Measuring effect of interactive learning application on student engagement of secondary school students

By

Hira Khan

2014-NUST-MS-ITE-63048

Supervisor

Dr Muhammad Muddassir Malik

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Innovative Technologies in Education (MS ITE)

In

School of Electrical Engineering and Computer Science,

National University of Sciences and Technology (NUST),

Islamabad, Pakistan.

(August, 2015)

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It is certified that the contents of thesis document titled "***Measuring effect of interactive physics learning application on student engagement of secondary school students***" submitted by

Hira Khan have been found satisfactory for the requirement of degree.

Advisor: Dr. Muhammad Muddassir Malik

Signature: ______________________________

Date: ___________________________

Committee Member1: Farzana Ahmed

Signature: ____________________________

Date: ___________________________

Committee Member2: Dr Sohail Iqbal

Signature: ____________________________

Date: ___________________________

Committee Member3: Dr Hamid Mukhtar

Signature: ____________________________

Date: ___________________________

Dedication

This thesis is dedicated to my beloved mother "Afshan Habib" and my supportive husband "Saad Tariq" without their support I would have never be able to complete this.

Who always helped and motivated me whenever I was down or I had lost hope in me. They have been an amazing support and my back bone throughout this course.

Certificate of Originality

I hereby declare that the thesis titled "**Measuring effect of interactive physics learning application on student engagement of secondary school students**" 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 NUST, 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 NUST, 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: Hira Khan

Signature: _______________

Acknowledgement

I thank all those who in one way or another contributed in the completion of this thesis. First, I give thanks to God for protection and ability to do work

I am greatly thankful to the designers at MS-ITE who helped and designed graphics for this application. Special thanks to Saba Khateeb and Erum Afzal for timely correspondence and providing the art assets in a very short duration of time.

Special thanks to my husband Saad Tariq for continually reviewing my application and gave positive feedback. The UI issues he pointed out actually helped me in the field-testing.

I am immensely thankful to my supervisor Dr Muddassir, who not only helped me in finding my true passion for the development but also guided me in wisely selecting the topic for making an educational application. My skills for game designing and coding have been developed because of his guidance and mentoring.

Dr. Salma Siddiqui, HOD Department of Behavioral Sciences, helped and guided me since the start of my thesis and opened my vision towards developing learning application and what possibilities can be covered in those applications.

Thesis office led under the supervision of Madam Farzana Ahmed and Erum Afzal, guided since the start of signing first activity on PTS till the end. Their timely responses and rapid actions at various instances of time helped me and my colleagues in saving lot of our time

Special thanks to Madam Farzana, who always helped even in her busy schedule. Her timely responses to all my queries always guided me and saved me from facing a lot of trouble. I would also like to thank the model school, who extended their support throughout the intervention duration and helped me in all capacity they could.

A big thanks to my class fellow Aleena Hasan Querashi, Mustafa Hassan and Zulal Ali who were always welcoming in answering my queries.

I also want to thank my family who encouraged me and prayed for me throughout the time of my research.

Abstract

In this study, we investigate outcome of incorporating an interactive learning application into a curricular education and then access its effectiveness on student engagement. The main goal of this study is to investigate if there is a significant difference in student engagement when interactive learning applications were used in their classroom.

Traditional classroom environment fails to incorporate multidimensional engagement among students. In traditional school system setup, students listen to the lectures in classroom, take notes and seldom ask questions or make comments. Very often they are given a chance to perform physics experiments on their own. This process leads to little active learning on students. Students are less engaged in this environment and lose their motivation to learn. As they think that physics is all about only memorization and not related to real life. As a result of traditional class room setting students are not motivated to attend school and learn.

Teachers also find it hard to cater to learning needs of each and every student. Teachers also have the load of class administrative issues, which makes it extremely difficult for the teacher to attend to every student in the class and make sure that every student has understood the concept being taught.

A learning application with right use of pedagogy and interactive elements was first tested on users with diverse background and then deployed in a model school located in Islamabad, Pakistan. The learning application was developed on constructivist learning theory. Following that learner will construct their knowledge based on their own experience.

Two groups of 60 students were selected for the purpose of the study. The same topic of "work and energy" has been taught to both the groups while a group of 60 students had their lecture in technology supported class having interactive physics learning application for 3 weeks, the other group of 60 students had their lectures in traditional way. This research has been conducted in a private school in Islamabad, Pakistan. The main resources of this research are the data collected through surveys, walkthrough checklist, and student achievement test and focused group discussion. The survey and walkthrough checklist is a result of the literature and suggestions of the experts on the topic. Data collected was coded in to the SPSS software and statistical

analyses were conducted. In order to test the significant difference between the mean scores of both the groups' independent t-test was utilized. The significance level chosen was 0.05. As the result of those analysis significant difference was found in the student engagement, their interest and participation in class and achievement of both the control and experimental group. In the view of literature review and the statistical analysis it was found that lectures supported by interactive learning application in physics subject not only increase student's understanding of those particular topics but make learning fun and enjoyable.

List of Abbreviation

ARS: Automatic Response System

MOE: Ministry of Education (Singapore)

UI: User interface

FGD: Focus group discussion

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Chapter 1

1. Introduction:

Traditional classroom structure fails to incorporate multidimensional engagement among students. Students may be coming regularly to classes, submitting their assignments and homework but not constructing knowledge on their own. They are just passive receiver of knowledge from their instructors by taking notes and copying them. They are not participating in the class activities. Hence fail to connect knowledge of physics concepts and laws with the real world. Their efforts are focused to get good grades and pass the examination. Their knowledge is assessed by the number of correct answers they give in exams.

In traditional teaching, teachers are active and students are passive receiver of knowledge. Information is loaded from teachers to students. When loading of information takes place without giving attention to student's attitude towards the subject, their expectation and motivation, they are turned into rote learners. Reference? Students find lessons boring due to constant loading of information and rote learning. Students find it hard to communicate with the teacher to ask questions related to the concept been taught. On the other hand it is difficult for the teacher to entertain questions of each and every student and satisfy them with answers.

Meaningful learning is negatively affected when this approach is followed on daily basis. Due to traditional way of teaching, students find it hard to combine their previous knowledge with recently learned things (Civelek, Erdem, & Gokcol, 2012).

In a traditional classroom setup there is one teacher for the whole class. The amount of information is growing and becoming complex. Use of computers in education is gaining importance due to individual difference and abilities of each and every student (Guzeller & Korkmaz, 2007). Flow of information takes place in one direction i.e. from teacher to students. Students are just passive receiver of the information.

In traditional classroom setting, one-way communication exists between teacher and students (Damron & Mott, 2006). Students focus more on taking notes. Teacher has to cover large volume of information which makes it difficult for him to assess whether each student has understood the concept being taught or not. A few students may ask questions or be called by the teacher to solve questions but by and large student participation is limited as teacher has to complete the syllabus. This approach leads to less engagement of students with the content material however more information is transmitted to students by the teacher in the limited amount of time (Steinert & Snell, 1999). The purpose of asking questions is way to attain student attention to stimulate their cognitive processes and to communicate information to the instructor. Students underlying understanding of concepts enhances by conceptual questioning. Deeper understanding of those concepts is necessary in solving physics problems (Beatty, Gerace, Leonard, & Dufresne, 2006.). But in traditional classroom setting this approach cannot be observed or observed rarely. Teacher does not find enough time to assess understanding of each and every child sitting in the class. Neither teacher asks questions himself nor encourages students to participate and have a discussion with each other. Absence of effective immediate individual feedback also prevails. Neither the student nor teacher is aware whether knowledge construction has taken place or not. Degree of psychological investment by the student in learning concepts is not observed.as each student is different and learns at different speed and pace it is important to note how much effort has been put by each student in learning a specific concept. In a traditional classroom there are no measures to check this, which leads to lack or nonexistent of cognitive engagement among students in the classroom. Absence of cognitive engagement leads to students inflexibility in solving problems outside the book (Thompson, Christensen, & Wittmann, 2011), inability to link content read in the book with the real world (Risch, 2010) and inability to reflect (Damron & Mott, 2006)

For those students who are not aiming for good grades and don’t take notes in class or listen to instructor lose interest in class. This affects student behavior in class (Damron & Mott, 2006). They don’t get any incentive for coming to classes. Classrooms are boring for them as learning does not take place in fun and engaging way. Students don’t participate in class activities or there are hardly any class activities organized that focus student’s participation. Students are not attracted to their work. Students are not given opportunity to interact socially and discussion the topics they are studying. There is not enough time to show persistence if they face challenges and obstacles while solving any problem. The only way to take pride in accomplishing their work is by getting more and more marks.

In traditional classroom setup it is not feasible for the teacher to model such activities that can foster higher order thinking skills in students and keep them engaged for longer period of time. Even if those activities are designed teacher does not have enough time to help students practice those skills in class and provide immediate individualized feedback. Students are unable to move to higher order thinking skills without guidance and coaching. Most of the students are studying for the exam however teacher may believe that they have started to learn and practice thinking (Leamson, 2001).

Class set up does not include elements of excitement and enjoyment among students. This sometimes leads to absenteeism and ultimately leads to drop out from the school. There are no measures to engage students in learning or facilitate them to take part in activities.

Traditional classroom set-up becomes more boring for student engagement as they grow. By the time they reach secondary school their lack of interest in learning and school activities may lead to drop out from the school (Midgley, Anderman, & Anderman, 1998,)

Teaching becomes an extremely complex task as teacher not only has to take care of the class management issues but also guide and monitor learning and progress of each and every student in the classroom (Spahiu & Spahiu, 2013).

All of the responsibilities lie on teacher’s shoulders and there is no support or aid for the teacher to share all these workloads (al-amarat, 2011). This study interviewed 196 teachers in the Tafila province and found out that most of teachers said that there is a dire need of an educational technology to help teachers activate the classroom activities.

In a class with large number of students, the interaction between students and teachers is further restrained due to class management issues. Classroom structure is designed in such a way that allows passivity and does not encourage students to take responsibility of their learning. Due to this setup, students’ opportunity to apply ideas and concepts taught to them is halted. Students focus in on memorization of facts due to which they fail to make connections between memorized facts with the world around them. Student’s efforts result in knowing more terms, definitions and details but ultimately fail to produce deeper evaluation and analytical capabilities (Brown & Clement, 1989). As a result student active participation and engagement in class is diminished. Peer interaction is also limited as it becomes unmanageable for the teacher to facilitate or moderate student’s discussions.

Some of the students face serious challenges due to disengagement in school life. As found in the research conducted for OECD countries, 20% of students are regularly absent from school, they are not interested and motivated to attend school. Percentage of students that experience low emotional engagement is 25%. Reduced levels of engagement in student's results in underachievement, frequent occurrence of negative behavior and increased risk of dropping out of school (Finn & Rock, 1997; Wu, Hughes, & Kwok, 2010).

Students are suffering from school disengagement all over the world. But the situation is extremely daunting for Pakistan as there have been no measures taken to engage students in school. Students studying in public schools become victim of this the most. These schools charge less fees compared to private elite class schools hence they claim that they are unable to bring engaging environment in the classrooms. Students who are found to be less engaged in academics and school activities are at a greater risk of dropout and alienation (Finn J. D., 1989).

School dropout has become a universal problem in education system around the world. Before student actually dropout from school, they show signs of disaffection from school social life. They are not seen emotionally involved in the school activities. In china 20% or one-fifth of the students were found to be disengaged (TAM, Zhour, & Fisch, 2012). Students who suffer from disengagement are at-risk of low academic performance, show deteriorating health conditions mostly caused by health related risk behaviors and have negative approach towards their health and lives. Disengaged students show recurrent absence from school (Taras, 2005; Henry, 2007)

Common reasons of disengaged observed in students all over the world are the traditional classroom setup which does not excite and motivate them to learn new concepts. One size fits all phenomena is the one that frustrates weak or slow learners in the classroom. Teachers finds it difficult to cater to individual needs of all the learners.

Previous empirical studies conducted in the field of physics education have shown that students encounter lot of misconceptions while learning physics subject. Students also face difficulty while learning different models, analogies, solving problems and deriving relationships. (Thompson, J.R, Christensen, andWittmann, & M.C, 2011). William .etal conducted a study on students studying in United Kingdom and found out that students consider physics to be a difficult subject. This perception has been formed essentially due to the fact the students find it hard to solve physics problem (Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003).

Especially in a country like Pakistan where the literacy rate is already very low and few projects have been started only to bring students to the school. But the important task is to retain students in the schools and help them to learn things meaningfully rather than rote learning. When students are engaged in the classrooms and they find learning fun and exciting there are fair chances that dropout rate of the students can also be decreased. Students find science subjects to be the most difficult ones as they involved lot of complex mathematical formulas. To make the task of teaching complex scientific concepts to students statics images are provided in the book. Teachers are not provided with any additional material that they can use to explain those phenomena to students (N, Mastang, H, & N, 2009.)

Scientists have indicated few reasons due to which students face difficulties while studying physics or attempting to solve physics problems. One of the reasons is student's misconceptions, those misconceptions have been caused due to wrong prior knowledge which is making even understanding of new concepts difficult for them (McDermott, Rosenquist, & van Zee, 1987). This approach destructively affects the knowledge construction process of students, as they are not able to reconcile their previous and new concepts

Engaging students in class is considered to be the most favorable technique to prevent dropout, (Reschly & Christenson, 2006). Student's engagement can be considered as a meta-construct of education (Fredricks, Blumenfeld, & Paris, 2004). It is composed to have multiple dimensions rather than only one. These dimensions include cognitive, behavioral and emotional engagement.

Student's attention and focus increases when they are engaged in the learning process. This approach motivates them to practice higher order critical thinking and support meaningful learning. Being engaged in in school has positive impact on student academic performance (Wang & Holcombe, 2010). Students willingly engage in their studies and show higher grades (Ma¨kikangas & Kinnunen, 2003; Salmela-Aro, K, Kiuru, Leskinen, & Nurmi, 2009), those students are also less likely to fall prey of study burn out in later academic life (Salmela-Aro, K., Tolvanen, & Nurmi, 2011). In a compulsory schooling context, engagement is correlated with improved academic achievement (Finn & Rock, 1997) higher chances of school completion rates (Finn J. D., 1989).

Learning and teaching activities have become effective and time saving by the use of computers. Student engagement is critical to student motivation during the process of learning. Learning environment empowered with technology assists students to have positive tendency towards lessons. Students tend to learn readily in the classes quipped with technology.

Interactive computer simulations and inquiry-based experiments have various advantages in physics education. The combination of computer simulations and inquiry based experimentation is considered as the most effective tool that can be used in learning environment (Zacharia, 2003).

ICT tends to produce major changes in the way students access knowledge and nature of the knowledge. It brings benefits to both learners and the teachers as it can lead to significant educational and pedagogical outcomes in learning environments (Jonassen D. H., 2000; Webb M. E., 2005). ICT can help in imparting increased motivation for among learners, deepen understanding and creative thinking (Siorenta & Jimoyiannis, 2008). There are new educational materials in the market that tend to increase student motivation in the process of learning, they help students to think creatively. Students can deepen their understanding with the help of those learning tools and take part in active and collaborative learning. Most of the students find computes attractive and want to spend time on computer. This approach can be taken as benefit of computers when leaners have to practice a skill. Increased practice is an important characteristic that comes along with the use of computers. As computer can motivate learners to undertake such practice. Those aspects of curriculum that demand practice, their practice can be easily supported with the help of use of ICT.

In a lecture-based class environment students remain isolated and as a result students remain passive in knowledge building process. Student engagement in science is directly proportional to teaching and learning activities associated with it. The classroom in which different measures of interaction, hands on activities and application in science subject take place show greater level of student motivation, enjoyment (Hampden-Thompson & Bennett, 2013).

Provision of ICT rich environment cannot increase student achievement. It depends upon the way that particular equipment and resources are been used by the teacher and the students.

In instructional practices computers have come out to be the most common devices for teachers and students. They are affordable and economical to purchases, easy to use and maintain, effective in presenting variety of information to the users and have good speed (Akdemir, Kunt, & Tekin, 2012). Those approaches are considered to be effective in teaching physics that have combination of instruction, practice and most importantly giving feedback to students in problem solving. These aspects support the development of cognitive skills in students which are essential in physics (Ferguson-Hessler & T., 1993). When students are given specific identifiable problems, which are in their capacity to do so maximum learning takes place at that time when students tries to solve those problem. When human brain is engaged with actively stimulating environments then its activity increases (Ewell, 1997) .

Keeping in mind this situation a solution needs to be developed not only engages students in their classes imparts meaningful learning among students but also tends to share the load on teachers shoulders. With the use of technology this task can be achieved easily and efficiently. Use of technology elements inside the classroom will not only excite students towards learning but will also help teachers to transfer complex and difficult concepts to students easily and effectively. When students will enjoy learning and put an extra effort towards understanding difficult concepts their grades will also improve. They will not only perform better in the exams but also would be able to relate the knowledge learnt with the real world.

An interactive learning application will be developed to engage students in class. The application will cover the content as mentioned in the text book but in an interactive and enjoyable way. With the help of stories and real life examples adopted from the context of Pakistan will help students to make a connection between the concepts learnt with the real world.

Constructivist learning theory will help students to construct their knowledge based on their own experience. They will experience the new concepts while working on the interactive application and then will reflect on their concepts in this way will be constructing their own knowledge. Central element in engaging elements in the classroom is the structure and design of learning activities (Ames, 1992). The organization of those activities not only determines that how students approach learning but also directs how students will use their available time (Good, 1983). Students should be given short-term goals in such a way that they believe that they can accomplish this task with reasonable effort.

The combination of right pedagogy and immediate effective feedback will form the basis of this application. Students would be able to view response to each wrong answer so that they can correct their decision learn from it and go towards the right answer.

Research questions formulated for the purpose of this study are as follows:

- How use of interactive learning application increase student cognitive engagement in class?
- How use of interactive learning application increase student emotional engagement in class?
- How use of interactive learning application increase student behavioral engagement in class?

