre and post achievement test scores within the Control group

	Groups	*N*	Mean Rank	*U*	*Z*	*p*
Pre Achievement Test Scores	**Male**	25	22.0	226	-.264	.792
	Female	19	23.0			
	Total	44				
Post-Achievement Test Scores	**Male**	25	19.5	164	-1.742	.081
	Female	19	26.3			
	Total	44				

Note. * $=p< .05$, ** $=p<.01$, *** $=p<.001$.

The results indicated that the associated null hypothesis with this analysis was accepted which means that the conventional science instruction had no effect on content knowledge or learning outcomes test scores of males and females before and after instruction.

4.2.3 Summary of the results for quantitative data analysis

4.2.3.1 Results for the comparison of student engagement

The following null hypothesis associated with quantitative data analysis of observed engagement levels on various factors was rejected;

H_{01}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on student engagement.

Therefore, it has been concluded that the learning app "patterns of reactivity" had a significant positive effect on the observed engagement level of the treated students on various factors such as, positive body language, fun and excitement, student confidence, and consistent focus.

4.2.3.2 Results for the comparison of learning outcomes

The following null hypothesis associated with the quantitative data analysis of learning achievement between control and treatment groups was accepted.

H_{02}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on learning outcomes.

Therefore, it was concluded that the learning app "patterns of reactivity" had no significant affect on the learning outcomes of the students as compared to the control group. However, with-in the treatment groups, students performed significantly better after receiving app instruction i.e., on post-test as compared to the pre-test.

4.2.3.3 Results of engagement and learning outcomes based on genders

Through various analysis, it was concluded that the girls performed significantly better than boys with in treatment group in terms of learning outcomes or content knowledge test. Moreover, girls demonstrated high observed engagement level on various factors as compared to the boys with in treatment group. Apart from this, girls and boys of treatment groups showed high level of engaged behavior on various factors such as positive body language, consistent focus, confidence, and fun and excitement as compared to the girls and boys of control groups, respectively. Therefore, the associated null hypothesis based on these results was rejected.

H_{03}: Learning through an interactive Science app "Patterns of Reactivity" has no significant effect on gender difference.

4.3 Qualitative Data Analysis

The FGD was analysed using NVIVO tool. This method helped in collating and triangulating the discussion with the various quantitative data analysis approach.

4.3.1 Comparison of Focus Group Discussion

This analysis reported the major themes that emerged from FGD, and their comparisons based on gender. Six male and six female respondents participated in the FGD. The majors themes were engagement, disengagement, pedagogical aspects, and instructional design elements of learning app.

4.3.1.1 Engagement

According to FGD, participants were behaviorally and emotionally engaged. In terms of behavioral engagement, students got totally involved in educational app. Less effort was exerted in comprehending concepts since it was easier to learn from app than conventional instruction approach, according to FGD. However, some students responded that they had to put in some effort in game, and videos during work. Since, game and videos required lot of effort exertion for understanding, one of the female respondents quoted: "I put in effort to focus on things but did not put in any effort to understand the learning concept. Though, I put in some effort in game and activity because it revolved around thinking." The focus of the participants was totally on the app as it was evident from their responses, according to FGD. The activity 2 i.e., a game based on reactivity series kept the male respondents focused for a long time where as activity 2 i.e., videos/animations kept the females focused for a long time (as depicted in figure 4.6). One of the female students quoted: "…the whole app kept me stay focused. No such thing distracted me." The software promoted retention of learning concepts among students contrary to rote learning. Following responses were recorded: "Videos made me learn better and I can retain concepts for a long time." and "I got involved and learned far better and memorized in a good way." The app was equipped with better conceptual understanding which helped students learned a lot. The responses of participants were positive regarding comprehending learning concepts via educational app. "Through this educational app, I comprehended the concepts way better. Concepts were clarified compared to classroom instruction." and "Conceptual understanding was better. The way we were taught through game and an activity was unique to me." The students reported that they were emotionally engaged during work measured by fun, interest and thinking. This app developed interest among students according to a male respondent who quoted: "…lot of interest developed for playing games. Our learning was real while playing activities and games". The participants deemed learning from this app as fun. The responses of participants regarding this app were "It feels good. You find everything fun", "I had fun interacting and learning using it" and "It was fun to learn". In participants' opinion, thinking was involved for comprehension ("…allows thinking for understanding concepts"). A respondent said that this app revolved around thinking ("Though I put in some effort in game and activity because it revolved around thinking."). Females reported high level of engagement (*90-100%)* as compared to the males during work since, it was attractive and developed interest among them (as illustrated by figure 4.7).

Figure 4.6 Bar chart illustrating the students' focus on the specific activities in an app based on gender. Activity 1 is based on the reaction of metals. Activity 2 is based on the reactivity series. Activity 3 is based on the game of reactivity series.

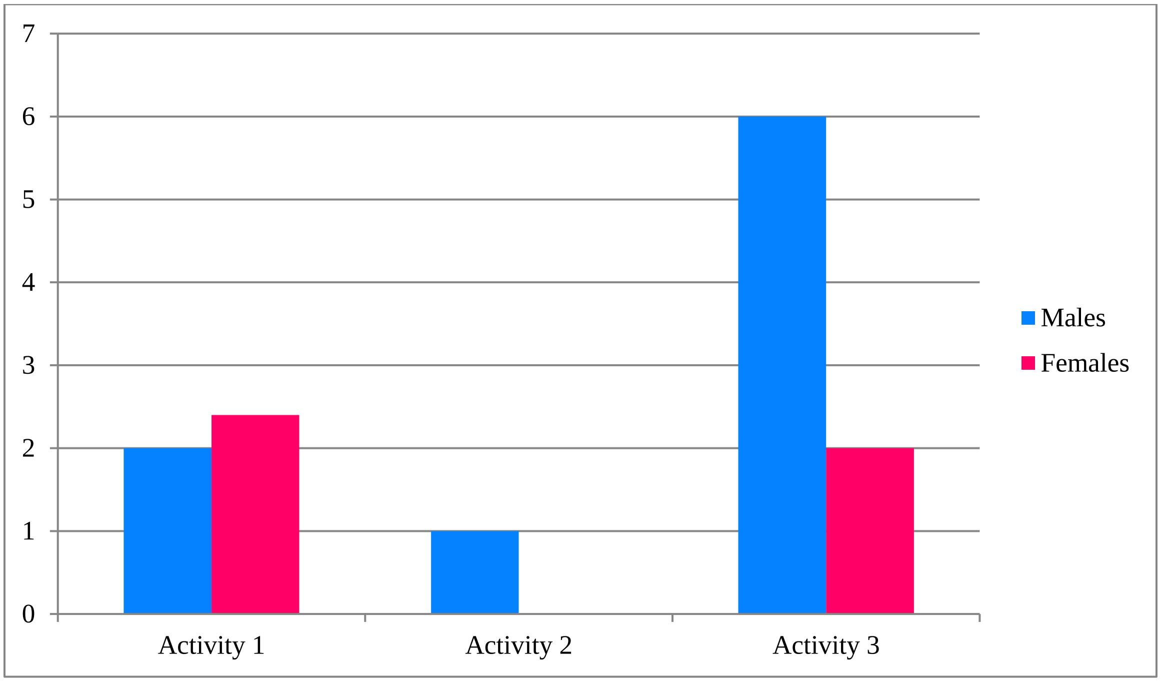
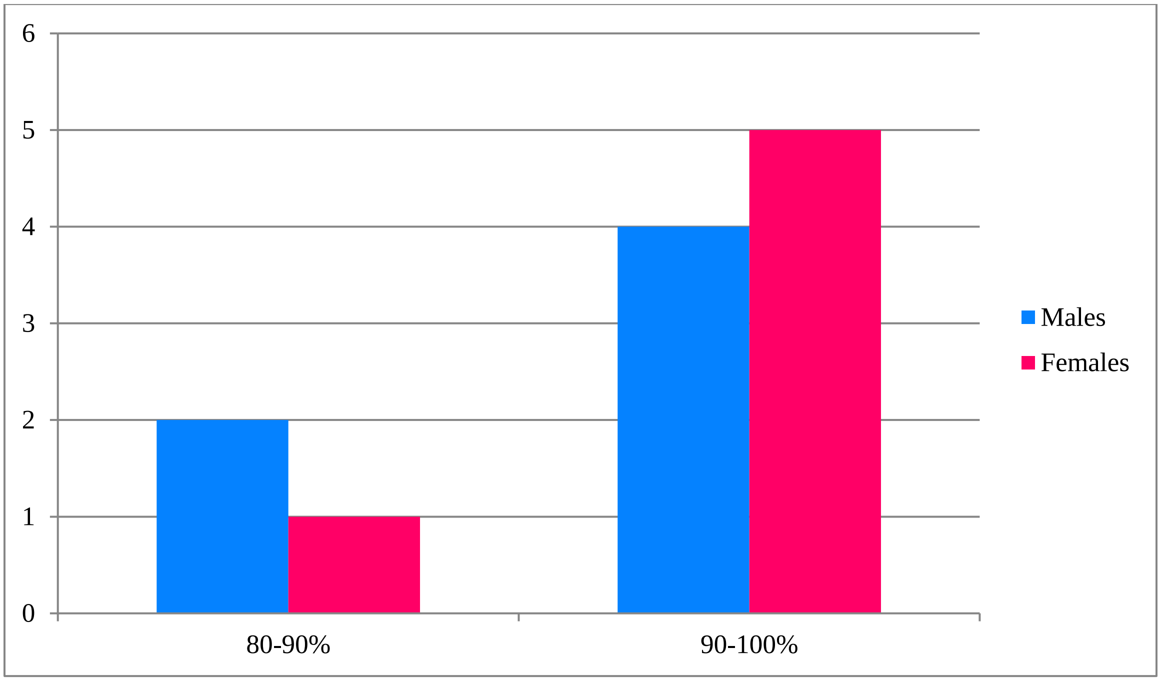


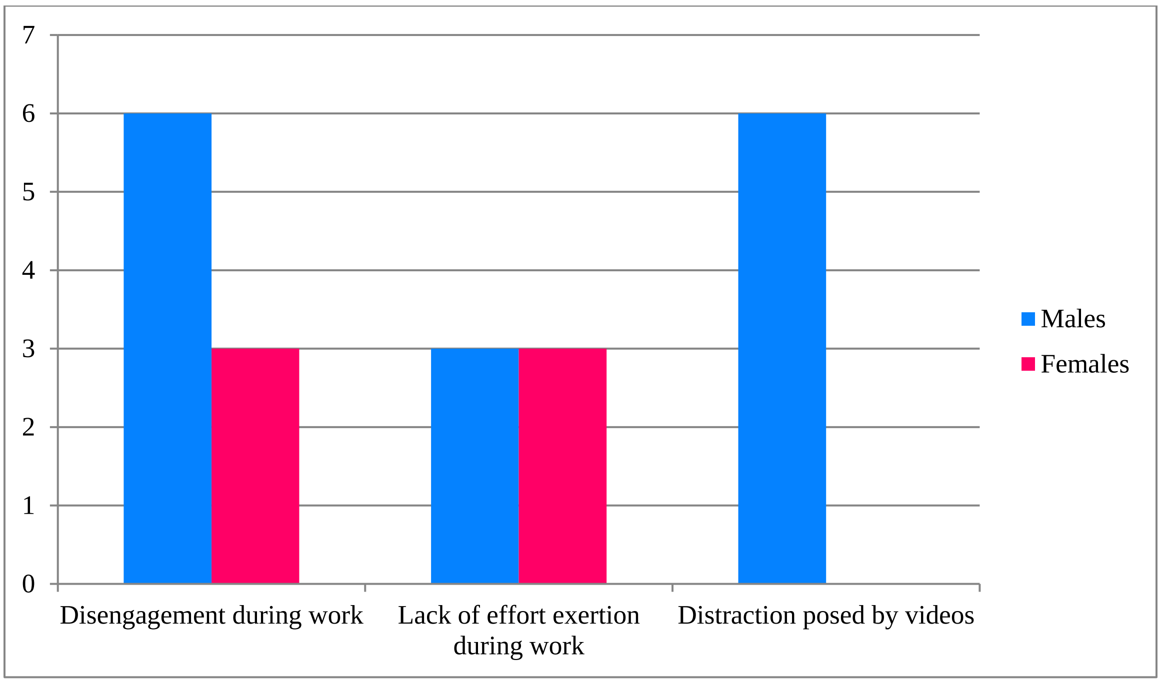
Figure 4.7 Bar chart depicting the engagement level of the students during work with an educational app "Patterns of Reactivity"



4.3.1.2 Disengagement

In general, participants also described themselves as behaviorally disengaged at some point during work. Mostly the dominant percentage of behaviorally disengaged were of male respondents during FGD. Male respondents were distracted at the beginning of the intervention. The systems kept getting stuck due to malware attacks at first revealed by the responses of male students “Videos keep getting stuck that distracted me a lot”, “videos were not playing well at start.” However, one of the male students was distracted due to the “concepts” as evident by the response, “Some concepts distracted me because at that time, I could not understand them well at once.” Some students reported that they did not exert any effort during work. As it was easy for them to better comprehend learning concepts while interacting with the app as compared to their usual Science instruction, so they were not required to exert any effort during work. The students quoted: “I did not exert effort. In class, while writing on notebooks we had to exert effort but in a lab the case was opposite.”, “Better understanding here so no effort required”, “We were watching videos so did not need to exert effort”. It was evident from students’ responses the primary reason of not putting in effort. Compared to learning via educational app, students had to exert lot of effort in writing on note books and attending the expository lecture simultaneously and it was difficult to catch up the pace of a teacher as evident from their responses. Figure 4.8 illustrated that the male respondents reported themselves more disengaged as compared to female respondents, according to FGD. They revealed high pattern of behavioral disengagement while interacting with an educational app during work as compared to the female participants.

Figure 4.8 Comparison of student disengagement during work with an educational app based on gender