The outcomes of this study will help us in the following ways:

- ❖ To make recommendations to policy makers for including interactive learning applications as part of the curriculum for all public/government schools.
- ❖ To increase student retention rate and decrease the dropout rate in schools.
- ❖ To inspire other schools to adapt this methodology of teaching by showing students' academic performance and improved grades.
- ❖ To propose an effective pedagogy for making interactive learning applications on all physics topics.
- ❖ To propose an effective pedagogy for making interactive learning applications on all science subjects.
- ❖ To propose the training to be held for teachers so that they should be able to use this technology in their classrooms.
- ❖ To attract gaming industry and cooperate sector to invest in this field and develop learning applications especially for students of Pakistan.
- ❖ To propose other researchers to extend this study for longer period of time and then observe its effects on students engagement

Chapter 2

2. Literature Review

2.1 Education System of Pakistan:

Public sector formal education system is the largest service provider, which consists of twelve academic years. Education system in Pakistan is divided into five levels. Primary level which goes from grade one through five, middle goes from grade six through eight, secondary goes from grade nine to ten leading to the Secondary School Certificate SSC, intermediate includes grade eleven and twelve, leading to a Higher Secondary School Certificate HSSC and university programs leading to graduate and advanced studies. Education system is overseen by the Ministry of Education of Government of Pakistan. Provincial government takes the responsibility of academic institutions whereas the federal government takes part in development of curriculum, accreditation and financing of research projects.

Pakistan Education for All report 2015 states that in Pakistan there are 146,185 formal primary, 42,147 middle level and 29,874 secondary schools (Malik, Amin, & Ahmad, 2015). Education for all program spans across broad set of educational dimensions focusing on early child hood care, universal primary and secondary education. In Pakistan the gross primary school enrollment rates stand at 93 % but as the students reach secondary education stage this figure drops dramatically to 37%. 37 % of boys in urban areas and 36 % in rural areas are not willing to attend school. Similarly 11% of girls in rural areas and 10% in urban areas are not willing to attend school (Pakistan, 2013-2016). Other reasons of dropout are low academic achievement of students in school and unattractive teaching methods (Anwar, Tahir, & Batool, September 2012)

Study conducted in 2012 in Sindh, Pakistan highlighted range of significant reasons for student dropout. The study revealed that in the view of teachers, student’s dropout rate is increasing because they are simply not interested in acquiring education. Engagement gaps are found across different countries and cultures. Students who belong to low socio economic background and minority groups show disengagement but Williams found out that family background only partly affects students’ academic engagement, school rules and policies do play major role in keeping students engaged in school (Willms, 2003) check the spellings

Secondary education is an essential sub sector of the entire education system. It not only acts as the provider of the middle level force for the economy but also functions as the feeder for the higher levels of education (Anwar, Tahir, & Batool, September 2012). This is the most crucial stage of life as student enters in to adolescence. The basic perception towards life and modes of behavior start taking shape. It determines the manner and measure of an individual performance as an individual and citizen (National education policy review–2006). These students will enter the nation workforce and be able to contribute their share in national development as play their role as a responsible citizen.

2.3 Problem in science subject

After lot of research and findings it has been established that decline of student's interest in physics subjects starts during the years of lower secondary education (HA È USSLER, 1987). Traditional teaching instruction aims at providing science information in the form of strict body of facts, theories and rules that should be memorized. It does not focus on presenting this information as a way of thinking and knowing about phenomena of the real world. (Hewson, P.W., & Hewson, 1987) (Koballa et al, 2000) (McDermott & L.C., 1993)

Physics subject consists of lot of mathematics equations and symbols. It would be meaning less if students use those equations without understanding. Students should not be using those equations without understanding rather they should try to get the concept behind that particular equation (Sherin, 2010.). Physics problems are solved by either memorizing the formula or following already worked examples in the book. Students are not in charge of their knowledge, as there is not enough time for the teacher to ensure that whether each child has understand the concept well or not.

Teachers following traditional instructional approaches aim at transmission of content knowledge by means of verbal lessons. They strictly follow the textbooks and approved written material only. In secondary physics education stress is laid in preparing students for the examination. Hence only those skills are taught that will help students in solving paper-pencil problems by remembering complicated mathematical formulas. (Hewson, P.W., & Hewson, 1987) (Koballa et al, 2000) (Lederman & N.G., 1999) (Tsai & C.C., 2002). Ding et al in his studies found that students attempt to solve questions either by following worked examples or looking for mathematical equations instead of focusing to understand the concept (Ding, Reay, Lee, & Bao, 2008).

Young people are found to be disaffected towards science subject, as shown by the reports published by governing bodies and examination boards in the last decade (Treasury, 2004). A multi nation study was conducted by Lyson in 2006, this study included English, Australian and Swedish students. This study found that student engagement increased when curriculum addressed contemporary issues and teaching style was made less didactic. Student engagement increased when there was room given to student voice and an effort is been made to make science subject less difficult (Lyons, 2006). Students perform trial and error while finding solution to many science problem, this is mainly due to memorization of formulas and without understanding nature of the problem (Ding, Reay, Lee, & Bao, 2008) (Savelsbergh, de Jong, & Ferguson-Hessler, 2011)

2.4 Defining Engagement:

Concept of engagement takes center of the stage in the field of education. To understand school dropout model, engagement emerged as the most prominent one (Finn, 1989).It also encompasses the gradual process by which a child gets disconnected from the school. As dropping out of school is not an instantaneous process rather a phenomenon that takes place over time. When student's sign of disconnection from school and learning are noted, engagement provides the means to both for understanding and addressing those signs (Connell, Halpern-Felsher, Clifford, Crichlow, & Usinger, 1995). Engagement brings focus to underlying psychological processes to help increase school completion rate.

It is also defined as the agile involvement of a person in a task or an activity (Reeve, Jang, Carrell, Jeon, & Barch, 2004)

Student engagement was developed as an academic concept during 1970s and 1980s (Smyth, 1980). Student engagement is considered as student willingness to participate in routine class activities, such as coming regularly to class, submitting required work and following teacher's instructions in class (Chapman, 2003). Early definitions of student engagement include psychological and behavioral component but later many models were discussed that focused on psychological and cognitive dimensions of engagement (Miller, Greene, Montalvo, Ravindran, &

Nichols, 1996). Later it was found out that student engagement is not a one dimensional construct (Fredricks, Blumenfeld, & Paris, 2004). Student engagement includes student behavior at school along with their psychological and emotional attachment to school.

The multidimensional definition of student engagement thus involves cognitive, behavioral and emotional indicators of student engagement (Skinner & Belmont, 1993). These student engagement indicators are essential dimensions of student engagement and defined as below (Fredricks, Blumenfeld, & Paris, 2004):

Cognitive engagement: It is indicated when a student tries to apply mental efforts in comprehending complex ideas and master difficult skills (Fredricks, Blumenfeld, & Paris, 2004). Examples of which includes student's flexibility in problem solving, investment in learning beyond just behavioral engagement, mental effort and urge to master a task. Examples also include student learning and achievement (Connell, Spencer, & Aber, 1994). Cognitive engagement is considered to have less observable and more internal indicators of every child it includes self-regulation, usefulness for learning, personal goal setting and self-determination towards learning. Cognitive engagement is the most important indicator of student positive learning outcomes (Fredricks, Blumenfeld, & Paris, 2004). It is examined to be related to student motivation and increase with respect to teaching strategies (Cadwallander, Cairns, Leung, Clemmer, & Gut, 2002). It also includes the studying strategies that student adopts (Sedeghat, Adedin, Hejazi, & Hassanabadi, 2011). When student tends to participate in the academic activities given to him by the teacher and manage with different academic tasks successfully a student is said to be cognitively engaged (Skinner & Belmont, 1993; Wang, Willet, & Eccles, 2011). Students who show attachment towards their school and participate, they are more probably to be cognitively engaged (Harris, 2011). There is powerful relationship between student academic performance and cognitive engagement (Ainley, 1993; Lee & Anderson, 1993). Students who are not actively taking part in school activities but focused in their school work and effectively taking part in learning are cognitively engaged (Pietarinen, Soini, & Pyha¨ lto¨, 2010).

Behavioral engagement: It is measured as student participation in academic, social and extra-curricular activities (Fredricks, Blumenfeld, & Paris, 2004). Examples include: completion and submission of tasks assigned by teachers, contribution in class discussion, asking questions, following rules and following teacher's instructions and being regular and punctual in class attendance. Student retention at school (M.Gunnar & Eds.). It is used to compute student involvement in school often gauged as examining student's compliance with school rules, class participation and attendance (Zyngier, 2008). It is shown by students' positive conduct in school environment, where students are showing efforts and persistence, continuing their work with concentration and attention. Taking part in class activities by asking relevant questions. Completing and submitting the work assigned to him in time

Behavioral engagement is divided in to two dimensions by few researchers. These two dimensions are behavioral engagement and academic engagement (Anderson, Christenson, Sinclair, & Lehr, 2004; Appleton, 2008). Behavioral engagement includes student attendance and operating participation in classes. However the time spent while doing the homework or classwork by the student, homework completed and academic credits come under the category of the academic engagement.

Behavioral engagement includes student participation and involvement in academics, which is considered critical for achieving positive academic outcomes and preventing dropping out (Connell & and Wellborn, 1991). It entails students active involvement in class room interaction and extracurricular activities (Archambault, Janosz, Fallu, & Pagani, 2009; Powell, Burchinal, & Kontos, 2008)

Affective engagement: It is represented as student's feelings about learning (Skinner & Belmont, 1993). Emotional engagement is strongly related to student attitudes (Fredericks J. , Blumenfeld, Friedel, & Paris, 2005).

Affective engagement of students is shown as positive attitude towards academic activities. Examples include feelings and attitude towards school and teachers. Not only has that it also included the feelings of enjoyment, satisfaction and enthusiasm.

Enthusiasm, enjoyment and satisfaction. Affective factors make emotional engagement which includes enjoyment, support, belonging and attitudes towards teachers, peers, learning and school (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Watt, 2004). Affective factors play major role in the process of acquiring knowledge (Mathewson, 1994, Wigfield, 1997). All the three dimensions of engagement encapsulate associated yet separately developing features of engagement that contribute to student's active involvement in school (Jimerson, Campos, & Greif, 2003; Wang, Willet, & Eccles, 2011). Student cognitive engagement in academic activities and learning outcomes is affected by the emotional engagement in student-teacher relationship and the peer group. Intensity of student involvement in learning activities and social relations impact the school engagement (Gresalfi, Martin, Hand, & Greeno, 2009; Linnenbrink-Garcia & Pekrun, 2011). Literature found on emotional engagement stresses that it has strong relation with student attitudes (Fredericks, Blumenfeld, & Paris, 2004)

Emotional and behavioral engagement are the important aspect of student academic engagement and they can be measure with the help of tools developed by the experts. These two types of engagement can be achieved if students are given incentives like free food to eat, free game to play , extra bonus academic credits to given etc. but actual thing is that learning should take place while they are playing a game or having fun in the class. A classroom having enthusiastic and motivated learners is meaningless if there is no learning taking place inside the classroom. Against to this situation if students are learning but they are not motivated towards learning and not enjoying about the learning experience then they are not engaged. Barkley defined student engagement to be a product of motivation and active learning (Barkley, 2010).

As seen from the Venn-diagram that engagement takes place at the overlap of both the motivation and active learning. If any one of the components is missing then engagement will not take place. That is why it is defined as the product rather than the sum.

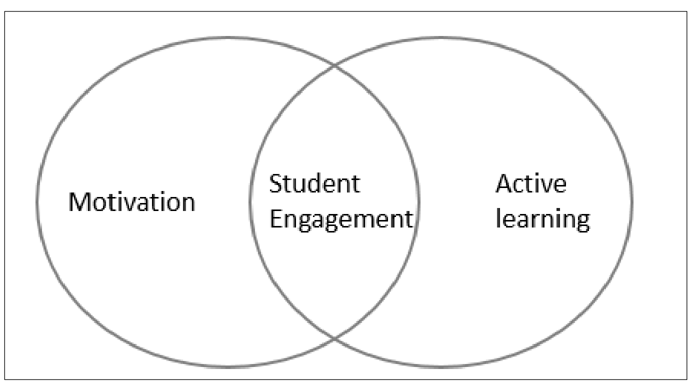


Figure 2.1 -Venn diagram model of Student Engagement

Nystrand and Gamoran, 2010 stated hierarchical models of engagement which includes procedural and substantive engagement. *Procedural engagement* begins when student completes class activities and homework given to him by the teacher thus constituting behavioral engagement however *substantive engagement* refers to psychological and cognitive engagement. It takes place when student commits to the academic study. This model presented that substantive engagement is more beneficial to students compared to procedural engagement. This model also claimed that cognitive engagement is linked to learning and behavioral and psychological engagement may facilitate it hence cognitive engagement is considered to be the most important form of engagement (Nystrand & Gamoran, 1991).

School and learning environment greatly impact student level of interest and their desire to be engaged in learning. Students who are engaged in learning take part in learning activities with enthusiasm and curiosity. They tend to initiate action when given opportunity and select learning tasks that extend their skills (Lumsden, 1994).

Opposite of engagement is disengagement which ultimately leads to the low academic performance and then to school dropout. In educational documentation there are different synonyms used for school disengagement. This school disengagement is termed as disengagement by Vaughn (Vaughn, et al., September 2011) emotional disengagement by Fredrick (Fredricks, Blumenfeld, & Paris, 2004) and psychological disengagement by Strambler and Weinstein (Strambler & Weinstein, 2010). It is seen as a state of disorganization for a child and he is not able to utilize his energy for productive purpose.

2.5 Benefits of Engagement:

Concept of engagement is tensile all over the world. Outcome of students who are at-risk can be saved by increasing their academic engagement (Lamborn, Brown, Mounts, & Steinberg, 1992) Classroom instruction is said to be successful if it engages students in the learning process (Kenny & Dumont, 1995).

Students who are found to be engaged in school environment consider school work meaningful (Kenny, Blustein, Haase, Jackson, & Perry, 2006). Those students perform better in academics and get higher grades (Ladd & Dinella, 2009; Wang & Eccles, 2012). Compared to those students who are disengaged from their studies and school work these students are appeared to be more persistent when they face any problems in their studies (Sharkey, You, & Schnoebelen, 2008). High levels of academic engagement not only ensure higher performance of student in academic but also a predictor of his well-being (Wang & Holcombe, 2010; Carini, Kuh, & Klein, 2006). Academically engaged students are likely to be persistent with the study demands, efficient and ready to invest time and energy in studies (Wang & Eccles, 2012; Kuh, 2003). That is why these students are prevented from negative states for example exhaustion which may lead to study collapse (Hakanen, Bakker, & Schaufeli, 2006). Academically engaged students show attachment towards their school, participate in activities. These indicators have proved to have strong relation with student academic achievement (Harris, 2011). Engaged students retain more and learn more effectively. When they are actively engaged in their own learning (Wolfe, 2001).

Engagement is perceived as the possible way to eradicate social inequality and produce positive outcomes for all students (Harris, 2011). When students are engaged in learning positive attitude is inculcated among them they enjoy their lessons and also in a state to appreciate the concepts taught. All these exercise are the means to build student confidence to continue learning new material and show better personal adjustment in the school environment (Dev, 1997).

Students willingly select those tasks that stretch their skills and exert extra concentration in their learning. They are curious and excited about learning new things and building new knowledge by experiencing compared to unengaged students who tend to give up easily and quickly whenever they encounter any problem or face a setback.

2.6 Students misconceptions for “Work and Energy” topic:

Much research has been done to understand children misconceptions about science (Henriques, 2000). Study conducted by Ayşegül SAĞLAM-ARSLAN & Mehmet Altan KURNAZ found that most of the students confused the concepts of energy power and force with each other or with concept of force when they were trying to define them (ARSLAN & KURNAZ, 2009). Since the concept of power relies on concept of work done and concept of force is the fundamental concept used while explaining the work. One of the possible reasons of intense confusion for students is that all these concepts are referred to as alternative of each other in daily life (Duit, 1984; Kruger, 1990; Küçük, 2005). This study also revealed that students find it difficult to differentiate between the properties of work, energy and force. Students tend to lay more emphasis on the memorization of formulas for these terms giving importance to quantitative aspects of the concepts rather than qualitative aspects. This practice negatively affects the learning capacity of these concepts (Goldring & Osborne, 1994)and Kurnaz, M. A. (2007).

Enerji Kavramının Üniversite 1. Sınıf Seviyesinde Öğrenim Durumlarının Analizi. *Yüksek Lisans Tezi*, Karadeniz Teknik Üniversitesi, Trabzon. Students usually remember a formula and then try to use it in the questions/numerical without understanding the problem. It not only increase cognitive load on their memory, caused due to memorization of complex mathematical formulas without any sense but also affects their approach towards problem solving.

There is vital relationship between these concepts and their daily life applications. Students should direct daily usage of these concepts starting from scientific usage (Aycan, Ş. & Yumuşak, A. (2003). Lise Müfredatındaki Fizik Konularının Anlaşılma Düzeyleri Üzerine Bir Araştırma. *Milli Eğitim Dergisi*, *159*, 171-180. Due to immature knowledge of these concepts students are unable to apply this knowledge in real world. The text book is not designed in a way to teach a concept using real life scenarios. This makes it hard for students to relate to the concepts learnt in the book with the real life. They think that what is read from the book stays there only and has no existence in real life. These confusions have appeared to exist in all students of all age groups as founded by (Küçük, 2005; HIRÇA, ÇALIK, & AKDENİZ, 2008). There are other confusions associated with topic of work and energy which makes learning of these concepts difficult.

In case of topic of work:

Failure in identifying the direction of force, notion that any force times any distance results in doing work, in what direction work done is positive and when it is negative? Are there any conditions where force is applied and displacement is moved and till no work is done on the body? How work done is affected by the value of the angle between applied force and the displacement? At what angle work done is maximum and at what angle it is zero?

In case of topic of energy:

Differentiation between energy and force, does the object at rest has energy or not? Potential energy is of only one type i.e. gravitational which depends on the height of the object. How that potential energy which is stored in the body changes as the object falls on the ground? Or does it change at all? How energy can be changed from one form to another form? (Weiler, 1998)

2.7 Role of ICT in Physics Education

ICT-based learning environment have shown educational potential in science education as they provide opportunity for active learning (de Jong & Joolingen, 1998). These environment make student capable to perform at higher cognitive levels (Webb & Cox., 2004). They help to promote scientific inquiry among students (de Jong & Joolingen, 1998) and conceptual change in students (Jimoyiannis A. a., 2001) (Tao, 1999). Learning can be transformed by the use of ICT rich environment integrated with the right use of pedagogy (Ministerial Council on Education, 2005). *BERA (British Education Research Association)* states that ICT environment has the potential to increase student motivation and engagement (Higgins, 2015)

A lot of ICT based applications are available that give learners opportunity to access, visualize and investigate dynamic phenomena that are otherwise difficult to experience in classroom or lab setting. These applications help in developing students understanding about phenomena and laws. Students can also use those applications to express their understanding about those concepts by using variety of representations. Some of those applications are spreadsheets and databases, simulations and modeling tools and microcomputer based laboratories (Jimoyiannis & Komis, 2001).