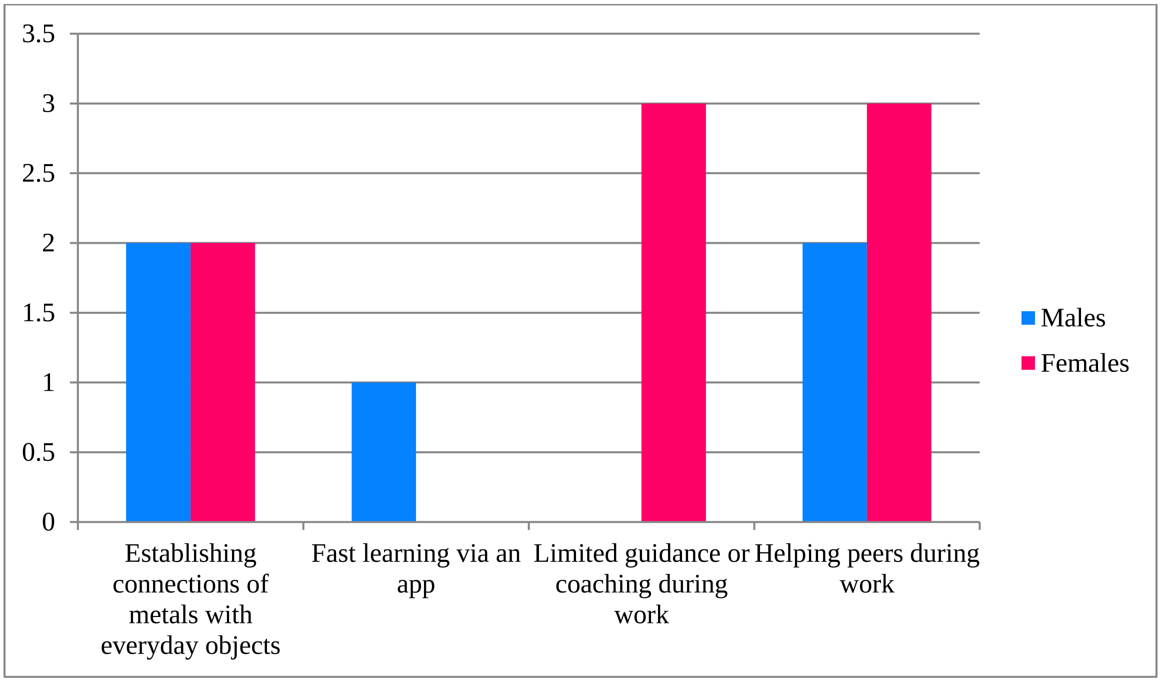
4.3.1.3 Instructional design elements

In general, design elements of the educational app were mentioned during FGD. One of the participants reported the drawback of this app, “It was less interactive. I want it to be more interactive”. This app attracted the students since it contained animations, and a game. The students quoted, “The app attracted me a lot because it had animations. Game was most attractive of all.”; “Animation attracted me a lot.” The female participants also provided their remarks on the content presentation of an educational app, according to FGD. The student quoted: “content presentation was attractive in educational app.” However, a female participant reported that this app had failed to transfer deeper knowledge in her since, this app lacked in definitions and description of some of the learning concepts.

4.3.1.4 Pedagogical aspects

The participants discussed and stated the relevant learning goals, individual misconceptions and some of the missing features in the learning app. The students summed up their feelings when posed with learning outcomes. When the students described their learning outcomes at the end of intervention, they deemed them clear and relevant to their curriculum and listed their primary learning goals, followed by the benefits of metals in life and their misuse, reactions, products formation, reactivity series, and connection of metals with everyday life. The students reported their misconceptions they previously had and some of them stated that the learning app helped them address their misconceptions. The misconceptions had revolved around chemical reactions, metals and their appearance and relation with everyday life, reactivity series, and product formation, according to FGD. Figure 4.9 revealed that the male and female participants emphasized equally on establishing connection of metals during FGD. However, males reported that their learning capability was enhanced via educational app and females stated that use of educational app during instruction promoted peer tutoring where students helped each other in understanding concepts or activity during work. A female student quoted: “Teacher should be present there to guide us”. Though, limited guidance or coaching offered by this app was a primary drawback as revealed by the female participants.

Figure 4.9A bar chart illustrating the pedagogical aspects of an educational app based on gender



4.4 Summary

This section analysed the data gathered during the experimental process of the present reserach. The quantitative data analysis included the comparison of student engagement and learning outcomes, and the qualitative data analysis included focus group discussions. Several non – parametric tests were used to examine the quantitative data using SPSS tool. However, the FGD was analysed using NVIVO tool. The findings suggested that the students who received Science app instruction demonstrated high level of engaged behaviour on various factors based on positive body language, confidence, focus, and fun and excitement as compared to those who received conventional Science instruction. Though, gender differences prevailed within the treatment group contrary to the control group. Females demonstrated high level of engagement using educational app in science classroom as compared to males in this study. Moreover, the learning outcomes or content knowledge for the students of engagement groups was somewhat similar. However, gender difference prevailed in experimental group than control group. Females outperformed males after being taught with an app. Though, the students performed significantly better in content knowledge test after receiving an app instruction as compared to their performance on pre-test. Furthermore, male and female students participated in FGD to shed some light on the pedagogical aspects, instructional design elements of app, and the student engagement and disengagement during work.

5 Discussion

Technology plays a vital role in enhancing the learners' engagement and academic achievement (Chapter 2). This study was conducted on 8th grade students to measure the impact of an interactive Science learning app "Patterns of Reactivity" on student engagement and their learning performance, and on gender difference.

The findings analysed in the results section suggest that this app has a significant effect on student's engagement which supports the existing research conducted in this field(Hung ibid 2014; Lester ibid 2014, Tatar ibid 2013). Moreover, this study concluded that the learning app "Patterns of reactivity" has no significant effect on student's learning outcome supporting the findings of Terri ibid (2014) who revealed that experimental group did not gain significantly in terms of content knowledge. However, the literature reviewed for this research reveals a significant impact of educational technology and computer games on academic and learning performance (Hung ibid 2014, Lester et al. 2014, Cheng-Yu et al. 2014, Zafar et al. 2014, Kushwaha et al. 2014 ,Tatar et al. 2013).

Nevertheless, this app promoted significant gender disparity among students who received Science app instruction further supporting the studies previously stated in literature review section of this report (Chang ibid 2014, Klisch ibid 2012). While few previous studies reviewed in literature review section of this study indicated equal gains among both genders (Dorji ibid 2015, Lester ibid 2014).

The factors that contributed to these findings in the study are discussed in this section.

5.1 Reason of significance in repeated measures of observed engagement level on various factors

Student confidence, positive body language and consistent focus rose till day 2 and declined sharply on day 3. The reason of low SC, PBL, and CF on day 1 as compared to on day 2 is due to videos posing distraction according to FGD since these videos were not playing and getting stuck at first due to some hardware compatibility issues.

5.1.1 Reason for the decline of observed engagement level on various factors such as SC, CF, F&E and PBL on third day of the intervention

However, the factors that resulted in decline of observed engagement level on day 3 as reported in results section were: a) difficulties in getting started, and b) videos getting stuck during activity according to FGD. Though, the later problem was considered affecting body language, confidence, focus and fun negatively as reported in Results section. This was true for the bunch of students who considered time valuable and did not want to waste it (Whitton 2014).

Students learned about reaction of metals on day 3 via a learning activity based on videos and animations on various reactions. However, the decline on day 3 is associated with various reasons, according to FGD. Some of the reasons included a) getting used to the videos based on reactions b) difficulty in comprehending some of the learning concepts c) missing details and description of learning concepts d) limited guidance or external support.

In general, learning same old thing through videos on day 3 led to low PBL, SC and CF as compared to on day 2. May be some of the learning concepts distracted where a student could not understand them well at first. Moreover, they required teacher guidance according to FGD. Some of the concepts distracted participants because they could not understand them well at first according to FGD, so they had to watch some reactions again and again for better comprehension for instance; reaction of metals with oxygen. They had to exert effort on few difficult learning concepts and to stay focus on reactions with oxygen which they learned on day 3, according to FGD.

5.1.2 Reason for the high observed engagement level on various factors such as SC, CF, and PBL on second day of the intervention

The SC, CF and PBL was high on day 2 since the visuals were easy and helped the students learned a lot in short span of time and it was easy for them to predict the products formed in those reaction. Thinking was involved in this learning activity where students established connections of metal and reactions with everyday life. However, students paid full concentration on their learning and these videos based on reactions helped them clarify the concepts thus retaining them for a long time, according to FGD. Moreover, it was easy to memorize since no rote learning was involved and this boosted their learning capability.

5.1.3 Reason for the rise of observed engagement level on various factors such as SC, and CF on fourth and fifth day of the intervention

However, from day 3 onwards, SC, and CF rose till day 5 whereas PBL declined from day 4 to day 5. The students played learning activity based on reactivity series where the goal was to drag and drop element to construct the series and a game "Shooting the balloon" on days 4 and 5. The reason behind elevation is associated with students' focus on learning, thinking and exerting effort, according to FGD. The students had to put in effort in game since it required thinking. Game had positive impact on them and they had learned a lot through it. No rote learning was involved. The learning activities revolved around thinking for the better comprehension of learning concepts, according to FGD.