ICT rich learning environment can help students in meaningful construction of knowledge by encouraging students to collaborate and solve problems (SOONG, Mercer, & ER, 2009)

There are different ways to provide interactivity in classroom with the help of technology one such method is by the use of clickers, ARS (audience response system). This approach has been used in teaching concept of quantum physics and has proved to be a positive interactive experiment and also inspired teachers to create an interactive classroom learning environment. This study also suggested that the combination of technology elements, rapid feedback mechanism and inquiry driven methods are core didactical aspects of a powerful classroom environment (Puent & Swagten, 2012). Similar approach is been followed in teaching Quantum Physics to second-year physics students. The instructional design for quantum physics consists of interactive lectures using ARS (audience response system) and tutorials. This system has shown remarkable increase in student's achievements compared to traditional classroom setting. With the addition of individual formative feedback students were able to view rapid assessment of their progress. Components of technology application and inquiry driven methods combined with immediate individualized feedback are the core pedagogical aspects of powerful learning environment (Puent & Swagten, 2012).

Interaction is considered necessary in learning process (Tu & C.H., 2000). Interaction is defined to be of three types. First one is leaner-learner interaction, second is learner- instruction interaction and third one is learner-content interaction. These three types of interaction types were offered by Moore in 1989 (Moore M. G., 1989). He said that leaner-instruction interaction is most desirable by the learners as it fosters an ambience that encourages learners to understand the content in a better way.

In leaner-learner interaction, the interaction occurs between one leaner and other learners. It may occur with our without presence of instructor in real time. This form of interaction adds to learner's experience (Bull, Kimball, & Stansberry, 1998). Practical experiments conducted showed that learner's likes to prefer leaner-learner interactions more compared to learner-instruction interaction method (Grooms, 2000; King & Doerfert, 2004).

Interactivity is defined as a two way communication process between two or more people (Hillman, et al., 1994). Interactivity also occurs between the students and the course content. Course content includes assigned texts and related instructional material (Moore, 1989) (Northrup, 2001). Learners, texts and other materials and resources that are provided to the learner may have interactivity (Bannan-Ritland, 2002) (Soo, 1998, June) (Tremayne, 2001). In the process of learner-content interaction learner interacts with the content intellectually and this interaction helps changes leaner's understanding about a particular concepts, changes his perspective and may result altering his cognitive structures of learner's mind (Moore M. G., 1989)

For the case of leaner-content interaction there are not generalized rules and guidelines as, different content requires different interaction patterns. The instruction method and model of delivering the content should be tailored according to the content area been taught. Palloff and Pratt in 1999 reported that interaction in contemplated as the key to learning process that take place between the learner and teachers and within the leaners (Palloff & Pratt, 1999). It is important to look in to the definition of interaction and interactivity as there is lot of debate reported in the literature review over the definition of these two terms (Gilbert & Moore, 1998).

This distinction is necessary as interaction is often used interchangeably with the term interactivity (Rose, 1999).

In 1980s and 1990s computers were used as the medium to incorporate constructivist learning theory. Those learning environments included construction kits and micro worlds, learning environment that intentionally foster scaffolded learning. Effective and easy approach of computer to embed various strategies in the instruction method makes them an excellent medium to employ constructivist learning theory in educational practice.

Interactivity in limited to the degree of interaction which comes with the communication channel so it depends more on the feature set of the system. However interaction is a procedure which focuses on the vigorous actions. This term interactivity can be used to differentiate between new technologies, as the attributes of software technology may differ from one other. Functionalities provided by the one software may differ by the other one (Heeter, 1989). Compared to those students who are not interactively engaged, the interactively engaged students enjoy learning more, retain more information thus learn more (Barkley, Cross, & Major, 2005; Davis, 1999; Dowson & McInerney, 2001)

2.8 Similar projects to increase student engagement

Use of technological innovations have been used worldwide and are changing the way of instructional design. They have redefined the meaning of teaching and learning for teachers and learner by imparting knowledge to students in more efficient and effective way. Pakistan is still far behind in following these approaches in traditional classroom setting. There was not enough literature to be found where technological practices increased student engagement however all the developed and mostly developing countries are following these approaches and benefiting from it. Below is the brief description of some of the projects where technology has played a vital role in imparting physics education among students and students' performance greatly improved by use of those pedagogical interventions supported by technology.

1. **Teach Quantum physics to second year students by the help of ARS (Audience Response System)**

Use of technological innovations in teaching physics concepts has shown promising results. Another examples is of teaching Quantum physics to second year students in Netherlands (Puent & Swagten, 2012). This project showed remakrable improvement in student's restuls with the use of interactive lecturing and ARS (auidence response system).

This method of instructional design was different than traditional teaching method. In traditional teaching method students don't find opportunity to apply the concepts they have learnt in the class.

In this class students were being taught with the help of interactive lectures, web links , videos and peer talk .Content was presented using real life problems. Students were first taught a concept in interacitve lecture then followed by a peer talk. Later on students were encountered with questions which they had to answer with the help of clickers. Students were given assignments, that they did in their time. Diffucuilites or confusions in the assignments were discussed in the interactive lectures. Students dedicated most of their time to self study where they spent time on their homework by reading books and tried to apply the knowledge of concepts learnt.

Students were posed with different questions at various points in the lecture. Every question had to be answered with the help of ARS.These questions were made part of the lecture and nature of these questions varied as the lecture unfolded. At some point it checked whether students remembered the concept previously taught or not and at other time they checked conceptual understanding of the students. With the help of interactive exercises and ARS students showed steady growth in their exams. These gains had been caused with the help of immediate individualized feedback system embedded in this system.

2. Students' use of the interactive whiteboard during physics group work

Interactive white board is another use of technology in to the classrooms. It not only provides opportunities for multimedia presentations but its touch sensitive facilities make it efficient to use. Teaching material can be easily stored, shared and re-used. It provides a large amount of opportunities for student interactivity and participation as explored by Hennessy in 2011 (Hennessy, 2011). Students can collectively work on same project and then share their views and ideas with rest of the group. Interactive white boards constitute an important part of teacher led classrooms. But they are expensive to purchase and their timely maintenance and cleaning also costs a lot. For schools in Pakistan where hardly any money is spent on providing basic facilities to students it would not be possible for public and government schools to buy interactive white boards for every class. Additional amount has to be spent on training of teachers and students in training them to use those interactive white boards. Existing technological equipment that is available in the schools of Pakistan is the desktop computer. Those educational solutions and programs are best suited for most of the schools in Pakistan that can easily run on desktop computers.

3. Strengthening Student Engagement in Classroom by interactive slides/videos – Singapore Study

The Singaporean education system has undergone great changes from 1960s till 21st century. In 21st century classroom importance is given to understanding of the concepts rather than passing the exams. Stress is given to incorporate those strategies into learning and teaching that engage learner's minds and hearts (Ms Ho Peng, 2004a). Initiatives like "Teach less learn more" and "Innovation and Enterprise Thrust" have tried to redefine the meaning of teaching and learning. In these projects stress is laid on quality of the education instead of quantity. It does not matter how much content has been covered by the student if he does not know how to apply that knowledge it is a waste. Knowledge should be used in solving problem rather than gaining good grades in exams.

The curriculum has been redefined by giving importance to the learner's backgrounds, expectations and customized curriculum to engage students in learning. These projects focused more on students learning rather than achieving more marks in exams.

Stress is given to all three dimensions of engagement which includes cognitive, behavioral and emotional. Students were involved in authentic tasks, make them self-directed learners, engaged to construct their own meaning and take part in problem solving.

Major approaches used by Singaporean education system to increase classroom engagement are demonstrations, simulations, videos, interactive slides, classroom discussions and small group activities. Teachers were given with power point slides in which those slides simulations and videos were embedded. Computer simulations were used as a powerful tool to bridge the gap between student's conceptual understanding and the teaching. Simulations were able to invoke curiosity among students and students felt more engaged when they felt they were controlling those simulations. Simulations specific to physics chapters were designed and used by the teachers in their classroom and then student's response was collected. Student's population included samples from both the genders i.e. male and female.

Physics topics of kinematics, electromagnetic induction and magnetism, dynamics, D.C circuits were included in this study. The lesson package to be used by the teachers was designed to encourage students to explore their current beliefs, create new ideas, reevaluate and redefine and then construct their knowledge. Thus it followed constructivism approach that learner should construct their own knowledge by exploring new ideas, reconciling with their prior knowledge, reflecting and reconstructing knowledge on their own.

These lectures catered for students with different learning styles with the addition of text/visual instruction and videos/simulations and inspired students for higher order thinking skills.

Student engagement in three dimensions of cognitive, behavioral and psychological aspect has been measured by the help of checklist and rating scales. Data from teachers serving in different schools was collected. 76% teachers used videos/visual in their class to engage students, 44% teachers used demonstrations, and 46% used small group discussions to engage students.

But this study had the limitation that teacher has to manage everything and it was dependent on the teachers. These approaches can be used only when teachers are willing to engage students in class. Teacher has to take care of lot of things going in the class that is why it is hectic for teachers to use them. A teacher is responsible not only for administrative issues in the class but for adopting a suitable pedagogy to engage all the learners in class. Teachers usually underutilize these engaging approaching due to lack of time.

Teachers will be more willing to adapt to these changes when their burden can be shared. Technology can be best utilized in this scenario by sharing the load of teachers. Technology can be used as an aid to monitor student's progress and learning and most importantly imparting learning in fun and engaging way. Technology can be used to access student's knowledge in more flexible and innovative ways rather than just checking student's memorization of facts and formulas.

4. Use of interactive exercise to increase student achievement- Turkish Study

This study investigated the use of interactive computer exercises on the physics topic of atomic structure on 8 grade students in turkey. The study continued for four weeks. The interactive exercises were developed by the open source authoring tool and it aimed to increase student academic improvement for this topic.

The research followed quasi control-experimental research design. Students were randomly assigned to both groups in private educational institution. Prior knowledge of both the groups was tested. It was also proved by the significance value of t-test. The t-test conducted for the pretest scores of both the groups did not show significant difference. In one group traditional instructional approach was used while in other group interactive computer exercises were used. In control group the participants followed textbook and solved exercises on the black board while in experimental group the students used interactive computer exercises. Posttest scores were compared to find the significant improvement between both groups.

Students' achievement on the topic of "atomic structure" was measured through multiple choice test. It had sixteen questions and each questions having five multiple choices to choose from. Each student was given twenty minutes to finish the test.

Results found that students who used interactive computer exercise during their classes showed significant increase in their academic performance compared to those students who did not use interactive computer exercises in their classrooms. This approach of teaching and learning was not only found useful for students but teachers also found it useful to foster learning among students. The study also proposed that this type of applications should be made permanent part of the curriculum (Akdemir, Kunt, & Tekin, 2012).

5. E-learn Punjab Website

In Pakistan, the Punjab government has taken the initiative to provide free digitize content on a website. The website is functional by the name of elearnpunjab and can be visited by following the link: http://elearn.punjab.gov.pk/index.html. This website is free to access by anyone. Currently it provides content for class 8^{th}, 9^{th} and 10^{th} for mathematics and science subjects which includes physics, chemistry and biology. The website follows the content as given in the Punjab textbooks. Chapter and topics are followed in sequence as given in these textbooks. It gives a look of digital book where student can go forward and previous to read the content of their choice. The pedagogy used in this website is more or less the same as used in Punjab textbooks, at few places few videos, simulations and audio files are embedded. Critical pedagogical review for grade 9^{th} physics topic of work and energy is mentioned below:

- Content designed is not in a way that encourages students to solve their daily life problems. They think that what is learnt in book is restricted to the book and cannot be applied outside the book.
- The content has lot of text and less pictures or use of graphics. No link with the prior knowledge. Link with previously learnt concept is given by just mentioning the name of the topic and class.
- Rule of 4 emphasizes the understanding of the concept in 4 following different ways:
    1. Story
    2. Table/data,
    3. Use of graph Analytics
    4. Visual /images/pictures

  The topic of work and energy has been designed in a way that it, focuses more on the analytics part and little on rest of the three things. Analytics make even the simplest concept scary to students in the introduction part. They can be introduced at a later stage when students have already understood some part of the concept.

- Abstraction makes things more difficult for students to visualize a concept
- Students find it difficult to make relations, as the knowledge in the book can't be related to the real life
- The content designed does not cater to all learning styles

For audio learners -> Audio files have been embedded in the digital book at some places but not for all the topics. These files also open to another page and website from where there files have been taken. Learner has to go through lot of switching of pages while reading one topic only. Audio files don't use any visual while explaining the concept.

For visual learners -> although colorful pictures are included in the book, but static pictures can also hurdle understanding of visual learns. To cater this problem at few places simulations are used but these simulations are not in the control of the learner they are playing and then repeating. This makes learner less in charge of controlling the content.

For kinesthetic learners-> no option for those students who learn by doing. There should be activity for each topic that encourages students to perform some activity with minimum/or easily available resources.

- Order of the content: Order of the content is the same as in the textbook. Every concept starts with a daunting definition followed by the mathematical expression of this concept then leading to more abstract terms. Examples are included after all these explanation. At that time topic has already become horrific for the student.

  Each topic includes an introduction with abstract terms like mass m or force f, it is difficult for a student to actually to relate to those terms right at the beginning of the topic. Physics is a very "abstract" field from a student's point of view. It's not abstract to a scientist, but most students don't see the applications.

- Use of problem based or project based learning.

  No proper pedagogical approach is used to teach a topic. Neither are they given a problem to solve nor a project to follow. They are given a number of problems at the end of each chapter. If they have to solve a problem with step wise instructions and guidance and then they are made to reach a conclusion they will learn more. Learner is not confronted with problems and then there is no help for them to find solutions on their own. Discovery learning is an active process of inquiry-based instruction that encourages learners to build on prior knowledge through experience and to search for new information and relationships based on their interests

- Interactivity

  Interactivity is limited to few controls for examples, switching pages, pausing and starting an audio or simulations. There are no means to control the content and then see its affects .No mean to engage students while teaching any topic. Lack of interesting and fun activities that could have ensured that students would continue reading from this site.

  Student understanding is measured by the number of correctly solved questions at the end of chapter which can be achieved by memorizing only required formulas and solving questions.

- Means of collaboration among students

  Every student can sit alone on his own and rote learn all the concepts, there is no way in that encourages students to collaborate and work together. Though there is an option to share the content but that option only provides a link to email the content to your friend. There is no platform that can initiate a discussion among all the learners.

- Restricted means of expression:
  The only way to know whether student has understood a concept or not, is the right answer to the particular question. There is no other mean to access student understanding of a concept

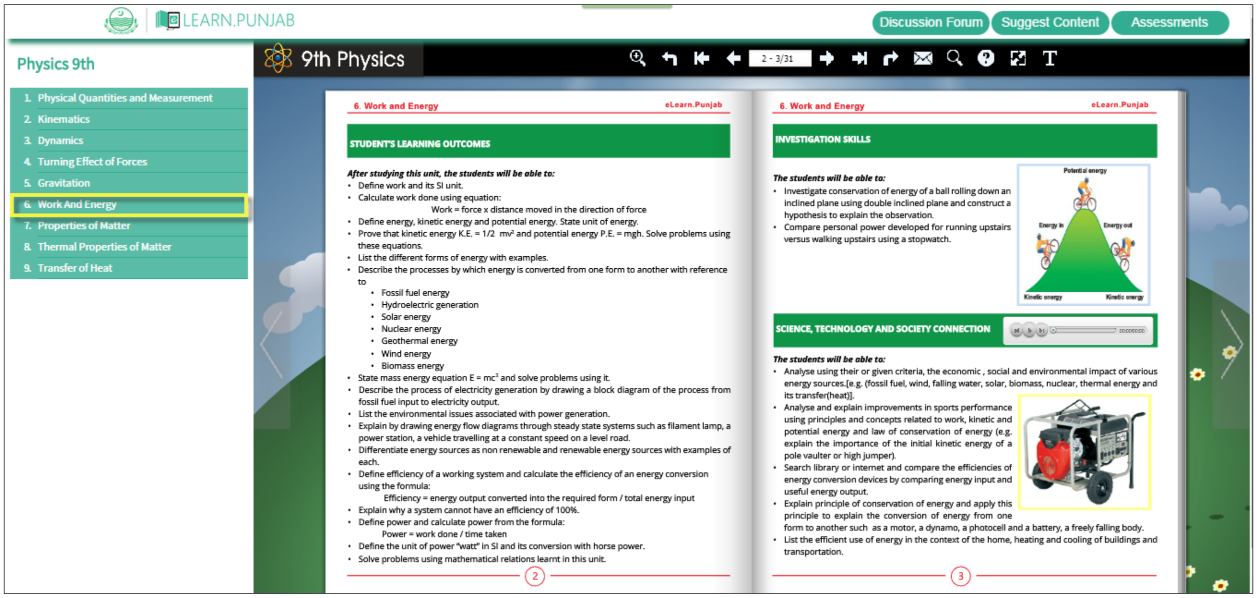


Figure 2.2 Snapshot of Elearn Punjab website

2.9 Learning Application/Educational Software:

With every passing year ICT applications in educational field are increasing and providing more innovative ways for teaching and learning. These techniques provide means to teach existing curriculum more effectively and efficiently. With the availability of bulk of these applications, not all of the applications can be trusted and implemented in the classroom. Educationist and policy makers should be cautions of easy adoption of every technology available in the market. A learning application with right mixture of pedagogy and technology, catering to individual needs of every learner should be used.