Apart from this, content presentation was attractive. During the game play, students had to complete levels within limited time frame so they had to focus on it. Game was fun to play and the students had learned a lot in short span of time which means that these students were focused and demonstrated high PBL, and SC. These activities kept them stay focused for a long time and kept their interest intact in one place according to FGD.

5.1.4 Reason for the decline of PBL from fourth day to fifth day of the intervention

On day four and five, students played learning activity on reactivity series and a game "Shooting the balloon". However, it was difficult for them to construct reactivity series since; details and descriptions were missing, according to FGD. Moreover, 2-3 participants shared a single pc while the app was designed for an individual use. The students had to wait while one of them played the activity and a game. Though, the game has two levels which were completed in less than 5 minutes. That is why, most of the time students were sitting idle which resulted in low PBL.

5.1.5 Reason for the decline and rise of fun and excitement during intervention

The fun and excitement of students keep on declining mildly till day 3 and then, from this point onward, it rise sharply till day 5. The reason behind decline may be the students exhibiting interest and enthusiasm towards the integration of technology in Science instruction on first day of an intervention. Since it was a new thing for them, they were excited on their first day of receiving instruction through an app. However, the decline was due to the videos and some of the difficult learning concepts where students lost their interest towards work, according to FGD.

Moreover, learning the same old thing every day via videos may have resulted in decline. Nevertheless, the rise in F&E on day 4 and 5 was associated with the fun during game and activity play, according to FGD.

5.1.6 Reason of insignificance in terms of content knowledge

Factors such as student's absenteeism, teacher experience, short period of intervention, intervention time, approach to technology, and reduced sample size might have contributed to this outcome (Terri ibid 2014). However, this study could lead to better results if students had attended all the classes during intervention because it may be possible that the low achievers could have benefitted from it (Klisch ibid 2012).

5.2 Science app instruction promoted Peer learning

During FGD, both male and female participants stated that the educational app promoted peer or collaborative learning. The collaborative learning in this study means that the students helped their fellow peers when faced with an issue or a difficulty in an app since this app was designed for an individual use. Furthermore, research shows that peer learning is effective in engaging students and promotes academic growth whereas the peer learning defined in this study was different than usual (Cassell and Daggett 2014).

5.3 Positive feedback of the participants on the content presentation of an app

Participants offered positive feedback in terms of the content presentation in an app. In fact, they deemed it appealing. The content was structured, organized and presented well; this was one of the essential elements considered in app designing and development (Shiratuddin and Landoni ibid 2002). Students indicated that the app helped them learn concepts rapidly and establish connections, retain learning concepts, and comprehend those concepts easily. Moreover, the students exerted effort in game and learning activity based on series as these activities demanded thinking (cognitive thinking).However, during work these participants did not have to put in lot of effort understanding the learning concepts. Though at first, app distracted boys as videos were taking forever to play or systems get stuck on videos' play. Still, students had fun playing with and learning through an educational app and this helped them stay focus for a long time. Therefore, they reported their engagement level in a range of 80-100 percent, according to FGD.

However, the impact of positive emotions and behavior were not transferred to learning outcomes assessment.

5.4 Limitations

Several gaps and limitations, existing in this study, are discussed in this section.

5.4.1 Not piloting the learning app "Patterns of Reactivity" prior to an intervention

Though, formative assessments are basis of an instructional framework, the instructional design elements such as content presentation, or an interface were evaluated in general (Williams ibid 2004). However, the learning app was deployed for experimentation instead of piloting in schools. According to Williams ibid (2014), without pilot testing in schools and targeting specific set of students may consider the appropriateness of an app questionable.

5.4.2 Lack of appropriate and constructive feedback offered in an pp

Feedback is an essential element in designing learning activities or games. In fact, appropriate constructive feedback is necessary to promote curiosity in learners (Whitton 2010). This study lags behind in offering constructive feedback to the students. Students were offered positive feedback on successful completion of a goal. In addition to offering positive feedback in learning activity based on reactivity series, negative feedback with appropriate hints was not offered to the students.

5.4.3 Lack of basic computer skills

The students had difficulty in dragging and dropping objects in an activity scene at first because they did not know the meaning and basic knowhow of this functionality. Later on, after following the guidance, students find learning through and interacting with an app more fun, according to FGD. Moreover, this notion is supported by Cheng-Yu et al. (2014) who deemed "dragging and dropping" as an essential element to feel the flow of learning activities in an app and encourage learners to be engaged in these activities.

5.4.4 Inexperienced instructor in experimental group

The instructor who taught the students with an educational Science app had no teaching experience as compared to the teacher who taught control group.

5.4.5 Lack of resources

The teacher's peers recorded individual observations of the students. Only one person was present in a class at a time to observe the students individually. During observations, videos were not captured due to lack of resources. However, observer gauged the engagement level of individual students and jotted them down on a piece of paper.

5.4.6 Length of observation cycle

Each observation cycle spanned for 10 minutes in this study where as keeping it to at least 3 minutes might have resulted in accurate observed measurements. The best practice to gauge accurate observation and to examine the effect of technology in classroom is to minimize the length of observation cycle in future studies.

5.4.7 Limited coaching or guidance

Some of the students took long in comprehending several learning concepts through an app PATTERNS OF REACTIVITY, and required guidance or external support according to FGD. However, theoretical description regarding the reactivity pattern was missing that could have helped them construct the reactivity series and understand it better.

In spite of not affecting the learning outcomes of the students, this study believes to represent an important step in investigating and measuring the relationship between learning approaches and student engagement, and gender difference. However, this study contributes significantly to the existing research.

5.5 Summary

The findings clearly result that the app has a significant effect on student engagement and gender difference. However, this app has no effect on learning outcomes. These findings are explained in depth while making their comparison with existing literature and studies. The factors that have contributed to this study are also discussed in depth besides the limitations and gaps in methodology.

6 Conclusion

Engagement is a prime element in the learning process. To enhance student's emotional and behavioral engagement, an educational technology with gamification and GBL has been embedded in instruction. This study has investigated the affect of educational app "Patterns of Reactivity" on 8^{th} grade student engagement and performance. Moreover, this study investigates the impact of this educational app on gender difference. The essential finding that has emerged from the insights of the whole quasi-experimental study is that the learning app "patterns of reactivity" positively affects the emotional and behavioral engagement of the students in Science classroom. Moreover, the comparative analysis with conventional Science instruction revealed that this app has a significant effect on observed engagement of students on factors such as, fun and excitement, student confidence, positive body language, and consistent focus. However, the comparative analysis with the control group does not demonstrate any significant effect of learning app on students' Science learning outcomes. Nevertheless, the present study significantly contributes towards the student engagement and gender difference thus, indicating a significant performance and engagement gain in females over males.

6.1 Student Engagement

The results show that the students who received Science app instruction demonstrated high level of observed engagement on PBL, CF, SC and F&E as compared to those who received conventional Science instruction. Moreover, girls exhibited significant engagement towards the learning app as compared to the engagement level of the girls taught using traditional science instruction. Similarly, boys demonstrated high level of engagement when taught with a learning app than the boys of control group. The reasons of significant gain in pattern of observed engagement level are involvement of thinking, establishing connections with real life objects, better comprehension of learning concepts, enhanced learning capability and retention, easy memorization of some of the learning concepts, effort exertion during work, and content presentation, according to FGD. To gain further insights, the trend of observed engagement level on factors such as PBL, SC, CF and F&E are studied and triangulated with FGD. The decline in engagement factors such as, PBL, SC, CF and F&E is observed on day 3 where students learned about reaction of metals and faced difficulty in comprehending some of the reactions, according to FGD. The themes that emerged as a result of FGD included behavioural engagement, emotional engagement and behavioural disaffection. The analysis of FGD from male and female students reveal the effort exerted by the students in comprehending concepts that revolve around thinking for instance, “shooting the balloon” game and learning activities.

Moreover, the learning app has promoted retention, confidence, and thinking according to FGD. However, the videos in an app posed distraction to some of the male students according to FGD. Despite the distraction during work, this app let the students stay focused for a long time. In addition to this, this app boosted fun and interest among students according to FGD. Though, the app promoted peer learning according to FGD, the concept of collaborative learning conveyed was taken in other way i.e., the students asked their peer fellows in case of guidance or support required during work. Since, the app was designed for an individual use where the collaboration was not required and the teacher did not give any assignment or task in group work, so verbal participation was not involved in this study. However, the observers measured the participation of the students when they needed guidance or coaching from the teacher or their fellows. This factor is not measured accurately and there is not a need to gauge this factor in this study as this app promoted individual learning. However, the future researchers may consider the verbal participation in their study.

6.2 Learning outcomes

The findings reveal that the students who received Science app instruction have not performed significantly better than those who received conventional Science instruction. However, after being taught with an app, students performed significantly better in learning outcomes test as compared to their pre-test. This app has addressed the students’ misconceptions relevant to the metals, chemicals and reactions, according to FGD. Apart from this, participants stated learning goals relevant to patterns of reactivity in FGD. The FG participants have reported some of the clear and concise learning goals and responded with connection of these goals with real life such as, metals and their benefits and composition in objects of everyday use etc. However, the primary drawback of the app as mentioned in FGD is the limited coaching or external support provided to the students. Moreover, this app has promoted self directed learning. It could be better to embed a feature in this app where students can reflect on their own learning in future.

6.3 Gender Difference

The findings associated with gender show that the girls have exhibited more interest towards the videos embedded in an educational app “patterns of reactivity” whereas boys have demonstrated more enthusiasm towards game “shooting the balloon”, according to FGD. However, the girls are observed to be more engaged in terms of positive body language, confidence, consistent focus, and fun and excitement during work that is interacting with an app in the whole study than boys. Moreover, the girls performed better in terms of learning outcomes than boys after being taught with this educational app. This is the evidence of girls showing more interest towards work when technology is embedded in their education. Though, it can be seen that the app has promoted gender disparity instead of minimizing it. Apart from this, the girls interacting with an app are observed to be more behaviorally engaged towards the work as compared to those girls who learned the similar chapter with usual teaching approach (conventional teaching method). A similar outcome has resulted in boys promoting the use of technology in an education. Since girls show more interest towards the use of learning app, this low cost solution can help eliminate illiteracy among girls and those who are not allowed to attend school due to various reasons.

7 Recommendation

7.1 At teacher level

7.1.1 Training programs on offering the use of TPACK in classrooms

Teachers usually pose resistance to the use of technology in their classroom as reviewed in Literature review section. To address this, the training programs on the use of TPACK can be offered to the teachers. This will help the teachers integrate technology and pedagogy appropriately in the specific subject targeting particular set of learning outcomes. Moreover, teachers can be trained on gamifiying certain set of learning outcomes in the classroom to boost engagement and learning outcome of the learners. Furthermore, these training programs will not only boost engagement and content knowledge of the students but will also promote blended, collaborative, constructivist and game based learning in classrooms thus encouraging and promoting student interest towards study in classrooms. This interest can only be developed if the experts including teachers, and technologists design and plan curriculum together under one platform.

7.1.2 Creating student centered classroom environment

Instead of traditional classroom, constructivist classrooms tend to focus on students centered learning replacing teacher centered and passive learning. The students instead of receiving the instruction are active in the learning process. However, teacher can facilitate the students instead of pouring knowledge which is hard to digest for the students thus resulting in boredom. Though in this study, the students according to FGD required a guidance or support. However, this can be addressed in future studies by embedding social constructivist approach where teachers act as mentor, and supporter thereby prompting and helping students develop and assess their own learning and understanding, apart from collaborating and working with peers.

7.2 For future developers

7.2.1 Modification in game

Developer can embed meaningful and clear instructions so that students can start with the game play without getting lost in an activity. Moreover, content knowledge needs to be sufficient for students' understanding of concepts so as to bridge the learning gap.

7.2.2 Integrating appropriate feedback mechanism in game and educational technologies

Appropriate and constructive feedback mechanism should be embedded in games to enhance student engagement with technology or game. However, the feedback should be adaptable according to the needs and interests of the player.

7.2.3 Use of taxonomy in designing games

The Bloom's taxonomy approach help learners in comprehension and implementation of learning concepts as this is a wide accepted method for planning and designing curriculum (Iliya Ibid 2010).The developers can consider this taxonomy while designing games for an educational purpose where students can make connections to previously learned concepts and build new concepts on existing ones.

7.2.4 Use of collaborative and blended approach in learning to enhance critical thinking skills

Games should allow students to collaborate and promote class discussions and enhance problem solving skills thereby using blended approach in games. Moreover, games should bridge the learning gaps by providing students with appropriate scaffolds. Apart from this, games should provide optimum challenge to the student so as to maximize fun and interest instead of leading to frustration and anxiety among them.

The goals of an app should map the learning outcomes of the subject or curriculum to boost content knowledge of the students. The app should not promote rote learning of concepts instead it should help learner make connection of the content learned with everyday life.

Moreover, future developers can embed game elements in their app that can promote collaborative learning apart from individual learning.

7.3 For future researchers

7.3.1 Minimizing gender disparity

This study lags behind in enhancing gender parity. However, the researchers can deduce a solution to bridge this gender gap thus promoting equal gain in terms of engagement and learning achievement in their future study. Moreover to address this issue, game understandability and reliability should be promoted for both genders to gain maximum benefit from it.

7.3.2 Providing quality education to everyone, everywhere

Since the girls seem more interested in the use of educational app in Science classroom in the present study, hence, this could be the alternative solution to those who are not allowed to attend the school. This study has provided a low cost, and reliable solution in a low cost private school which if incorporated in future studies can enhance retention and eliminate illiteracy particularly in Pakistan. Since, literature reviewed in this study show that girls are unwilling to attend school due to various reasons mentioned in literature review section of this report (AlifAilaan 2014). The future researchers can help eradicate this major problem by providing quality and low cost education to these girls at home.

7.3.3 Promoting verbal participation through an educational technology

Future researchers can study verbal participation by encouraging collaborative or social constructivist learning environment in classrooms. Though, in this study, PATTERNS OF REACTIVITY app promoted individual learning, still participation of the students can be accurately measured by integrating design elements that promote collaboration and where students can reflect on ideas and express their answers when posed with questions via a technology.

References

Abdul Jabbar, A. I. & Felicia, P. (2010). Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review. Review of Educational Research, 85**,** 740-779.

Alimoglu, M. K., Sarac, D. B., Alparslan, D., Karakas, A. A., &Altintas, L. (2014). An observation tool for instructor and student behaviours to measure in-class learner engagement: a validation study. Medical Education Online, 19, 10.3402/meo. v19. 24037. http://doi.org/10.3402/meo.v19.24037

AlifAilan. 25 Million Broken Promises. The crisis of Pakistan's out-of –school children, 2015 - 10-02

Aserpakistan.org,. (2015). Welcome To ASER Pakistan. Retrieved 16 December 2015, from http://www.aserpakistan.org/index.php?func=report

Barata, G., Gama, S., Jorge, J. &Goncalves, D.(2013). Engaging Engineering Students with Gamification. Games and Virtual Worlds for Serious Applications (VS-GAMES), 5th International Conference on, 11-13 Sept. 2013 2013. 1-8.