An educational software should be easy to use, self-explanatory and more intuitive. Instructional design issues are considered to be the most critical while designing any learning application (Williams, Boone, & Kingsley, 24 Feb 2014). It should be pedagogically, socially and cognitively appropriate for students (Haugland & Shade, 1994)

Effective teaching approaches for the content area of physics subject state that combination of instruction, practice and provision of feedback are the educational components that help to develop cognitive skills among students (Ferguson-Hessler & T., 1993)

Technology can be made integral part of learning if it is utilized to implement inquiry, problem solving and collaboration rather than an isolated compartmentalized part of the curriculum

(Benson, 2003) (Kelley & Ringstaff, 2002). This mostly happens in the textbooks that students have to follow for the entire year. Not only for one subject for all science subjects the content and pedagogy used in the book is the same. Students find it hard to think out of the book, they think that the facts and concepts written in the book remain there only and it has no relevance to the real world. There is not enough time for students to collaborate. Problem solving and inquiry takes time that teacher does not have. As there is massive amount of syllabus that needs to be finished before the exams start. An interactive learning application that can provide all the above things to learners, will make learning experience enjoyable for the learner and he can learn even difficult concepts in an engaging and fun way.

Designers of an educational give special importance to the fact that when there users are young children their software will cater for different learning styles (Shiraruddin & Landoni, 2002)

Howard Gardner proposed his theory of multiple intelligences in 1983. Gardner's theory of multiple intelligences states that child learns in at least in eight different ways (i.e. verbal/linguistic, logical-mathematic, visual, spatial, kinesthetic, musical, interpersonal and intrapersonal. Every child is unique and he/she learns in a different way. In a classroom setup, there are children of every type and each child has his own learning style who can learn better if the information delivered to him in his preferred learning style.

They have different learning styles and different approaches towards understanding and solving a problem. By providing a wider variety of more occupying learning experiences for students, learning for each child can be increased (Steinert & Snell, 1999). This learning design was advocated several years ago by Fox and Ronkowski that an instruction should be designed sensitive to learning needs and learning styles of students so that students strengths can be utilized in the learning process rather than their weaknesses hampering their learning process (Fox & Ronkowski, 1997). When learners use more senses to process information then this information is retained for a longer period of time. Learning environment should also include rehearsal activities at regular intervals to help make learners sense of that information (Wolfe, 2001)

Students show more interest in those activities that give them opportunity to experiment and investigate (Osborne & Collins, 2000). Cerini, Murray and Reiss found that 71% students reported that they find doing science experiment enjoyable (Cerini, Murray, & Reiss, 2003).

Activities that engage students in classroom the most are those that require students to collaborate with class mates be self-directed towards their learning (Hampden-Thompson & Bennett, 2013). Osborne and DeWitt termed those activities and “points of engagement” that were possibly able to encourage and motivate students to study science (DeWitt & Osborne, 2008). The academic activities and peer interaction exercises should be designed in a way that they create positive opportunities for students to participate (Ulmanen, Soini, Pyhältö, & Pietarinen, 2014).

Real life problems should be incorporated in the learning application as there is found to have strong relation between physics content and student’s every day experience (GERBER, 1998).

Learning opportunities should include different preexisting knowledge and variation in teaching methods (LABUDDE, 1997a)

Integrating real life problems in to the learning application provide means for enhance learning and scaffolding. With the help of technology real world scenarios can be communicated in the learning application efficiently (Bransford, Brown, & Cocking, 2000)

Students build meaning and make sense of their environment by interaction with real life scenarios. It is easier for students to learn from those scenarios that they experience in everyday life. This forms the foundation of constructivist learning theory.

The constructivism learning theory which states that knowledge is constructed by the learners with their interaction in the environment. Constructivism theory is one of the major theories of learning and technology. This theory says that in the process of knowledge acquisition learner plays an active role while interacting with the teacher and peers and construct his own knowledge (Harasim, 2012). This theory of learning holds that a leaner first experience with in his surroundings then he reflects on those experiences and then finally constructs his knowledge. Leaners construct knowledge by continuously asking questions. Leaner has a previous knowledge which is called prior knowledge and new incoming information. As the learner encounter with the new ideas, new things and new perspectives he tries to reconcile new incoming information with the prior knowledge. If the new information does not harmonize with the prior knowledge should he discard it or not? If not discard it then should he change his existing views and beliefs or not? This whole process of asking questions to yourself or taking part in a dialog and exploration and reflecting upon our knowledge makes a learner constructor of his knowledge. So knowledge is not constant is absolute but changing as the leaner explores, negotiate, reflect and reassess more. Vygotsky explained process of intellectual development from birth to death instead of focusing on particular period of development. He said that social and cultural differences effect one’s thoughts and language (Harasim., 2012). David Jonassen proposed that learning environments should have provision of multiple representation of the real scenario but at the same time should portray natural complexity of the real world. It should encourage construction of knowledge rather than duplication of the knowledge as it would be of no gain for the leaner. It should help learner to reflect on his concept and understanding. Knowledge should be constructed in collaboration instead of competition. Learner should work jointly in collaboration (Jonassen D. H., 1994).

Constructivism brought new aspect to 20^{th} century learning both in terms of theory and epistemology. It is preferred over behaviorism and cognitivism. Since behaviorism asserts that learning to be tightly controlled by the use of pedagogies and technologies which are associated with the instructional design. Cognitivism was an extension of the behaviorism trying to understand what happens between the stimulus and the response. Mind of the learner is treated as the information processing unit which acquires information by the transmitter. The transmitter in traditional classroom set up is the teacher. Hence there is no construction of knowledge by the learner. Those technologies that use constructivist learning theory as the baseline are called as learning environments or micro world. A computer program that is open-ended and requires learners to give input and perform action is called as a learning environment.

Learning abilities could be improved by game play behavior (Marc Prensky, 2003). Integration of interactive game elements in learning applications improve learner’s efficiency, performance and motivation (Kim, H.S., Kim, S.B, 2005)

Students tend to choose those interfaces that are rich in graphics and have multitasking. As use of these components make learning as a cognitive, constructive and active process. In this process learner tries to create his new knowledge by interacting and looking at the content, experiencing new concepts and then integrating with this prior knowledge.

Visual instructions are considered to be the one way to increase student interest and motivation in the content area. Combination of visual with interactive exercise encourages students to participate actively in knowledge building process. Abstract concepts in science subject can be more effectively taught with the help of interactive exercises (Akdemir, Kunt, & Tekin, 2012). Content area of physics is well suited for games (Hays, 2005; Randel, Morris, Wetzel, & Whitehall, 1992).

It is highly recommended to use visual materials in order to teach abstract concepts (Yalın, 2007), as it helps the recall of information. They are more engaged when a narrative story is present inside the game (Barab, Arici, & Jackson, 2005).

Games are built with clear goals and they give immediate feedback (Dickey, 2005). Along with that maintaining a balance between ability level and challenge and sense of control are the attributes of the game that make it more engaging for students which is strongly associated with student achievement(Shute, Ventura, Bauer, & Zapata-Rivera, 2009). Games attract students to stick to their work despite all the challenges and hurdles this quality of games keep students engaged in their learning process.

Half of the circular model of gameplay is described as feedback (Heaton, 2006). In this mode gamer's input and out reciprocally affect each other (Arsenault & Perron, 2008). Visual and auditory feedback is used to inform player whether his specific action was successful or not. Feedback gives opportunity to player to reflect on their strategy and then reevaluate their decision. If one option appears ineffective then player may change his strategy. In game feedback can be given to player in different forms. In games, players can try again and again unlike traditional classroom (Turkay, Hoffman, Kinzer, Chantes, & Vicaric, 2014).While playing games learner feels he is in charge of his knowledge. Game should be designed in a way to give learner maximum control (Turkay & Adinolf, 2010).Designers of the game should address following questions while designing games for educational purpose. Does game provide conceptual learning and practice? On which learning theory game is based, is game providing immediate feedback? Is game interface appropriate for instructional situation? (Turkay, Hoffman, Kinzer, Chantes, & Vicaric, 2014)

Games are capable to bring together combination of motivating elements in various ways. They provide fun which gives enjoyment and pleasure. They are built on rules so they have specific structure. Goals of the game give motivation as players have to struggle to achieve them.

Interactivity in the games engages them as it requires players to do something all the time. In games learning takes place by giving continuous feedback (Marc Prencsky, 2006).

Many teachers believe that interactive computer simulations provide large number of advantages in imparting physics education. Combination of computer simulation with the inquiry based experiments are considered to be the most effective ones in the learning environment for the students (Zacharia, 2003).

An important aspect of keeping students interactively engaged is by the means of immediate feedback either from the instructor or by the peers (Puente & Swagten, 2012). This aspect of giving immediate feedback to students at the same time, can be provided in traditional classroom setup with the help of an interactive learning application. An interactive learning application has the capability to keep learner engaged, as for each leaner's action there is something happening related to the action leaner has taken.

Activities in the application should allow learner to experiment and alter variables and then witness its effects. In the traditional classroom set up, if given time and chance teacher take students to the laboratory , but either the lab equipment is outdated or not functional or it is too less to suffice needs of individual students. Usually there is one working apparatus on which mostly teacher performs and students just watch it

Visualization is one of the best ways to teach science topics effectively to students. Animation is a type of visualization that has movement of many images in sequence. Every sequential movement of images explains a phenomena or working of scientific principle. By the help of animations information is not only presented in an attractive and engaging way but it also makes it possible for students to perform experiments without any cost or risk. Information is also retained for a longer period of time when delivered through animation (A. Goldstein, 1982). Animations have the power to make abstract concept turned in to real so that they can be viewed and inspected. It is a common practice in teaching physics concept to use animations.

They can be used to introduce a topic to students as these visual representation arouse curiosity and make students more focused towards a topic by stimulating more ideas in students' minds. Animations are proved to be dramatic enough to excite students once they are shown to students (Heckert, 2008).

Animations can act as an instructional support for teachers. Teacher can make use of these animation during the lecture whenever needed. It is helpful for teachers, when teacher wants to explain a concept he first plays the animation, then can ask students about their views regarding that particular animation or he may prompt questions about the concept explained in the display using animation.

An interactive learning application should have combination of authentic activities to impart meaningful learning among students and help them in problem solving and knowledge construction. Authentic activities are very important as they have shown many benefits in online learning environments as well (Jan Herrington, 2003).

Following are the attributes of authentic activities:

- These activities should include student beliefs and values. A learning environment that gives importance to student beliefs and values has the capability to actively involve students in problem solving phenomena (Young, 1993).
- Problem solving sparks creativity in students (Marc Prencsky, 2006).
- Activities should be inspired from real world problems and have appropriate level of complexity (Jonassen D. , 1991). When students find activities that have real life relevance then they engage more
- Students carry out systematic inquiry to find solution of single complex problem by following series of activities. These activities are logically related to each other (Bransford, Vye, Kinzer, & Risko, 1990).

A lot of literature has been published on the attributes of authentic activities which states that authentic activities have real world relevance. They consist of tasks that students have to investigate over a sustained period of time in collaboration. Most importantly students are given chance to reflect on their understanding and their knowledge (Reeves, Herrington, & Oliver, 2002).

These activities indulge learners in the learning process, making them capable to self-regulate their learning and learning behavior by taking part in personal and collaborative knowledge construction process. These are the key principals of engaged learning environment (Tan, Hung, & Cheung, 2004)

Chapter 3

3. Methodology:

We have capitalized on older idea of computer based simulations as proposed by Lee in 1999 (Lee, 1999). The interactive learning application is played after expository lesson delivered by the teacher. We define interactive learning application as relatively simple computer application that does not require special skills to play by the users. The educational objective of such application is to help students clear their concepts and to reinforce and integrate part of the knowledge learnt in expository lecture (Thomas & Hooper, 1991). Thus this approach helps students in better understanding of core concepts. Students can play the interactive application as many times as they want, they are also provided with the web link of the application to practice and learn concepts at home also.

3.1 Overview of the application and its targeted outcomes:

In this research it was targeted to teach concept of work and energy to students by playing different interactive activities. This application uses four daily life scenarios to teach students in which case work done is maximum and in which case work done is zero. Students can choose any one option out of four available options given in the menu screen. Students should have freedom of choice so that they perform activities for their own sake. Fun is associated with playing for pleasure (Draper, 1999).

All of the scenarios have interactive activities, user has to perform certain actions to move forward. This keeps student engaged and controller of the application. Lennon and Maurer proposed that for an educational software to be played and made useful for learning for children it should have real world scenario, media rich, challenging and controllable environment (Lennon, 2004). Activities should be inspired from real world problems and have appropriate level of complexity (Jonassen D. , 1991).

With the help of ICT rich environment, information was represented in different forms. Those different forms included text, visuals, simulations and tables. Learner was given freedom to enable or disable a control and see what happens in response to those changes in the control. This approach helps students to learn different complex processes in science (Jonassen, 1994). Information was organized in small chunks so that it does not become boring or tiring for students while using this application. The concept of work done in different scenarios was explained in four different modules so that at one time learner can concentrate on one situations thus making it less distracting and more focused for students.

Human being process information for ten to twenty minutes before psychological dullness or boredom takes place and they are distracted (Sousa, 2006). Adhering to this concept, the application is designed in smaller and simpler chunks for both the topic of work and energy.

3.1.1 Application Design:

This application was designed was grade nine students. The national curriculum for grade nine was considered before designing the application. The flaws in the already designed content were noticed and extra caution was taken while designing the digital interactive learning content. The topic “Work and Energy” was picked from the grade 9 physics book published by Punjab textbook board. This was the sixth chapter in the book. Basics of this topic had been covered in class 5^{th} science topic of “energy” and class 7^{th} topic of “Input, output and efficiency”. Successful understanding of this topic will help students in learning work and energy in high school and use those concepts in solving real life problems.

For work topic, there are four components covering four different scenarios. For energy there is only one scenario of gravitational potential energy. The number of visual learners are more as compared to any other type of learners (Riggs & Gholar, 2009) that is why interactive visuals and images are used in this application. Instructional design was mapped to student learning outcomes. At the end playing with the application every student should be able to answer questions related to work and energy concept. Depth of these concepts covered is the same as in the physics book of grade 9 students.

Pedagogical approach of problem based learning is implemented in the application. Learners will be given formal instruction on the topic followed by topic’ real life interactive problems.

As learner will play this application in each scenario he will be facing a real life problem. Those real life problems have been taken from the daily life scenarios of Pakistani students. In order to solve that problem they will choose different options and use multiple controls to reach at the solution. In this journey learner will learn the concept. There is no negative marking for choosing a wrong option or going in the wrong direction instead leaner is given feedback at every instant to correct his choice and then move forward.

Furthermore the application is supported with audio and textual information. In this way learners will use more senses to process information and retain information for longer period of time. Learning outcome of each scenario is stated at the beginning of every scenario.

So that learner already knows what he will understand at the completion of any specific scenario. This approach also helps him to focus his time and energy and engage in active learning (Barkley, 2010)

Figure 3.1 Options Screen

Scenario 1: Ice-cream Truck:

This scenario explains the situation in which work is done. Force applied in horizontal direction and displacement also covered in horizontal direction.

Figure 3.2 Screen shot of truck scenario 1

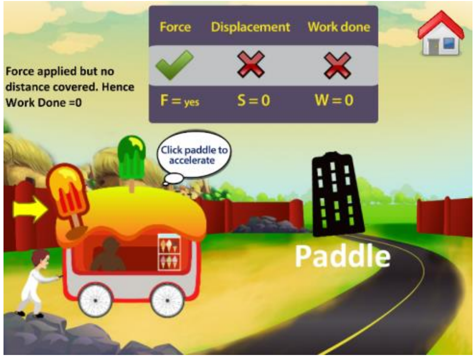


Figure 3.3 Screen shot of truck scenario 2

User is asked to move the truck by applying force on it, as user presses the truck the table for force, displacement and work done is updated. The table shows the though force is applied but still truck is not moving and no work is done as brakes are applied. To accelerate the truck press paddle.

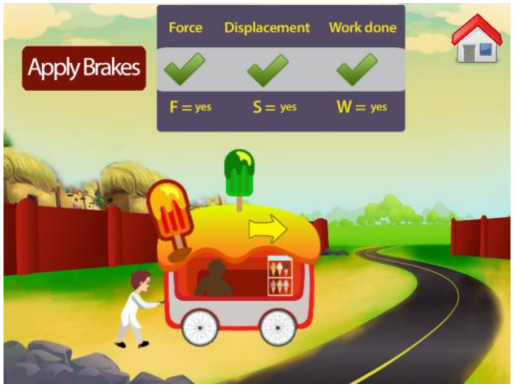


Figure 3.4 Screen shot of truck scenario 3

Figure 3.5 Screen shot of truck scenario 4

As accelerator paddle is pressed, truck moves forward and table for force, displacement and work done is updated to show that now force is applied, displacement is taking place hence work is done. To stop the truck again click the apply brakes button. Information related to work done on the ice-cream truck can be quickly changed and observed by altering various controls. This helped learner to evaluate the effect of one variable on the other. The visuals were connected to the table on the table. By playing with the scenario, changes were updated in the table for easy understanding of the learner.

Scenario 2: Fly Balloon:

This scenario explains the situation in which work is done in vertical direction. Force applied in vertical direction and displacement covered in vertical direction.User can visually see and interact with the whole scenario. Visual information is saved after less than a second, kinesthetic informatio for 2 or 3 seconds and auditory information after 4 seconds in brain (Keles & E.ve Cepni, 2006)

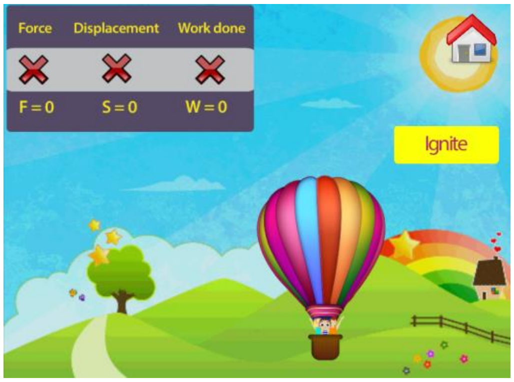


Figure 3.6 Screen shot of balloon scenario 1

Figure 3.7 Screen shot of balloon scenario 1

User is asked to ignite the balloon. As balloon is ignited flames are shown below it to tell that ignition has taken place. The table for force, displacment and work done is shows that force is applied but since no displacement covered so work done is zero.