Brom, C., Preuss, M., &Klement, D. (2011). Are educational computer micro-games engaging and effective for knowledge acquisition at high-schools? A quasi-experimental study.Computers & Education, 57(3), 1971-1988.doi:10.1016/j.compedu.2011.04.007

Byun, J., &Loh, C. S. (2015). Audial engagement: Effects of game sound on learner engagement in digital game-based learning environments. Computers in Human Behavior, 46, 129-138.doi:http://dx.doi.org/10.1016/j.chb.2014.12.052

Campbell, D.T., Stanley, J.C. (1966). Experimental and Quasi-Experimental Designs for Research. Skokie, Il: Rand McNally.

Cassell, W. and Daggett, W. (2010). Peer Learner Engagement: Enhancing the Promise of School Improvement. In: LeaderEd. [online] Available at: http://www.leadered.com/pdf/Peer%20Learning%20white%20paper.pdf>. [Accessed 24 Dec. 2015].

Chai, C.-S., Koh, J. H.-L., & Tsai, C.-C. (2013). A Review of Technological Pedagogical Content Knowledge. Educational Technology & Society, 16 (2), 31–51.

Chang, M., Evans, M., Kim, S., Deater-Deckard, K. & Norton, A.(2014) Educational Video Games and Students' Game Engagement. Information Science and Applications (ICISA), International Conference on, 6-9 May 2014 2014. 1-3.

Cheng-Yu, H., Kuo, F. O., Sun, J. C. Y. &Pao-Ta, Y. (2014).An Interactive Game Approach for Improving Students Learning Performance in Multi-Touch Game-Based Learning.*Learning Technologies*, *IEEE Transactions on*, 7**,** 31-37.

Chu, H.-C., & Hung, C.-M. (2015). Effects of the Digital Game-Development Approach on Elementary School Students' Learning Motivation, Problem Solving, and Learning Achievement. 472-487. doi:10.4018/978-1-4666-8200-9.ch023

Cohen, L., Manion, L. & Morrison, K. (2007).*Research Methods in Education*, Taylor & Francis.

Coppock, D. (2007). Science Fact File Book 3. Oxford University Express

Cramer, D.(1998). Fundamental statistics for social research.London.Routledge

Cramer,D., &Howitt, D.(2004). The SAGE dictionary of statistics.London:SAGE.

Dickey, M. D. (2015). Aesthetics and Design for Game-based Learning (Digital Games and Learning). 1-175.

Dissertation.laerd.com,. (2015). *Convenience sampling | LÃ¦rd Dissertation*. Retrieved 15 December 2015, from http://dissertation.laerd.com/convenience-sampling.php#first

Doane, D.P., & Seward, L.E.(2011). Measuring skewness. Journal of Statistics and Education, 19(2), 1-18

Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., &Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. Computers & Education, 63, 380-392.doi:http://dx.doi.org/10.1016/j.compedu.2012.12.020

Dorji, U., Panjaburee, P. &Srisawasdi, N. (2015). Gender differences in students' learning achievements and awareness through residence energy saving game-based inquiry playing.Journal of Computers in Education, 2**,** 227-243.

elearning and Learning Management System LMS blog by GCube, (2014). Making Learning Games Effective: 5 ways of ensuring that players LEARN. [online] Available at: http://www.gc-solutions.net/blog/making-learning-games-effective-5-ways-of-ensuring-that-players-learn/ [Accessed 23 Dec. 2015].

Ferguson, T. (2014). Mathematics Achievement with Digital Game-Based Learning in High School Algebra 1 Classes. Ph.D. Liberty University.

Fielding, M. (2006). Leadership, radical student engagement and the necessity of person-centred education.*International Journal of Leadership in Education*, 9**,** 299-313.

Finn, J. D. (1989). Withdrawing from school. Review of Educational Research, 59, 117–142.

Finn, J. D., & Zimmer, K. S. (2012). Student engagement: What is it? Why does it matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), The handbook of research on student engagement (pp. 97–130). New York, NY: Springer.

Foster, A. & Shah, M. (2015). The Play Curricular Activity Reflection Discussion Model for Game-Based Learning.*Journal of Research on Technology in Education*, 47**,** 71-88

Fredricks, J., Blumenfeld, P., & Paris, A. (2004). School Engagement: Potential of the Concept, State of the Evidence. Review Of Educational Research, 74(1), 59-109.http://dx.doi.org/10.3102/00346543074001059

Ganeshini, (n.d.). Strengthening student engagement in the classroom. Postgraduate. National University of Singapore.

Hamari, J. &Nousiainen, T. (2015). Why Do Teachers Use Game-Based Learning Technologies? The Role of Individual and Institutional ICT Readiness.2015 48th Hawaii International Conference on System Sciences.Institute of Electrical & Electronics Engineers (IEEE).

Hampden-Thompson, G., & Bennett, J. (2013). Science Teaching and Learning Activities and Students' Engagement in Science. International Journal of Science Education, 35(8), 1325-1343. doi:10.1080/09500693.2011.608093

Harris, L. (2011). Secondary teachers' conceptions of student engagement: Engagement in learning or in schooling? Teaching and Teacher Education, 27(2), 376-386. doi:10.1016/j.tate.2010.09.006

Hinostroza, J. E. &Mellar, H. Pedagogy Embedded in Educational Software Design : Report of a Case Study.

Hsieh, Y.-H., Lin, Y.-C., &Hou, H.-T. (2015). Exploring Elementary-School Students' Engagement Patterns in a Game-Based Learning Environment. Educational Technology & Society, 18 (2), 336–348.

Huang, W. H.-Y. &Saman, D. (2013). A practitioner's guide to gamification of education.

Hung, C.-M., Huang, I., & Hwang, G.-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. Journal of Computers in Education, 1(2-3), 151-166.doi:10.1007/s40692-014-0008-8

Huotari, Kai, and JuhoHamari. (2011). "'Gamification' from the Perspective of Service Marketing." Paper presented at the Computer Human Interactivity Workshop, Vancouver, May 7–12.

Jan, M., Tan, E. M. & Chen, V. (2015). Issues and Challenges of Enacting Game-Based Learning in Schools. 67-76.

Jones, R. (2009). Student Engagement Teacher Handbook. Rexford, NY: International Center for Leadership in Education.

Kamisah,O.,&Nur,S.(2013). Conceptual understanding in secondary school chemistry : A discussion of the difficulties Experienced by students. American Journal of Applied Sciences,10(5):433-441

Kapp, Karl M. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. New York: Wiley.

Keengwe, J., & Hussein, F. (2012). Using computer-assisted instruction to enhance achievement of English language learners. Education and Information Technologies, 19(2), 295-306.doi:10.1007/s10639-012-9214-z

Klisch, Y., Miller, L. M., Wang, S., & Epstein, J. (2012). The Impact of a Science Education Game on Students' Learning and Perception of Inhalants as Body Pollutants. J SciEducTechnol, 21(2), 295-303. doi:10.1007/s10956-011-9319-y

Kushwaha, R. C., Chaurasia, P. K., &Singhal, A. (2014).Impact on Students' Achievement in Teaching Mathematics Using Geogebra. 134-137. doi:10.1109/t4e.2014.54

Ladd, G. W., &Dinella, L. M. (2009). Continuity and change in early school engagement: Predictive of children's achievement trajectories from first to eighth grade? Journal of Educational Psychology, 101(1), 190–206.

Leaning, M. (2015). A study of the use of games and gamification to enhance student engagement, experience and achievement on a theory-based course of an undergraduate media degree.Journal of Media Practice, 16**,** 155-170.