Figure 3.8 Screen shot of balloon scenario 3

Figure 3.9 Screen shot of balloon scenario 2

As the balloon tends to move upward table is again updated to show that now work is done. Movement of the balloon is shown by the animation. Learning process is more engaging and interesting for students when it has components of text, graphics, sound and animation (Inc, 1999) . User may check what is the displacement covered by the balloon by clicking on the button. To explain more about the angle betwwen the force and displacment user is taken to another screen to view (theta).

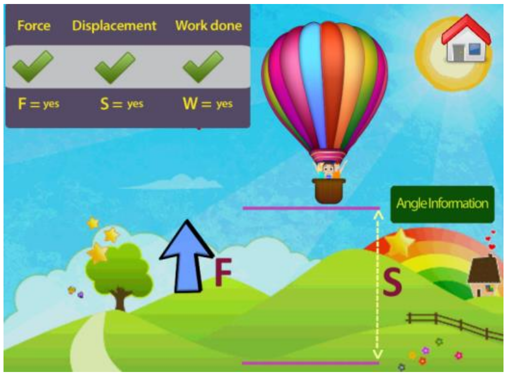


Figure 3.10 Screen shot of balloon scenario 5

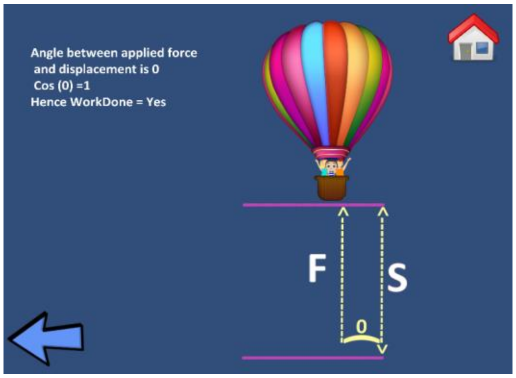


Figure 3.11 Screen shot of balloon scenario 3

Scenario 3: Walk to School:

This explains the scenario of work done on a specific body. What would be the work done on a body when force is applied on upward direction and distacne is covered in horizontal direction? Walking towards school is common scenario for people living in pakistan. It is one of those examples to which every child studying in school can easily relate to. Examples for the subjects should be taken from real life (Civelek, Erdem, & Gokcol, 2012).

Animation of a boy walking towards his school is used. Boy is holding books in his hands. By clicking on “Click to move boy” button boy starts walking towards the school.

Figure 3.12 Screen shot of school walk scenario 1

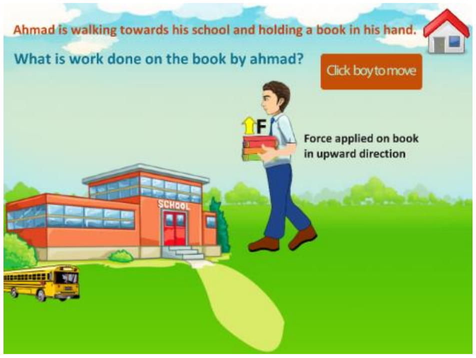


Figure 3.13 Screen shot of school walk scenario 1

The boy stops when he reaches near to school. To view angle information between the books and displacement covered user is taken to new screen.

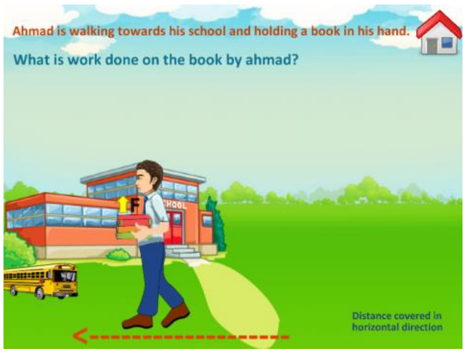


Figure 3.14 Screen shot of school walk scenario 3

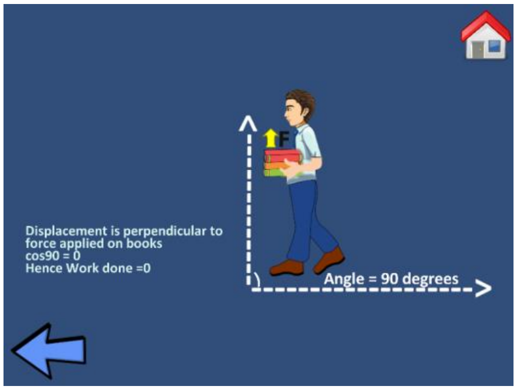


Figure 3.15 Screen shot of school walk scenario 2

Scenario 4: Cart Moving Uphill:

In this scenario simulation is used to teach students what would be work done when force is applied on a specific angle. Moreover two bodies can have same amount of work done if the displacement is same for both of the bodies. In that case the amount of force applied on each body and angle between the forces applied and displacement should be different for both of the bodies. Simulation of physics topics stimulate more senses by providing interactive learning opportunities to learners. They have power to increase student motivation and make lessons fun. Information is learnt faster and stored for longer period of time. By use of simulations students are more capable to consolidate concepts and improve their analysis and problem solving skills (Civelek, Erdem, & Gokcol, 2012).

User finds two questions at the start screen in which a girl is confused. On the next screen a simulation is used. Simulations are more effective for physics experiments as they provide dynamic environment in terms of graphics, sound and visuals (Koselglu & F.Ve Kavak, 2001).

A cart is moving uphill at the angle of 45 degrees. As the cart moves the work done is calculated.

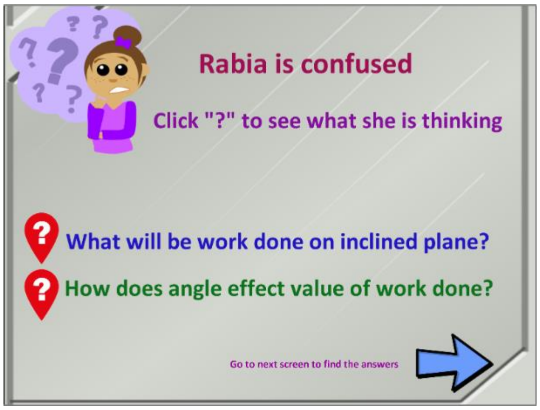


Figure 3.16 Screen shot of cart activity 1

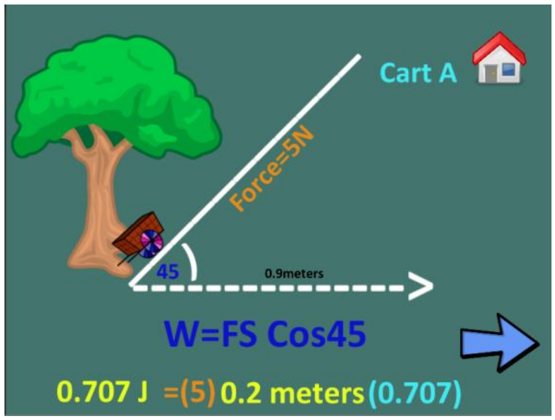


Figure 3.17 Screen shot of cart activity 2

Similarly on the next screen same cart is been lifted at 60 degrees angle and work done is calculated for this cart. On the next screen both scenarios are combined so that user can see at a glance what is different in both the scenarios. Change in what factors led to the same amount of work done for both carts.

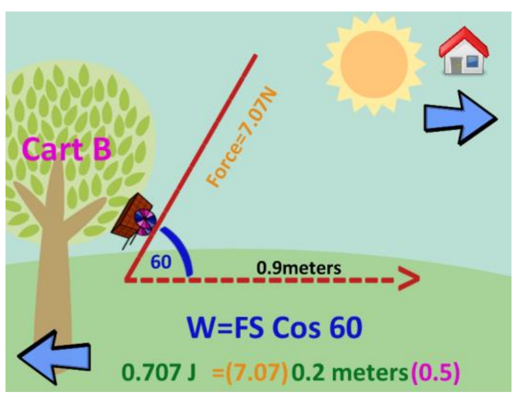


Figure 3.18 Screen shot of cart activity 3

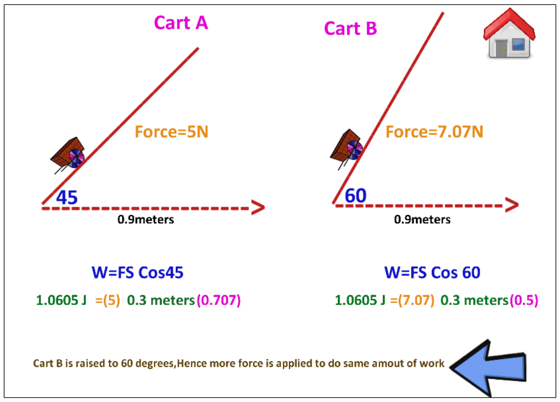


Figure 3.19 Screen shot of cart activity 1

Potential Engergy Scenario:

This scenario is added in the application to teach students abou the potential energy. The book students are currently following explains potential energy by the help of only matematical notation only. Students said it was hard for them to understand that mathematical equation with out any background of the concept. Potential energy is defined as the energy stored in the body as a result of its position (Jain, 2009).

The explains this phenomena in the form of a story of a boy, who is hunrgy and is looking for food to eat. The leaner will help the boy to find food by clicking on the various interactive elements of the scene.

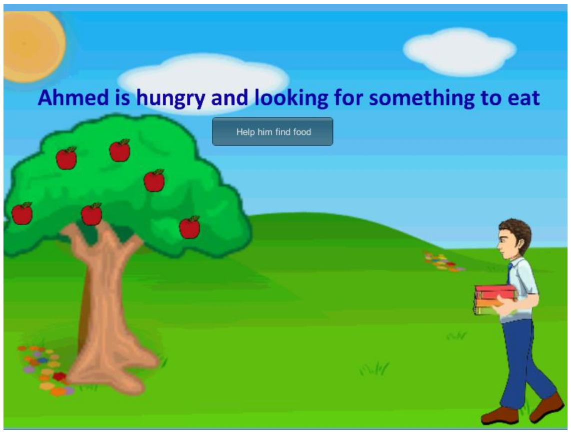


Figure 3.20 Screen shot of potential energy scenario 1

Figure 3.21 Screen shot of potential energy scenario 2

The boy finds food on the tree. To help him walk towards the tree, learner has to press arrow keys to make him move closer to the tree.

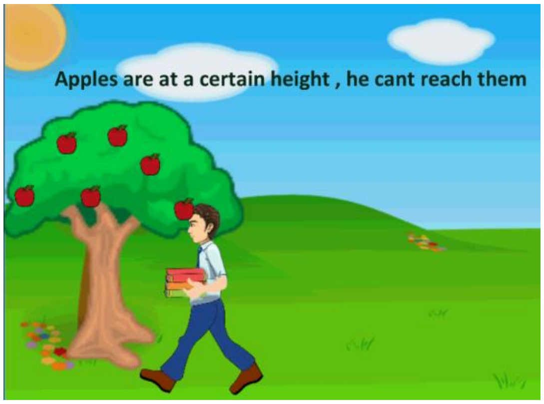


Figure 3.22 Screen shot of potential energy scenario 3

Figure 3.23 Screen shot of potential energy scenario 4

As the boy reaches near the tree, he encouters another problem. The apples are at a certain height and he cannot reach them. The reason for choosing apples as the food item , is that by the help of this example students can easily understand concept of potential engergy as apples are at a certain height. Learner can click on the apples and see the potetnial energy stored in them at that specific height.

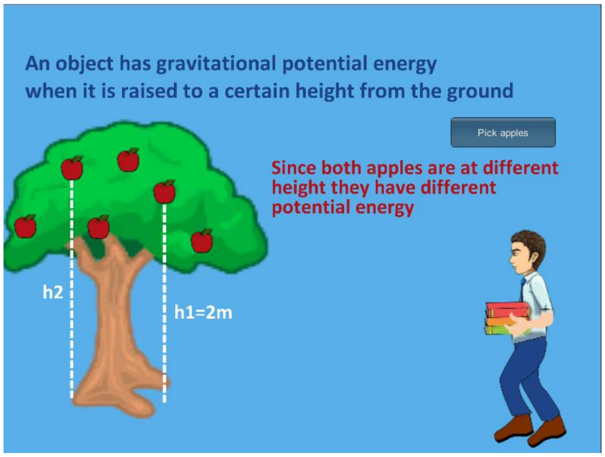


Figure 3.24 Screen shot of potential energy scenario 5

Since potential energy varies depending upon the height, so for two apples at different height will have different potentail energy.

Once reached at this screen , leaenr can then attempt to pick the apples from the tree. Stick is provided to the boy to help him pluck apples form the tree. Potential energy of the apples that the boy is trying to pluck from the tree is shown with "mass", m and "gravity" g as the contants and only variable is the "height"h. As the apple tends to fall towards the ground this height will keep on changing at every instant and hence value of potential energy for this specific apple will also change.

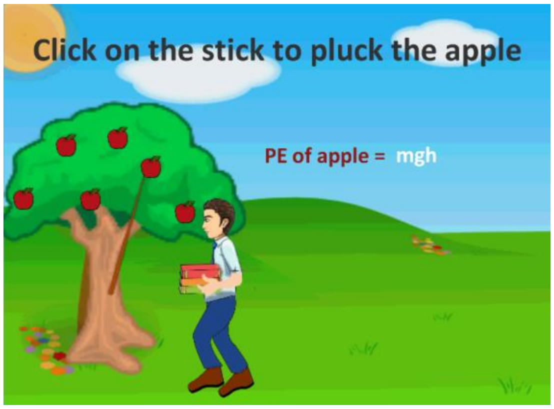


Figure 3.25 Screen shot of potential energy scenario 6

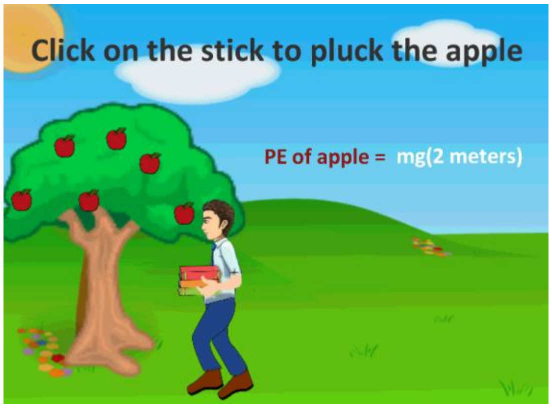


Figure 3.26 Screen shot of potential energy scenario 7

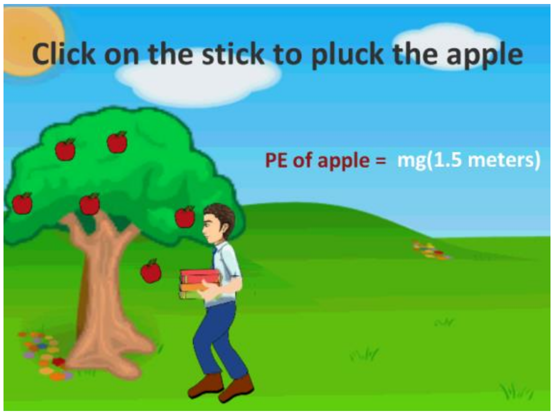


Figure 3.27 Screen shot of potential energy scenario 8

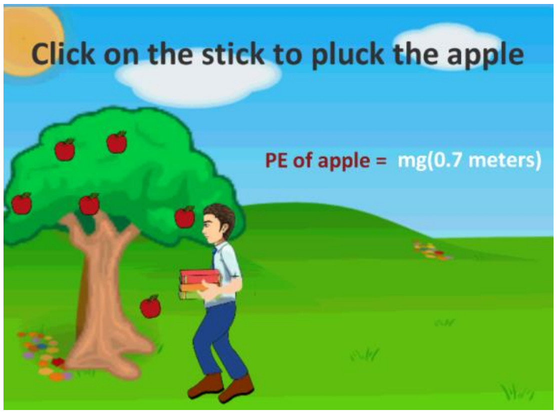


Figure 3.28 Screen shot of potential energy scenario 9

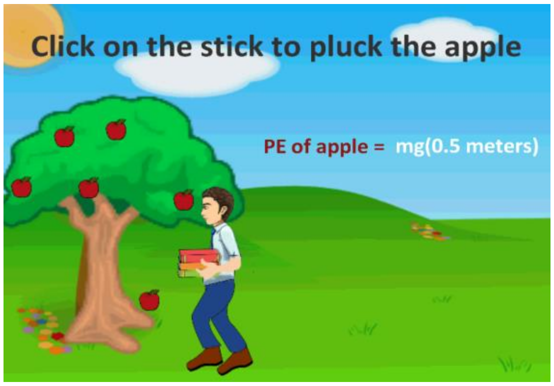


Figure 3.29 Screen shot of potential energy scenario 10

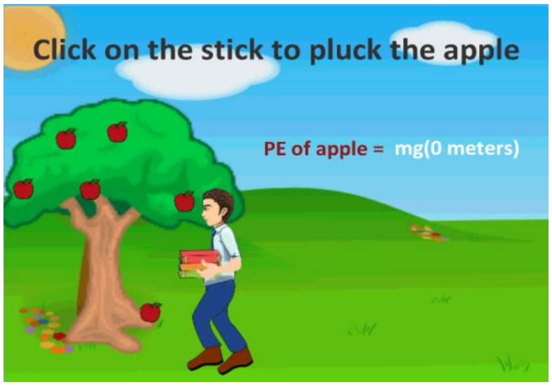


Figure 3.30 Screen shot of potential energy scenario 11

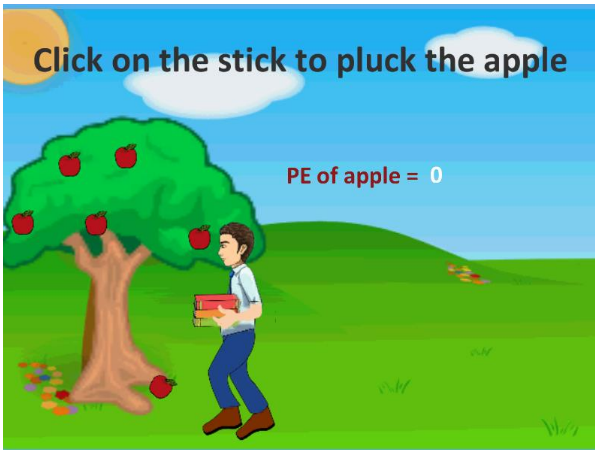


Figure 3.31 Screen shot of potential energy scenario 12

3.2 Usability testing of the application:

Usability testing is defined as a process in which participants are the representative of the target population and these participants evaluate the degree to which a product meets specific usability criteria (Rubin, 1994). Generally usability issues are extracted by observing users while they are using the system. Feedback is also collected from users in order to identify usability problems. This approach is helpful in discovering usability problems caused by human errors which may ultimately lead to termination of interaction with the system (Chen, Lau, Chuah, & Teh, 2013)

This application will be used by variety of different users which includes teachers, students, content designer and pedagogists. Thus participants of the usability tests were picked to be representative of target population.