Lester, J. C., Spires, H. A., Nietfeld, J. L., Minogue, J., Mott, B. W., &Lobene, E. V. (2014). Designing game-based learning environments for elementary science education: A narrative-centered learning perspective. Information Sciences, 264, 4-18.doi:10.1016/j.ins.2013.09.005

Li, M.-C., & Tsai, C.-C. (2013). Game-Based Learning in Science Education: A Review of Relevant Research. Journal of Science Education and Technology, 22(6), 877-898.doi:10.1007/s10956-013-9436-x

Marczewski, A. (2012). Gamification: A Simple Introduction and a Bit More. Seattle, WA: Amazon Digital Services.

Marks, H. M. (2000). Student engagement in instructional activity: patterns in the elementary, middle, and high school years. American Educational Research Journal, 37, 153–184.

Mastang, A. N., Bais, B., Husain, H., Kamal, N., Saibani, N., Hanafi, M., Atiq, R. & Abdullah, O. K. (2013).Impact of Fiber to the Home (FTTH) animation on student learning and motivation in electrical engineering. Information Technology Based Higher Education and Training (ITHET), 2013 International Conference on, 10-12 Oct. 2013 2013. 1-5.

Medved, J. (2014). Gamificationvs Games-Based Learning: Whatâ€™s the Difference? - Capterra Blog. [online] Blog.capterra.com. Available at: http://blog.capterra.com/gamification-vs-games-based-learning/ [Accessed 23 Dec. 2015].

Mitchell, I., & Carbone, A. (2011). A typology of task characteristics and their effects on student engagement.International Journal of Educational Research, 50(5-6), 257-270.doi:10.1016/j.ijer.2011.05.001

Mo, Y., Singh, K., & Chang, M. (2012). Opportunity to learn and student engagement: a HLM study on eighth grade science achievement. Educational Research for Policy and Practice, 12(1), 3-19.doi:10.1007/s10671-011-9126-5

Morris S. Y. Jong (2015) Does online game-based learning work in formal education at school? A case study of VISOLE, The Curriculum Journal, 26:2, 249-267, DOI: 10.1080/09585176.2015.1018915

Newmann, F. M., Wehlage, G. G., &Lamborn, S. D. (1992). The significance and sources of student engagement. In F. M. Newmann (Ed.), Student engagement and achievement in American secondary schools (pp. 11–39). New York: Teachers College Press.

Orthner, D. K., Akos, P., Rose, R., Jones-Sanpei, H., Mercado, M., & Woolley, M. E. (2010).CareerStart: A middle school student engagement and academic achievement program. Children & Schools, 32(4), 223–234.

Paisley, V. (2013).Gamification of Tertiary Courses An Exploratory Study of Learning and Engagement. 30th Ascilite Conference.

Parsons, S. A., Nuland, L. R., & Parsons, A. W. (2014). The ABCs of Student Engagement. Phi Delta Kappan, 95(8), 23-27. doi:10.1177/003172171409500806

Pietarinen, J., Soini, T., &Pyhältö, K. (2014). Students' emotional and cognitive engagement as the determinants of well-being and achievement in school. International Journal of Educational Research, 67, 40-51.doi:10.1016/j.ijer.2014.05.001

Prensky, M. (2001). Digital game-based learning. New York: McGraw-Hill.

Puntambekar, S., &Kolodner, J. L. (Accepted). Distributed Scaffolding: Helping students learn science by design. Journal of Research in Science Teaching.

Razali, N.M., &Wah, Y.B.(2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Journal of Statistical Modeling and Analytics,2(1), 21-33.

Reiners, T., Wood, L. C., Gregory, S. &Teräs, H. (2015).Gamification Design Elements in Business Education Simulations. 3048-3061.

Sandholtz, J.H., Ringstaff, C., & Dwyer, D.C. (1997) Teaching with Technology: Creating Student-Centered Classrooms, Teachers College: New York, 211 pages.

Schunk, D. H., &Pajares, F. (2005). Competence perceptions and academic functioning. In A. J. Elliot & C. S. Dweck (Eds.), Handbook of competence and motivation (pp. 85–104). New York: Guilford Press

Shaari, A. S., Yusoff, N. M., Ghazali, I. M., Osman, R. H., &Dzahir, N. F. M. (2014). The Relationship between Lecturers' Teaching Style and Students' Academic Engagement.Procedia - Social and Behavioral Sciences, 118, 10-20.doi:10.1016/j.sbspro.2014.02.002

Shapiro, S.S., &Wilk, M.B.(1965). An Analysis of variance Test for Normality(Complete Samples). Biometrika, 52(3/4), 591-611

Shiratuddin, N. &Landoni, M. (2002). Evaluation of content activities in children's educational software.Evaluation and Program Planning, 25**,** 175-182.

Shuttleworth, M. (Feb 3, 2008). Null Hypothesis. Retrieved Dec 23, 2015 from Explorable.com: https://explorable.com/null-hypothesis

Skinner, E.A. & Belmont, M.J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. Journal of Educational Psychology, 85 (4), 571-581.

Skinner, E.A., Kindermann, T.A., &Furrer, C. (2009). A motivational perspective on engagement and disaffection: Conceptualization and assessment of children's behavioral and emotional participation in academic activities in the classroom. Educational and Psychological Measurement, 69, 493-525.

Socialresearchmethods.net, (2015). Random Selection & Assignment. [online] Available at: http://www.socialresearchmethods.net/kb/random.php [Accessed 25 Dec. 2015].

Statistics.laerd.com,. (2015). *Mann-Whitney U Test in SPSS Statistics | Setup, Procedure & Interpretation | Laerd Statistics*. Retrieved 15 December 2015, from https://statistics.laerd.com/spss-tutorials/mann-whitney-u-test-using-spss-statistics.php

Statistics.laerd.com,. (2015). *Spearman's Rank Order Correlation using SPSS Statistics - A How-To Statistical Guide by Laerd Statistics*. Retrieved 15 December 2015, from https://statistics.laerd.com/spss-tutorials/spearmans-rank-order-correlation-using-spss-statistics.php

Statistics.laerd.com,. (2015). *SPSS Statistics Tutorials and Statistical Guides | Laerd Statistics*. Retrieved 15 December 2015, from https://statistics.laerd.com/

Statistics.laerd.com,. (2015). *Wilcoxon Signed Rank Test in SPSS Statistics - procedure, output and interpretation of output using a relevant example.*. Retrieved 15 December 2015, from https://statistics.laerd.com/spss-tutorials/wilcoxon-signed-rank-test-using-spss-statistics.php

Tatar, N., Akpınar, E., &Feyzioğlu, E. Y. (2012). The Effect of Computer-Assisted Learning Integrated with Metacognitive Prompts on Students' Affective Skills.Journal of Science Education and Technology, 22(5), 764-779.doi:10.1007/s10956-012-9429-1

Tatli, Z., &Ayas, A. (2013). Effect of a Virtual Chemistry Laboratory on Students' Achievement.Educational Technology & Society, 16 (1), 159–170.

Teachthought.com, (2015). [online] Available at: http://www.teachthought.com/uncategorized/difference-gamification-game-based-learning/ [Accessed 25 Dec. 2015].

Terri, F. (2014). Mathematics Achievement with Digital Game-Based Learning in High School Algebra 1 Classes. Ph.D. Liberty University.

Toussaint, M. & Brown, V. (2015). Educational Video Games: Impact on Students' Performance in Mathematics. In: SLYKHUIS, D. & MARKS, G. (eds.) Society for Information Technology & Teacher Education International Conference 2015. Las Vegas, NV, United States: Association for the Advancement of Computing in Education (AACE).