This usability testing was carried on twenty users who varied in age, gender, experience, computer usage, education and interest in physics subject. The application had to be stable and free from all the bugs or errors before to be used by the students. To ensure stability and usefulness of this application usability testing was conducted.

The usability test undergone four stages as described in (Nielsen, 1993).

1. Preparation
2. Introduction
3. Running the test

4. Debriefing

1. Preparation:

Usability testing was conducted at three different places. The distribution of the location was done to provide comfort to the users. The three locations are:

1. School where this study was undertaken

   In the school the application was tested on different users of grade 9 students who were not part of control and experimental group.

2. NUST
3. Ideofuzion Office in I-8/2

To minimize any sort of inconvenience for the user the application was installed and run before arrival of the users. Any screen saver running on the computer, other pop up notifications for example email notifications that may otherwise interrupt users in the experiment were turned off (Nielsen, 1993)

2. Introduction:

In the introduction phase test users were welcomed by the experimenter and gave brief description of the purpose of the test. Participants were also requested that they may not discuss this application with other participants who will be testing this application later.

3. Running the test:

During the test the experimenter was refrained to pass any comment or interact with the participants. He did not pass any personal opinions or judged user performance whether he was going well or bad. If at any stage participant stuck or faced any difficulty in the test where the aim is to time user performance, experimenter was not allowed to help him. Data collection technique depending upon the measuring method. In those cases where time was to be measured stop watch was used and for counting the clicks of the user paper pencil was used.

4. Debriefing:

Once the test was over, the participant was asked to give any comments. Those user comments may not lead to any tangible changes in the interface but they were saved as the rich source of information.

Each usability test is been measure with different measuring concept depending upon its functionality. Three measuring methods have been used:

1. Number of clicks
2. Time
3. Number of times user is misled from the interface

Following usability test results did not give satisfactory results and needed revisions of the user interface.

a) Option to go back to home screen

Previously home button was shown to the user once they have completed the scenario.
It was observed that lot of participants wanted to attempt the activity part in the middle of the scenario or wanted to go to another scenario.

b) Click paddle in the ice cream truck scenario

The paddle appears in the ice cream truck scenario screen and it is supposed to be pressed to move the truck. It was observed that lot of participants found it difficult to see, their focus did not go to left corner of the screen to click on the paddle. Though they managed to find that paddle and clicked it also but some participants said that they got panicked then they could not find it. For novice users who were not using computer on daily basis or not familiar with interactive controls they had difficulty while doing this task.

c) Complete scenario for playing with cart activity

Most of the participants said that it took them really long to understand what is going on the screen. As the screen has too much going with in it, it was difficult to make out what is the effect of one parameter on the other.

The order of the content in playing with cart activity was found to be very confusing as when first screen comes there are two carts just moving upward at different angles. Students reported that learning outcome of this screen was not established before. This design led to no learning even after user has seen carts reaching the peak of the incline plane. This problem was faced by most of the participants belonging to different age groups, having different computer expertise and varied likeliness towards physics subject.

d) Choose correct option in angle related question

This usability issues is directly related to the playing with cart activity. It was observed that how many participants gave correct answer to angle related question in one attempt. Confusions faced by the participants in the “playing with cart” scenario, were depicted in the activity section for this concept. Lot of participants gave correct answer after two or three clicks. Hence result of this usability issue further enforced that user design for the playing with cart scenario should be revised.

There are four test cases. Corresponding to each test case its measuring concepts, measuring method and best/planned result of the test case is mentioned. Along with that average and standard deviation of usability test conducted before and after redesigning the user interface is been recorded. The changes in user interface led to second version of the application which was found to be more stable. The second round of usability testing was conducted with same room settings and places but this time it was tested on different users.

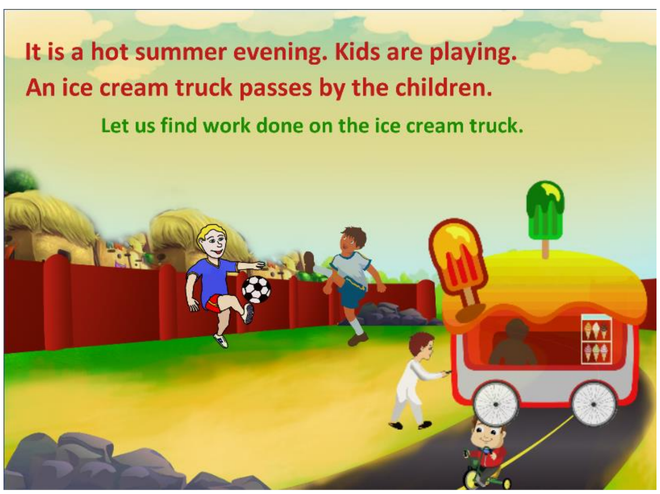
Usability test results of the four test cases is mentioned below. The values of average and standard deviation showed that in which test case design revision should be taken and in which case there should be no change in the user interface design.

3.2.1 Usability test results:

TEST 1			
Measuring concept:		Go to home page directly from Ice cream truck scenario	
Measuring method:		Number of clicks	
Best/planned		1 click	
Before			After
Average		5.3	1.05
Standard Deviation		1.63	0.2

Table 3.1: Usability test 1

Solution: Add icon to go to home screen at any time.

Before	After
	

By adding this option, user does not have to go through the entire process every time.

He can go till the screen he wants to go and then go back to home screen to choose another scenario, go to activities section or consult definition.

TEST 2		
Measuring concept:	Click "Paddle" in Ice Cream Truck Scenario screen	
Measuring method:	Time (seconds)	
Best	8 secs	
Before		After
Average	18.35 secs	7.9
Standard Deviation	2.680	1.19

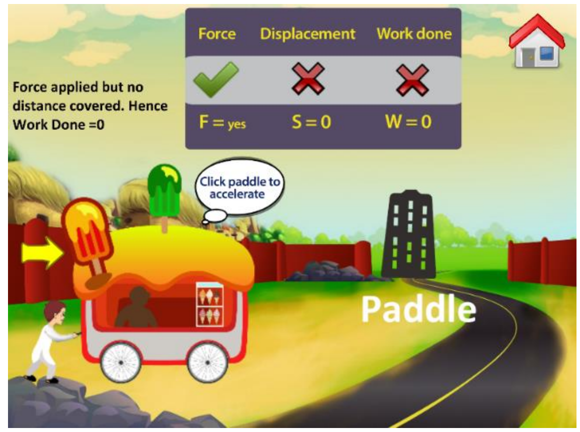
Table 3.2: Usability test 2

Result: There is significant difference between the average and standard deviation of the values before and after adding the home button option. Later values show that result is close to the best/planned level.

Solution:

Following changes are made:

- Position of the paddle is changed
- Paddle is moving (growing and shrinking in size) to get attention of the user

Before	After
	

Result: There is significant difference between the average and standard deviation of the values before and after incorporation the changes in paddle option. It was brought in to the focus by changing its position and adding animation on it.

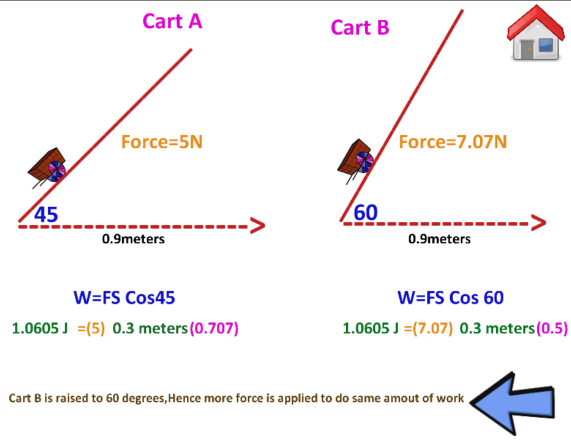
TEST 3		
Measuring concept:	Complete scenario for "playing with cart"	
Measuring method:	Number of times user is misled from the interface	
Best	0 times	
Before:		After:
Average	3.95~4	0.3
Standard Deviation	1.8~2	0.6

Table 1.3: Usability test 3

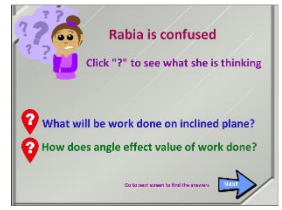
Solution:

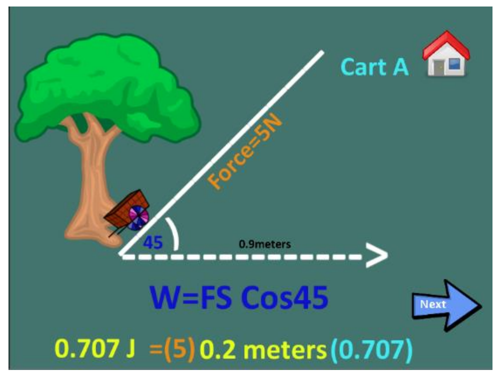
Story was incorporated in the scenario as stories are considered to be the traditional way of transferring knowledge (Bishop & Glynn, 1999). A large amount of research has been done that explores multiple benefits of stories for enhancing learning (Bergman, 1999; Boje, 1995; Davidhizar & Lonser, 2003; Miley, 2009)

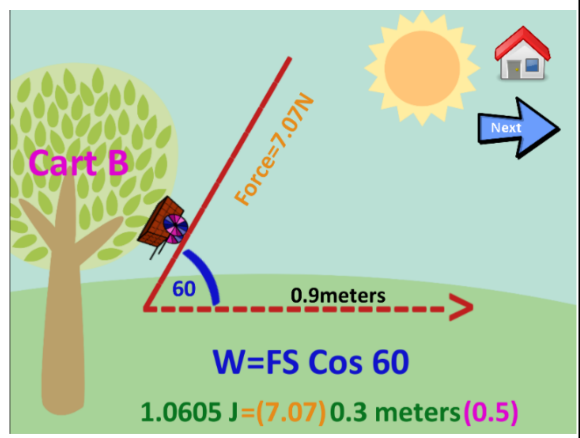
Instead of explaining effect of 45 degree and 60 degree angle on one screen, separate screens were designed for both cases. Once learner has understood one case only then he moves to the next one. This approach was adopted to make learner focus on one cart at a time. After both cases have been understood then a comparison screen will be shown on which two carts at moving at different angle will be shown.

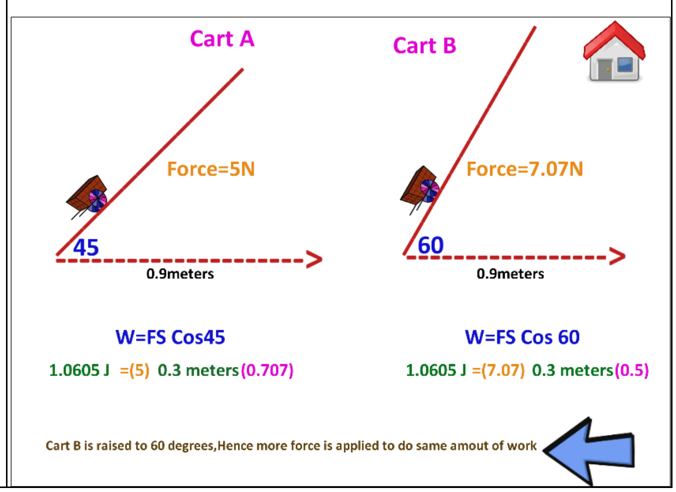
<table>
<tr><th>Before</th><th>After</th></tr>
<tr>
<td>


</td>
<td>







</td>
</tr>
</table>

TEST 4		
Measuring concept:	Choose correct option in angle related question	
Measuring method:	Number of clicks	
Planned	1 click	
Before:		After:
Average	1.8 ~ 2	1.1 ~1
Standard Deviation	0.7677	0.3

Table 3.2: Usability test 4

As the user interface for the playing with cart activity was re designed, most of the participants gave correct answer to the activity related to this concept in first attempt. Participants also reported that it was easy to solve this activity after going through "playing with cart" activity.

3.3 Research methodology:

3.3.1 Research design: Qualitative and quantitative data analysis

The school had three sections of grade 9 students. Each section had sixty students each. Out of those three sections only two had to be chosen for the quasi control experimental research design. In which one group would be taken as the control group and the other group as the experimental group. There were two teachers teaching physics to these three sections.

Hence those two sections were picked who were being taught by the same teacher.

The teacher was strictly instructed not to share the experiences of experimental group inside the control group. To ensure this the observer was present in all the classes of control group also. Total sample size is of 120 students. In which 60 students were made part of control group and other 60 students were part of experimental group.

This study followed convenience sampling technique. The school was located in Islamabad and in the area where daily commutation can be easily taken place. As the researcher had to visit school every day for more than three weeks it was found to be the most suitable place. In this study the use of interactive learning application is an independent variable and student engagement is three dimensions (cognitive, behavioral and emotional) is a dependent variable.

Since the samples were not collected randomly. It was a quasi-experiment design.

The two groups of students was found. Manipulation was introduced that should change the people. The important part is that sample needs to be test again to see if there were any changes. To ensure that change pretest and posttest were conducted. The order of conduction the pretest and posttest was as follows:

1. Participants were tested before the experimental manipulation.
2. Experimental manipulation was performed in which one group was given interactive physics learning application to play and learn from while other group studied in traditional manner from text book.
3. Participants were tested after the manipulation to see what changes occurred

Data was collected through quantitative as well as qualitative means. There were four ways by which data was collected:

1. Student engagement questionnaire
2. Focus group discussion
3. Student engagement walkthrough check list
4. Student Achievement test

Quantitative data was gathered by pre and post test conducted for both the control and experimental group. This data was collected through the questionnaires. It was coded in the SPSS software and then analyzed.

Student engagement questionnaire and student achievement test provided data for quantitative data analysis. While focus group discussions and student engagement walkthrough checklist provided data for qualitative data analysis.

Hypothesis	Tool	Data source
Use of interactive learning application in classrooms leads to significant difference in student engagement	Student engagement questionnaire	Questionnaire
	Student Achievement test	Questionnaire
	Focus group discussion	Interviews + Discussions
	Student engagement walkthrough check list	Observations

Table 3.5 Tools and data sources

Quasi experimental approach was used to study whether there was significant increase in student engagement of the group that used interactive physics application compared to the group that followed traditional classroom setup without use of that interactive application. There was one control group and one experimental group each group having 60 students. Pretest of both the groups was conducted to justify that it was fair to conduct research on both the groups. The pretest score of both the groups was found to be almost identical. T test analysis of pretest scores also verified that there was no significant difference between the pretest scores of both the groups.

In experimental group students were taught work and energy topic by use of interactive learning application while in control group text book was used to teach the same topic.

This intervention took place for two weeks and six days in a week. Duration of each class was 45 minute. Students from experimental group were taken to the computer lab and learning application was already deployed in the computer lab before the physics class began and students came to the lab. Teacher was acting as a facilitator, helping students if they found any difficulty and maintaining class discipline and order. In all of the classes students used to use the application for half an hour and then teacher would talk to them either accessing what they have learnt in this time or gave them homework or assignment for next class.

After that a post test was conducted with both the control and experimental group. Post test score were calculated and compared for both the groups in SPSS.

3.3.2 Research constraints:

Constraints of this study includes the limited time for development of the interactive physics application. As development did not only involve coding but designing of the assets, story boarding and scenarios specific to the Pakistani society for the application. This application has localized content designed specifically for the students of Pakistan, which means that new scenarios and story boarding had to be done as any other material from foreign books could not be taken. This approach was adopted specifically so that students can relate to those scenarios which they see in real life.

The school that gave permission for the intervention were teaching topic of "Work and Energy" in June 2015. This means that the application should be completed and tested for any usability issues before deploying in the field. The application should be stable and ready to use for the students in their classrooms before June 2015 so that students' and teachers' time is not wasted by waiting for the application to get finished.

3.3.3 Research site:

The study was conducted in a school located in Islamabad. School has classes from grade 1 to grade 10 with the availability of computer lab equipped with internet access. This research was conducted on grade 9 students. Informed consent (Cohen, Manion, & Morrison, 2007) had been attained from school authorities to conduct this research before the intervention started. This school was chosen as it was easily accessible and permission was also granted.

The topic “Work and Energy” was picked from the grade 9 physics book published by Punjab textbook board. This was the sixth chapter in the book. Basics of this topic had been covered in class 5th science topic of “energy” and class 7th topic of “Input, output and efficiency”. Successful understanding of this topic will help students in learning work and energy in high school and use those concepts in solving real life problems.

3.3.4 Participants:

Participants were students of class 9 who were studying physics. Intervention was scheduled to take place when student were studying this topic in their class so that their time was not wasted and they can equally benefit from this study. This school has three sections of grade 9, each section has 60 students each. Two sections were chosen to become part of control and experimental group each. While the third section was reserved for usability testing of the software. This approach was adopted so that the students who test the application in initial phase will not use the application later in the class. So over all there were 60 students in the control group and 60 students in the experimental group.

3.3.5 Ethical Issues/Concerns:

The permission for the intervention had already taken in advance. Convenience sampling was done as the school was in the vicinity of Islamabad and already had the availability of computers and internet (Cohen, Manion, & Morrison, 2007).This was a convenience sampling method as the participants of this research were easy to reach. The school was located in the Islamabad and so were the observer and principal investigator. The intervention continued for about three weeks and later on there were days allocated for focused group discussions and filling of questionnaires which required daily transportation to the site.

The principal and the teachers were already informed about the duration of the study and how it will be conducted in their school and signed the informed consent form (Appendix D).