Ulmanen, S., Soini, T., Pyhältö, K., &Pietarinen, J. (2014). Strategies for academic engagement perceived by Finnish sixth and eighth graders. Cambridge Journal of Education, 44(3), 425-443.doi:10.1080/0305764x.2014.921281

Whitton, N. (2010). Game Engagement Theory and Adult Learning. Simulation & Gaming, 42**,** 596-609.

Williams, D. L., Boone, R., & Kingsley, K. V. (2004). Teacher Beliefs About Educational Software.Journal of Research on Technology in Education, 36(3), 213-229.doi:10.1080/15391523.2004.10782413

Woldeamanuel, M. M., Atagana, H., &Engida, T. (2014). What makes chemistry difficult?. African Journal of Chemical Education, 4(2), 31-43.Available at: http://www.ajol.info/index.php/ajce/article/view/104070 [Accessed 24 Dec. 2015].

Yousef, D., Baadel, S. &Makad, R. (2014).Exploratory study on the impact of game-based learning on student engagement. Web and Open Access to Learning (ICWOAL), 2014 International Conference on, 25-27 Nov. 2014 2014. 1-4.

Zafar, B., Mueen, A., Awedh, M., &Balubaid, M. (2014).Game-based learning with native language hint and their effects on student academic performance in a Saudi Arabia community college.Journal of Computers in Education, 1(4), 371-384.doi:10.1007/s40692-014-0017-7

Appendices

Appendix A Learning Outcomes-Pre Test

Name____

Section___________

1) Gold is a non-reactive metal (True/False)

2) Water pipes are made of_____________

a) Copper Only

b) Copper and Iron

c) Zinc Only

3) Drinking Water is composed of Zinc element. (True/False)

4) Potassium metal is highly reactive in nature. (True/False)

5) Hydrochloric acid is dangerous in nature i-e; it burns skin on contact. (True/False)

6) Which gas is evolved when Zinc reacts with Sulphuric Acid?

$Zn + H_2SO_4 \rightarrow$ ___________ + ____________

7) What causes “Rusting”?

____

8) Steel is an alloy of _____________

9) Platinum shows reaction with hydrochloric acid. (True/False)

10) Human bones are made of_____________ element.

Appendix B   Learning Outcomes Post Test

Name____

Section___________

1) Silver is a non-reactive metal. (True/False)

2) Table salt is composed of _____________

   a) Zinc
   b) Magnesium
   c) Potassium
   d) Sodium

3) Drinking Water is composed of Zinc element. (True/False)

4) Sodium is least reactive than Potassium. (True/False)

5) When Calcium reacts with hydrochloric acid, fumes of Hydrogen gas are formed. (True/False)

6) What product(s) is/are formed when a metal reacts with oxygen?

   Copper + Oxygen $\longrightarrow$ __________________

7) A boy stuffs (adds) pieces/chunks of Zinc in a balloon. He puts the balloon on the mouth of a flask. The flask contains 6ml of Hydro Chloric Acid. After few seconds, balloon starts to inflate forming Zinc Chloride. What do you think how was the balloon inflated? What is the reason behind balloon inflation?

   ____

8) Steel is an alloy of ___________

a) Iron

b) Zinc

c) Copper

d) Silver

9) Lead burns in air on bringing it closer to flame. (True/False)

10) Match the metals with numbers in order from high to least reactivity.

Zinc

Magnesiu

Silver

Potassium

1

2

3

4

Appendix C Worksheet

Name ____

Reaction of Metals and Forming Reactivity Series

Worksheet

S.No	**Metals**	**Reaction with Water**	**Order of Reactivity**	**Products**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
	Metals	**Reaction with Acid(Hydrochloric Acid)**	**Order of Reactivity**	**Products**

14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
	Metals	**Reaction with Oxygen**	**Order of Reactivity**	**Products**
27				
28				
29				
30				

Appendix D STROBE tool for measuring observed engagement level

ID	Positive Body Language 1st 2nd 3rd			Consistent Focus 1st 2nd 3rd			Student Confidence 1st 2nd 3rd			Fun and Excitement 1st 2nd 3rd			Verbal Participation (Times)

Appendix E Observations

	Very High	High	Medium	Low	Very Low
Positive Body Language	☐	☐	☐	☐	☐

Students exhibit body postures that indicate they are paying attention to the teacher and/or other students.

	Very High	High	Medium	Low	Very Low
Consistent Focus	☐	☐	☐	☐	☐

All students are focused on the learning activity with minimum disruptions.

Verbal Participation

Students express thoughtful ideas, reflective answers, and questions relevant or appropriate to learning.

	Very High	High	Medium	Low	Very Low
Student Confidence	☐	☐	☐	☐	☐

Students exhibit confidence and can initiate and complete a task with limited coaching and can work in a group.

	Very High	High	Medium	Low	Very Low
Fun and Excitement	☐	☐	☐	☐	☐

Students exhibit interest and enthusiasm and use positive humor.

Appendix F Questions for Focused Group Discussion

Engagement Question:

Your thoughts on educational software based on Science? How was your experience? Share your experience with me.

Exploratory Questions:

1) Give at least 3 strengths and 3 weaknesses of app? Why? (Enjoyment, fun, boring, engaging, disengaging)

2) What did you learn from this work? Did you find this educational software relevant to your curriculum? (Learning goals)

3) What were your biggest misconceptions? Did this educational software help you address the misconceptions you had previously in Science (Chemistry)? (Addressing misconceptions)

4) Did you get distracted during work (playing with educational software)? Why did you get distracted or why not? (Concentration/Attention)

5) How much effort did you exert in this work? (Effort Exertion)

6) Which things/parts in an app kept you stay focused for a long time? Why? (Focus/Concentration)

7) How engaging did you find this educational software? What did you learn from it? (Engagement)

Exit Question:

Anything you wanted to add.

Appendix G Lesson Plan

Lesson Plan on Patterns of Reactivity for 8th Grade Students

8.16.2015

Subject	Overview
Science	Students will learn about differences and similarities in reactions of various metals with water, oxygen and acid. In addition to this, students will construct reactivity series based on the extent of reactivity of various metals. Apart from this, students will discover about the benefits of metals and their daily usage in everyday objects.

Grade Level

8

	Teacher Guide	Student Guide
Objectives	To help students in making observations, so they can make notes apart from identifying the products formed in various reaction To help students construct series by distinguishing between the reactions of metals with water, acid and oxygen	To show that although metals react in a similar way with oxygen, water, and acids, some react more than others To establish and use a reactivity series of metals
Goals	To help students where they need assistance or guidance	To identify and describe similarities in chemical reactions between metals and oxygen, water and acids. To recognize differences in the reactivity of different metals To use differences in the reactivity

Materials Required

Worksheet

Pens/pencils

Note Books

Prior Knowledge

Learning outcomes mapped to David Coppock's Science Fact File for Secondary Classes 3; Chapter 2 Reaction of metals

Word and Symbol Equations to describe chemical reactions of metals , metal oxides and metal carbonates with different acids

	Teacher Guide	Student Guide
		of metals to explain some everyday uses and occurrence of metals
Verification	To assess the learning of students by posing them with several questions To assess their worksheets in order to evaluate their learning	To reflect on their own learning by working collaboratively and To jot down the observations made during watching videos on reaction and reflecting on it by participating in class discussion or
Activity	To help students where they need support, guidance or coaching. To help students introduce these activities by carefully reading the instructions to them. To get a timely feedback from the students besides observing them play	Patterns of reactivity App Learning activity based on reactions of metals: This activity will show the videos or animations of desired metal's reaction followed by questions regarding the observations and products formation Learning activity based on reactivity series: This activity will help students construct reactivity series apart from exploring the daily usage of metals in objects or items of daily use. Shooting the balloon Game: This gamified activity will help students assess and reflect on their own learning by achieving the goal. The students will shoot the correct metal balloons from least to high reactivity order or vice versa. The game will be based on 2 levels.