Students will be highly encouraged to fill all the questionnaires with full honesty though they will not be forced to do that (Cohen, Manion, & Morrison, 2007). Students will have to fill questionnaires (as attached in the annex B) before and after the intervention and extra time for focused group discussions with the students and teachers was already informed. It was promised that results and data collected will be kept anonymous and students name will not be shared. This research will propose solutions to improve school's current situation. At any time school authority is free to withdraw themselves from this study.

The only discomfort involved for students is that they will have to go to computer lab from their classroom in physics period for three weeks. But the teacher and principal of the school both were eager for this intervention as now students would be learning in more engaging and fun way without their time been waster.

At the time of data collection when students had to fill the questionnaires and attend focused group discussion, if any student/students was absent then researcher visited school again to collect responses of those students.

3.3.6 Data collection technique:

One week was allocated for data collection. Two days were allocated for students to fill questionnaires. Four days to have focused group discussion with students. In this time "completeness", "accuracy" and "uniformity" (ibid) was be ensured and necessary measures were be taken to ensure them. The response collected from the questionnaire were further triangulated by focus group discussion with the teacher and students and walk through check list.

3.3.7 Tool to measure engagement:

Student engagement was measured in response to student's answers recorded corresponding to each question. The questionnaire was developed after reviewing already established tools to measure student engagement. Tool used to measure student engagement is the one developed by Dr Ellen Skinner at Portland State University. This tool is adapted from assessment package created by University of Rochester in 1987 and 1991. The tool included positive manifestation of behavioral and emotional participation of students (Skinner E. , 2009) Tool tends to measure student active participation in classroom activities (Connell & Wellborn, 1991). The tool used in this study is attached in annex: B

The tool is checked for validity and reliability in the study conducted by Ellen Skinner (Skinner, Furrer, Marchand, & Kindermann, 2008). The tool measures emotional and behavioral engagement of students. To measure student's cognitive engagement walkthrough check list and student achievement test was conducted for both the groups.

Since this tool was used in different demographic setting so it was recommended to calculate the reliability of this tool again. The reliability of this tool was calculated in SPSS software. The tool was evaluated for two dimensions of engagement i.e. emotional and behavioral. For the case of emotional engagement the value of Cronbach's Alpha is 0.8. Since this value is more than 0.7 and less than 0.9 hence it can be considered reliable. For the case of behavioral engagement the value of Cronbach's Alpha was found to be 0.794 ~0.8.

The questionnaire had Likert scale to measure student engagement in three dimensions. It provided students a range of responses to a given question or statement (Cohen, Manion, & Morrison, 2007). Likert scale options were given corresponding to the questions to measure student engagement. Following options were given in the scale a. never, b. on occasion, c. some of the time, d. most of the time, e. all of the time.

Research question formulated for this study is "what is the effect of interactive physics learning application on student engagement in Pakistan?

Null hypothesis that we tend to fail to reject or reject in this study is as follows:

Null hypothesis: H0 = Use of interactive learning application in classrooms does not lead to any significant difference in student engagement.

Alternate hypothesis: H1 = Use of interactive learning application in classrooms leads to significant difference in student behavioral engagement

Alternate hypothesis: H2 = Use of interactive learning application in classrooms leads to significant difference in student cognitive engagement

Alternate hypothesis: H3 = Use of interactive learning application in classrooms leads to significant difference in student emotional engagement

3.3.8 Data Analysis technique:

Data was analyzed by research question. As in this approach coherence of the data was preserved and all the relevant data for the research question was gathered. Multiple sources of data had been collected so that triangulation of data can be done.

Multiple data gathering sources included different streams of questionnaires, interviews and walk through checklist to give collective answer to the research question (Cohen, Manion, & Morrison, 2007).

How data will be analyzed?

1. Data was analyzed by comparing responses of both the control and experimental group in post test
2. Responses given in the questionnaires were matched with walkthrough checklist as filled by the observer.
3. Deviant and negative cases will be analyzed
4. Frequencies of occurrences and responses were calculated
5. Focused group discussions were conducted to further make the findings strong and gain more rich information related to this study in view of both the students and the teachers.

Chapter 4

4 Results:

4.1 Analysis of Student Engagement Questionnaire:

Pretest and post test scores of both the groups was coded in the SPSS software. Data was analyzed statistically in SPSS software for this research. Average pretest score for control group was found out to be 42.8 approximately 43 and 43.75 approximately 44 for experimental group. These scores indicated that it is justified to conduct quasi control experimental research on this sample. As there was less difference between the means of both the groups. Descriptive analysis was performed on the pretest scores of control and experimental group and results is shown in the table below:

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Experimental	60	43.75	6.819	.880
	Control	60	42.83	5.311	.686

Table 4.1: Pretest Score - Control and Experimental

Independent t-test was performed on the pretest scores showed that there was no significant difference (p>0.05) between the two groups.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pretest	Equal variances assumed	2.947	.089	.822	118	.413	.917	1.116	-1.293	3.126
	Equal variances not assumed			.822	111.329	.413	.917	1.116	-1.294	3.128

Table 4.2: T test on pretest of control and experimental group

Independent t test was run on the posttest score of both the groups. Significance values chosen is 0.05 which makes the confidence interval of 95%. Confidence interval of 95% indicates that on 95% of occasions, which indicates that when our sampling is repeated it would be expected that 95% of the times differences would lie within these parameters. There are two precondition tests that need to be run for Independent t test to run. These are:

1. Test for normality

2. Test for homogeneity of variance

- Tests for normality was conducted in order to check if the sample data was normally distributed or not. There are two tests that give this value. Kolmogorov-Smirnov test and Shapiro-Wilk test. Shapiro Wilk test was used, as it is the most appropriate test for sample sizes for 0 to 2000. In our study the sample size was of 120 students hence Shapiro Wilk test was used.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Exp	.092	50	.200*	.962	50	.110
Control	.117	50	.087	.957	50	.069

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 4.3:Test of normality for control and experimental group

P-values (sig) for both Control post test scores and Experimental post test scores were > 0.05 and W was very close to 1.Hence it was concluded that data was normally distributed and we proceeded to t-testing if the second condition was satisfied.

- **Homogeneity of variance**

This test is conducted to check that whether the spread of scores was similar in both the groups or not. The spread of scores was reflected in the variance. This was checked by the value of Levene's test.

If the Levene's test results is statistically significant ($p<0.05$) then the data does not show homogeneity of variance, however if the Levene's test results is statistically not significant ($p>0.05$) then data shows homogeneity of variance.

		Levene's Test for Equality of Variances	
		F	Sig.
Posttest score	Equal variances assumed	.005	.945
	Equal variances not assumed		

Table 4.4: Test to check homogeneity of variance

P value (sig) for Levene's Test was ($p>0.05$) hence it was conclude that post test scores for both control and experimental group showed homogeneity of variance.

The scores approximate normal distribute (as proved by the value of Shapiro-Wilk test) and by Levene'test ($p>0.05$) it was proved that spread of scores for both the control and experimental group had been similar hence parametric test to be used.

Post test scores from two different groups (control and experimental) had been taken so Independent t test was used (Greasley, 2008). Independent t-test tends to see whether difference of average between two groups (control and experimental) is likely to have occurred because of random chance in sample selection. The difference tends to be more plausible

- If sample size is large enough
- If there is large difference between the average of both the groups
- Standard deviation is less, i.e. responses from both the groups are consistently close to one another

T-test yields the value of statistical significance and effect size (Greasley, 2008). The statistical significance measures whether the difference between the populations can be represented by the difference in the averages of both the samples. First it is checked if there lies a difference between the averages of both the samples. The differences among the averages should be large enough and should make sense practically. The effect size indicates that value for meaningfulness (ibid).

Independent samples T-test assumes that there is significant difference between the means of post test scores of control and experimental group.

By looking at the table below the significance value of (2-tailed) gives the value of statistical differences since this values is <= 0.05 thus we can say that null hypothesis is rejected and there lies a significant difference in the cognitive, behavioral and emotional engagement of those students that used interactive learning application in their classrooms.

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PostTest score	Equal variances assumed	2.981	98	.04	4.440	1.489	1.484	7.396
	Equal variances not assumed	2.981	97.588	.04	4.440	1.489	1.484	7.396

Table 3: T test on post test score of control and experimental group

4.2 Test to check student Academic Achievement:

An academic test consisting of seven questions was given to students of control and experimental group at the end of the intervention. This test was prepared by the joint effort of teachers of both the sections thus it involved no bias from the researcher point of view. Students of both the group had to solve the questions without any help of the teacher, helping educational material or the interactive application. The result of the test showed that technology not only provided quality learning outcomes but also made learning and teaching fun for both the teacher and the students. The test included questions related to the topic of work and energy. Following questions were asked by the students:

Questions	Experimental Group Score	Control Group Score
1. What should be the angle between force and displacement for work done to be maximum?	Correct = 55 Wrong = 5	Correct = 50 Wrong = 10
2. Is there any work done	Wrong = 4	Wrong = 8

when force is perpendicular to the displacement?		
3. What is the unit of displacement?	Correct = 60 Wrong = 0	Correct = 54 Wrong = 6
4. What is the potential energy of the apple on the ground?	Correct = 57 Wrong = 3	Correct = 51 Wrong = 9
5. While moving on an inclined plane what should be the angle between force and displacement to have maximum work done? 30 degrees, 45 degrees, 90 degrees	Correct = 52 Wrong = 8	Correct = 44 Wrong = 16
6. Can work done be same if component of force is applied at different angles but displacement is same?	Correct = 56 Wrong = 4	Correct = 50 Wrong = 10
7. What is SI unit of energy?	Correct = 55 Wrong = 5	Correct = 51 Wrong = 9

Table 4.6: Result of academic test for control and experimental group

Looking at the test scores of both the groups it was evident that students' academic achievement did improve where interactive application was used. Though there was minor difference in few questions where students of both the groups performed almost same, but it was observed when complex questions were asked related to difficult concept then experimental group performed remarkably well than the control group. For example in the angle related question , where it was asked that while moving on an inclined plane for which angle the work done will be maximum? Only for this questions three options were also given still students in control group found difficulty in solving this question.

52 out of 60 students in experimental group gave correct answer to this question however in control group only 44 out of 60 students gave correct answer. Also it was observed by the observer who was conducting the test that students in control group were constantly asking for clarification of the questions and were requesting to seek help from their teachers. However in experimental group students were observed to be more confident and did not ask for any extra help or material. An amazing thing to discover was that in experimental group students did not ask for calculators while on the other hand students of the control group were constantly using the calculator throughout the test.

4.3 Focused Group Discussion with students

Focused group disccions (FDGs) were conducted with students from students and teacher of experimental group. As there were total 60 students in this group thus for the purpose of discussion students were divided in to ten groups each group having six students each. A mix of open ended and semi structured questions were included in the tool to elicit information especially on various aspects of the application.

Exact wording and sequence of questions was decided in advance (ibid). All interviewees were asked same basic questions in same order. Variable measured was student engagement. Video recording of these interviews was also done to avoid any loss of information. The responses obtained are summarized in the table below. As there were total of ten groups for the discussion, the numeric in front of the each comment shows the number of group(s) supported that comment

Category	Student Views
Favorite element of the application	• Fun, play and study physics at the same time (**7**) • Can play it at any time even in their home (**4**) • Ice cream truck scenario is the best as they like ice cream (**10**) • Boy walk to school , as lot of students still walk to school (**5**) • Free of cost (**8**)
Content/Flow of the application	• Real life content (**6**) • They could easily relate to it (**9**) • Simple things explained first (**7**) • Complex concepts for examples (angle related scenarios) explained later (**8**) • Exciting to make connections between the ideas learnt (**9**)
Images Vs Interactive exercises	• Interactive exercises as they are more fun to do (**10**) • Finding hints (**6**)
Learning	• Construction of knowledge by ourselves (**7**) • Prefer intuition rather use of calculators (**6**) • Able to clearly grasp difficult concept in less time (**5**) • Play and study physics at home (**8**)
Class participation	• I have more questions to ask now (**7**) • More discussion with friends and teacher (**9**)
Instant feedback	• Take closer to correct answer (**7**) • If the truck is not moving why is it not moving, what to be done to move the truck (**6**)
Control over exercises	• Start/stop/pause/resume at any time(**8**) • Choose activity of our own choice(**10**)

Visual instruction	• Helpful in telling learning outcome of every scenario (**8**) • Helpful in understanding what's happening on the screen (**9**)

Table 4.7: Student's responses from FGD

FGDs were recorded so that they can be transcribed later. The responses obtained were categorized according to the themes which emerged from the data set as follows:

I. Instant feedback

Feedback is acknowledge as the important component of overall learning process as it guides student learning (Crisp, 2007; Orsmond, Merry, & Reiling., 2005). A high quality feedback is the one that enables students to identify gap between their own learning and a given set of expectations and also give advice about potential areas for improvement (Nisi, S., & Kluger, 2000; Eom, Wen, & Ashill., 2006; Lizzio & Wilson, 2008)

The application has built in assessments or tests in the form of stories and real life problems that children had to answer as students may find paper based tests engaging but not fun at all (Dix, 2003). This is the inherit aim of technology based instructional method. It not only increase student active participation with in the learning environment but also increase learning by providing feedback (Majerich, 2011)

The software gives immediate feedback to the children's choice and tell whether a particular option is correct or wrong. It has found to be beneficial for children to tell them why an option is not a correct answer. Formative computer assisted assessment is more fruitful for students as it has shown an increase in their understanding and learning with immediate effective feedback (Charman & Elmes, 1998) (Peat & Franklin, 2002).

Students said that feedback given to them while playing activities gave them a chance to reflect on their answer and then reevaluate the option selected. Feedback from the application helped students to learn in a range of multiple ways.

Below is the screen shot of one of the questions asked by the students in activity section to test their knowledge about work concept? When a wrong option is clicked, the reason that why this option is wrong is explained so that learner can alter his decision and also makes out why this option was the wrong one. This feedback also helped students to reflect on their decision and then attempt to give correct answer.

Figure 4.1 Exercise in the activity section

Figure 4.2 Help text for wrong option 1

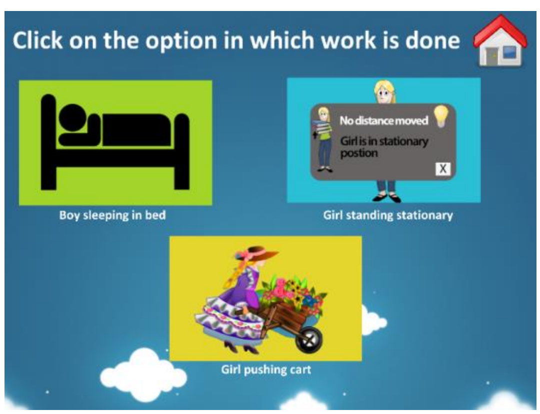


Figure 4.3 Help text for second wrong option 2

Figure 4.4 Reason for correct answer 1

This approach helped them in going closer to the correct answer and they enjoyed learning through failure and feedback without any stress of the punishment for the wrong answer. If the choice they selected was wrong, it was explained with a reason that why it is wrong.

In regular classroom set up they get easily discouraged due to negative feedback. However in this application while answering the questions they were allowed, repeatedly to try again if they don’t succeed in first attempt.

In all of the scenario students liked tabular depiction of the force, displacement and work done the most. They said that it was available in unambiguous format and language and appeared timely on the screen.

Immediate feedback in the form of visual instructions and tabular view helped students a lot in further gaining clarity of the concept for example pushing accelerator paddle or applying brakes immediately changes the value of work done. If truck is not moving what should be done to move it similarly to stop the truck how and when to apply brakes.

II. Control over exercises

Students say that this application gave students greater degree of control over the choice of activity to select for learning a concept. If children are given freedom to choose activities their perceived enjoyment will increase (Karimi & Lim, 2010)

They can learn any topic at their choice of time and take as much time as they want to understand a concept. Students can access information and other resources at times, which suit their lifestyles and their other commitments. If they do not like one scenario then they can easily switch to other scenario of their choice to learn the concept. They felt control over the scenarios explained as they can use controls to repeat/pause/start or stop it whenever they want.

III. Visual instruction

Learning process is made easier by the use of visual things (Harmer, 2001). Visual instruction is regarded as one of the effective learning strategies in different learning environment (Dwyer, 2006) because human beings are visually oriented (Norman, 2004)

It is suggested that effective use of visual things like pictures results in better learning of students (Nelson, Reed, & Walling, 1976). Study conducted by Johnson and Choi found that use of video instruction was more memorable than the traditional text-based instruction. This approach positively affected learner's motivation and retention (Choi & Johnson, 2010). Students found this approach helpful in understanding the most difficult concept of angles. They said that it was easier for them to understand what the effect of angle on work done is. However in control group students found this concept extremely difficult. This has already been depicted in their test score. Only 8 out of 60 students in control group were able to give correct answer to angle related question however in experimental group 54 students out of 60 students gave correct answer of that question. Also organization of information in the tabular form helped them in analyzing a situation and then asking meaningful questions.

IV. Learning

Students reported that they all tried to construct their own knowledge. The scenarios used in the application were those with which they can easily relate. They try to connect their knowledge with daily life scenarios now. This practice was missing before when they were studying form the book. They try to prefer intuition now than to quickly go for the calculator. It takes them less time to grasp difficult concepts like what is the effect of angle on work done? Using this application is more like playing than studying.

V. Class participation

There were 30 computers available, to cater 60 students, 30 groups of two students each was made. Students said that they enjoyed working in the group. Use of computers has shown to increase student achievement while working in group or individually. Individual perform better in groups while carrying out exploration and practice activities (Higgins, 2015)

While working in the group they tried to explain things to each other and help other group mates who were having difficulty in gaining a concept. This interactive application had active learning strategies that engaged students and encouraged them to recall and apply information in different contexts. Whole experience of using the application and then learning out of it was more exciting and enjoyable as they were in groups. Enjoyment is positively related to the desire to remain engaged and participative (Scanlan, 1989). Peers play a significant role in establishing academic engagement (You, 2011). Interaction with the teacher and with peers was seen in the classroom which teacher reported is more compared to the situation when students were reading from the book. A major reason for this is that students consider peer context to be more easily approachable and flexible. They find it to be another source for keeping them active and engaged in the class hours (Ryan & Deci, 2000; Fredericks, Blumenfeld, & Paris, 2004). Combination of interactive activities provided in this application along with opportunities for peer discussion increased student academic engagement

A lot of students never participated in the classroom activities. Boredom was evident from their faces as teacher reported and by the observer in control group without use of technology. Students also said that they used to wait for the class to get over and count minutes till class ends. This has been backed by lot of literature on the use of ICT in learning environment that computers support effective pupil’s talk and also improve their discussion while working in collaboration with in a small group (Weqerif & Scrimshaw, 1997).

Teacher said that students were asking more relevant questions and were found to be more inquisitive. Positive energy was seen in the whole classroom environment students were collectively building their knowledge and helping each other.

VI. Favorite element of the application

Students liked that how each scenario was built around the story supported by the daily life scenario. Experiments carried out in recent years by the educators and designers in digital narratives areas found that experience is fun and enjoyable when children are engaged progressively in the story environment while maintaining the educational values (Robertson & Good, 2005).

Two scenarios that were greatly appreciated by the students were ice cream truck scenario and boy walk to school scenario.

Students liked ice cream truck scenario as they said that they like ice cream and also its really hot now a days so they liked playing with the ice cream truck.

Walk to school to scenario was the one with which most of the students said that they can relate, as they also walk to school and if they don't walk to school they have seen students walking towards school in their real life.

The best feature of this application is that it can be used at their homes and it is free of cost. Students said that they like to play games and want to study interactive books but either they are not available easily in the market or too expensive to be purchase.

VII. Content /Flow of the app

Students said that they liked that simpler concepts were told first and then moved to complex concept of angles. This application successfully meets its learning objective of teaching topic of work and energy to students. The interface is intuitive and did not distract us. As founded by Sim et.al 2004 (Sim, Horton, & & Strong, 2004). Activities section in the application helped students to revise their concept and test them. These type of activities support the thinking process as they ask conceptual questions. With the help of those activity questions the fundamental understanding of topic of work and energy was increased. This practice is required to solve physics problems (Beatty, Gerace, Leonard, & Dufresne, 2006.).

VIII. Images vs interactive exercises

It is suggested that effective use of visual things like pictures results in better learning of students (Nelson, Reed, & Walling, 1976). Study conducted by Johnson and Choi found that use of video instruction was more memorable than the traditional text-based instruction. Students found interactive exercise more enjoyable in solving. Draper, 1999 suggested that presenting a test after incorporating multimedia stimuli that sense of fun can be gained. (Draper, 1999). Still images and interactive exercises were made part of the application. Students found interactive story exercise more interesting and enjoyable while solving. They said that it did not feel like their knowledge was tested rather they were only motivated to find the exact distance and save the royal jewelry from the thief.

Figure 4.5 Screen shot of Interactive story exercise

4.4 Focused group discussion with the teacher:

Physics teacher who was teaching students of grade 9 had done her Master in Physics. She was very welcoming when we told her about the intervention. She was of the opinion that technology should be made part of the classroom structure to help students learn better and also to share the load from teacher's shoulders. Teacher was willing to change and incorporate innovative solutions in classroom environment but they were not given authority to bring those changes in to action.

Teacher herself also used this application and suggested few modifications that were added in the application. Teacher said that this application was helpful for her also in managing the class discipline and helping students to focus. Teacher from the experimental group, had already following the traditional approach towards teaching reported that sometimes students tend to waste class time and ask questions just to distract teacher from the topic. Those students destruct class discipline. It is difficult to engage them during lecture. When students are not kept engaged in the classroom they try to utilize their energies by showing deviant and irresponsible behavior.

The teacher form experimental group was extremely happy with the use of this application in her classroom and said that she also enjoyed teaching. She said that students were asking more relevant questions. Atmosphere of the class was very collaborative and every student was trying to help their fellows. Teacher's energy was conserved, as she does not have to shout at students to maintain discipline and asking them to remain silent while she was giving the lecture instead her energy was positively used in helping students.

Teacher reported that students had already started thinking out of the box and now they were making an effort to give examples outside the book. Further the results of academic test scores of both the groups also revealed that students in experimental group not only had fun in physics class but they also learnt complex concepts related to the topic of work and energy. This boosted teacher's confidence that students learning and academic improvement also affected in a positive way by the help of this application

Teacher and the administrative staff of the school believed that this interactive application brought smile on students' faces and for the first time they saw them enjoying learning. Students were always found to be excited while coming to computer lab in physics lecture as observed by the school staff. The principal and the teachers both welcomed this intervention and said that they would like to incorporate interactive learning applications as a part of their curriculum for other classes and for other subjects.

4.5 Student engagement walkthrough Checklist:

Another tool to measure student engagement in class was walkthrough checklist. This checklist has been developed by International Center for Leadership Education attached as annex A.

This checklist was used to measure student engagement in Singapore Schools (Ganeshini & Aslaksen). Walkthrough checklist is considered to be another effective means to measure student's engagement in classroom. These checklist should be conducted by the external observers to avoid any bias. These observers could be an individual from school administration staff, instructional coaches or teacher peers.

This specific checklist was used to measure student engagement in Physics class for both control and experimental group. It included specific short observations of the class. It was not conducted to evaluate teacher performance in the class instead it was more focused on how well students were engaged in lesson. We requested two people from the school administration staff to fill this checklist for both the control and experimental group in Physics class. They were briefed in advance about the indicators they have to look in students specifically to fill this checklist. The observers were requested to observe and note readings after every 10 secs.

This walkthrough checklist list can be found in appendix A

This checklist had two parts. The first part was based on the direct observation of the observer in the classroom.

1. Positive body language: Students indicate body position that indicate listening and attention to teacher and their peers. Observers were asked to look for indicators like eye contact, position of the head and arms, leaning backward or forward.

2. Consistent Focus: Students encounter minimum disruptions while performing learning activity. Observer can look for answer to following questions while filling this option:

- Were students focused on the learning activity?
- Did their attention waiver in between the activity?

3. Verbal participation: Students are actively taking part in classroom activities. They are asking relevant questions and sharing their ideas with teacher and peers.

4. Student confidence: Students are showing confidence in initiating a task and completing the assigned work in limited time and coaching. Students are actively working and helping each other in groups.

5. Fun and excitement: Students are excited to learn things. They are showing interest and are curious to know about the topic they are been taught.

The second part of the walkthrough checklist required a conversation with students to access the degree by which they were engaged in the learning experience. This assessment included following criteria:

1. Individual attention: Every single student felt comfortable to ask for help from the teacher and peers. Observer may ask questions like: what do you do in this class if you need extra help?

2. Clarity of learning: Students can explain purpose of the lesson in simple and their own words

Observer may ask questions like: what are you learning from this exercise? What are working on currently?

3. Meaningfulness of work: Students find the lesson interesting. They thought that exercise were challenging and connected to their learning.

Observer may ask questions like: do you know why are you learning this? How this will help you?

4. Rigorous thinking: Students attempting to solve difficult problems and find solution to it and also reflecting on their proposed solution

Observer may ask questions like: do you find this work challenging? Do you think you created something new on your own, or found new example of the concept?

5. Performance orientation: Students understands quality of their work and how it will accessed.

Observer may ask questions like: how do you know you did a great job in work?

Observations	Very high	High	Medium	Low	Very low
Positive Body Language		Experimental	Control		
Consistent Focus	Experimental		Control		
Verbal participation		Experimental		Control	
Student confidence	Experimental			Control	
Fun and excitement	Experimental				Control
Perceptions					
Individual attention		Experimental		Control	
Clarity of learning	Experimental		Control		
Meaningfulness of work		Experimental		Control	
Rigorous thinking		Experimental		Control	
Performance orientation	Experimental				Control
Overall student engagement		Experimental		Control	

Table 4.8: Observations through Walkthrough Checklist for Control and Experimental group

Chapter 5

5. Discussion:

Present study has contributed in the field of educational research especially for a country like Pakistan where dropout rate is increasing day by day and it is becoming impossible to motivate and excite students towards learning. In urban and rural areas percentage of boys and girls willing to go to school is not at all satisfying (Pakistan National Plan of Action , 2007-2008)

Traditional classroom set up is considered to be the main cause of school disengagement. Traditional classroom setup that focuses on transmission of information from teachers to students has failed to incorporate multi-dimensional engagement among students. Students either rote learn or memorize formulas to solve difficult problems. This approach may help them to get higher grades and more marks but they are unable to solve any problems in the real world or for that matter any problems outside the book.

Students act like passive receiver of the syllabus while the teacher is the sole in charge of the classroom does not have enough resources to access whether each student has understood the concept or not. There is no way by which students can construct knowledge on their own that is way the processing to going to school and getting education seems boring to almost all the students. Most of the students don't find it exciting to come to school and those who come are only taking notes without understanding the concepts well. As every day there will be a typical boring lecture, teacher will call either one or two students to solve few problem on the black board and then lecture ends. There are no means to check that whether each student has understand the concept or not.

As teachers have to cover large volume of syllabus in a short duration time because they are held responsible not only to complete the whole syllabus but also make students capable to get the highest grades. Lack of elements of fun, enjoyment and engagement in the school environment not only leads to student's disengagement from school but ultimately to dropout from school. Every learner is unique and has a preferred learning style it is very hard for the teacher to deliver a lecture that will cater to learning needs of every child in the limited class time.

The education system is Pakistan has also become victim of these problems. In countries like Singapore and Malaysia lot of initiatives were taken to give importance to quality of education rather than the quantity of the syllabus to be covered. Singapore Education System started projects like “Teach less and Learn More “and “Innovation and Enterprise Thrust” have reformulated the learning and teaching styles. Use of engaging approaches in the classroom environment not only increased student engagement but affected student’s achievement positively. Few initiatives have also been taken place in Pakistan but they need more refinement. Sound pedagogical principal should be embedded in them. Mere digitization of the content book by addition of few videos would lead to sufficient increase in student understanding and engaging.

Students are in the race of getting grades and less importance is given to the actual understanding of the concept. The pressure of getting more marks falls directly on teachers. As this responsibility rests on teachers to make students capable of getting best grades and more marks.

Teacher has to cover huge amount of the syllabus before the final exam. Teacher to student ratio is more than what teacher can manage. It becomes completely difficult for the teacher to cater to individual needs of each and every students and deliver concepts in a such a way that students understands the concept well and apply that knowledge in the real world problems. Thus there is only transfer of information from teachers to students. Where teachers are the source of information and students are the passive receiver of that information.

This approach becomes extremely daunting when students are studying science subject especially physics concepts. The text books are not designed in a way that foster problem solving among students. The books first give definition of the concept, which is followed by the mathematical expression and then description. This method makes it extremely hard for students to relate those concepts in real world scenario or find them useful in solving daily life problems.

A learning application with clearly defined learning outcomes and incorporating all the elements to engage students is the best solution for a traditional classroom. The sound learning theory embedded in the application should be constructivist so that learners can construct their knowledge on their own by experience (Harasim, 2012). Combination of instruction, practice and effective immediate feedback are the component for effectively imparting physics concepts as they lead to the development of cognitive skills among students that help in solving real life physics problems (Ferguson-Hessler & T., 1993).

Elements of investigation and experimentation engage students in the learning process. Every learner can be engaged in the application if the application cater to all learning styles.

The application should have combination of game play behavior and effective feedback strategies to monitor learner’s progress and learning. Interactivity plays a vital role in keeping learners engaged. This interaction should be limited between the learner and the content but it should open opportunities for learner-learner and learner-teacher interaction also. This will not only encourage students to take part in class activities and discussion but will also boost their confidence.

Use of interactive learning applications in the physics classroom not only increases student motivation towards learning physics but students also experienced fun and excitement while learning. The interactive learning application impacted student’s engagement in all three dimensions. Students were observed to be engaged behaviorally, emotionally and cognitively with in the classroom. Use of real life scenarios helped students to relate the concepts learnt in physics subject with the real world. Students were passionately solving the problems outside the book.

This low cost easily deployable solution turned out to be an effective remedial solution for maintain student’s interest in class at the same time increasing their understating and achievement in physics subject. Students found it extremely helpful as they were using this application at their home desktop and getting benefit out of it. They started to find real life example of work and energy from their surroundings and became more participative and attentive in class. The idea that they can play/pause replay this application as many number of time as they want gave them the control over their learning. Most of the students were found to be collaborative and they were helping their classmates in understanding the concept. Contrary to the control group where students and teachers followed traditional method of teaching from the book and solved few problems on the black board, they were not able to enjoy learning physics concepts. Not only that these students demanded use of calculators throughout the class and said that even simpler problems could not be solved without the help of calculator.

Chapter 6

6. Recommendation

Following recommendations are offered for related research in the field of innovative educational technologies especially for the country of Pakistan.

Recommendations for improving this study

- A series of longitudinal study based on this model would recommend trends and thus will increase the potentials of taking decisions to make these interactive learning applications part of the curriculum for all schools and students of all age groups and classes.
- Extension of this interactive learning application to include more forms of energy.
- Addition of email feature that can email progress of each student to their parents.

Recommendation for policy makers

- To use this application as the base for building more interactive applications on more science subjects.
- More interactive learning applications can be built following the same the pedagogy and interactive learning elements use in this application
- In all of the educational material/resources designed for students, fun and enjoyment should be given highest priority.
- Short trainings of teachers so that that they can easily incorporate these technologies in their classrooms.
- School administration should support and encourage teachers who want to use these innovative solutions in their classrooms and should provide all facilities and assistance to them in making it possible.
- School administration should encourage teachers who want to go to conferences and participate in staff development
- Teachers should attend technology conferences to see what other schools are doing how other teachers are integrating technology in their classroom.

Recommendations for Corporate sector

- Gaming industry and cooperate sector should develop more interactive games and learning applications for students of Pakistan.
- These sectors should encourage enthusiastic individuals to make learning applications and online digital material for students of Pakistan. This can be initiated in the form of gaming hackathons and competitions
- Interview with teachers and staff should be conducted before developing any application so that their concerns can also be addressed in the application.
- Educational solutions should be available for school at low cost. Those solutions should be compatible with the devices that are already available in the school or easy to purchase by the school authorities.
- Educational solutions should be developed not for students coming to schools only but for those students who are unable to go to school and still have urge to get education. Freely available solutions for students who are working at day time or staying at their home.

Chapter 7

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Chapter 8

8.Appendices

Appendix A - Student Engagement Walkthrough Checklist

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.

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.

Student Confidence	☐	☐	☐	☐	☐

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

Fun and Excitement	☐	☐	☐	☐	☐

Students exhibit interest, enthusiasm and can use positive humor.

Perceptions

	Very High	High	Medium	Low	Very Low
Individual Attention	☐	☐	☐	☐	☐

Students feel comfortable seeking help and asking questions. Question to ask: What do you so in this class if you need extra help?

Clarity of Learning	☐	☐	☐	☐	☐

Students can describe the purpose of the lesson or unit. This is not the same as being able to describe the activity being done during class. Questions to ask: What are you working on? What are you learning from this work?

Meaningfulness of Work	☐	☐	☐	☐	☐

Students find the work interesting, challenging and related to learning. Questions to ask: What are you learning? Do you find this interesting? Do you know why you are learning this?

Rigorous Thinking	☐	☐	☐	☐	☐

Students work on complex problems, create original solutions and reflect on the quality of their work. Questions to ask: How challenging is this work? In what ways do you have the opportunity to be creative?

Performance Orientation	☐	☐	☐	☐	☐

Students understand what quality work is and how it will be assessed. They also can describe the criteria by which their work will be evaluated Questions to ask: How do you know you have done good work? What are some elements of quality work?

Overall Level of Student Engagement	☐	☐	☐	☐	☐

Appendix B - Student Engagement Questionnaire

Behavioral Engagement

- ☐ I pay attention in class.
- ☐ I study for this class
- ☐ I try to get the most I can out of this class
- ☐ It's hard to make myself come to this class.
- ☐ In this class, I do just enough to get by.
- ☐ Outside of class, I don't put much work in on this course.

Emotional Engagement

- ☐ I enjoy the time I spend in this class
- ☐ It's exciting to make connections between the ideas learned in this class
- ☐ The material we cover is interesting
- ☐ The instructor's lectures are pretty dull
- ☐ This class is stressing me out
- ☐ Sitting in class is a waste of my time

Adapted from Una Chi and Ellen Skinner

Appendix C- FGD for Students

Guideline for M&E Assistants:

Each M&E assistant will carry out focused group discussion with 5 to 6 students as per the suggested frequency. In case of a co-ed system, select almost equal number of boys and girls both.

Collective responses will be recorded and number of responses will be mentioned against each question statement, e.g. could not recall the previous content=2 and could recall the previous content=4. Spaces are left under each question statement to record the responses.

It is recommended that FGD should not exceed 30 min. video recording is also advised at the time of discussion which needs to be transcribed later.

1) **Student perception of story telling**

Q1. Did you find story in the questions interesting?
Q2. Did you like hints given in the story? Why?
Q3. Were they helpful in solving questions?

2) **Students' perception about control over the exercises**

Q1. Which activity did you like the most?
Q2. Why do you like this activity?
Q3. What made you feel that you have control over it? **Play/pause/go to home screen at any time, start activity all over again**

3) **Still images VS interactive exercises**

Q1. Did you like answering to still questions or solving a problem? E.g. "Saving Castle Scenario".
Q2. What did you like in it?

4) **Student perception about instant feedback**

Q1. Did you like the instruction for every question in the activities?
Q2. Did it help you in finding why particular option is a wrong answer?
Q3. Did it help you in going closer towards correct answer?

5) **Student perception about visual instruction**

Q1. Did you like that instructions were given on every screen?

Q2. Were those instructions helpful?

Q3. Were they easy to understand?

6) **Student perception about engaging element of this application**

Q1. Do you like to use this application at your home?
Q2. Do you like to study more on this application?
Q3. What does this application has that makes you do that?
Q3. Does this application keeps you interested/engaged in class?
Q4. How does it do that?

7) <u>Student perception about overall content and flow of the app</u>

Q1. What did you like about the content most?
Q2. How Different scenarios helped you in connecting value of angle with work?
Q3. Did you like that activities were solved by connecting ideas already learnt?
Q4. How did it help you?

Appendix D – Consent Form for School

Date: 18th May 2015

To Whom It May Concern:

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam

It is to inform that Ms Hira Khan bearing CNIC no: 61101-6507525 is a registered student on MS in Innovative Technologies in Education at School of Electrical Engineering and Computer Sciences (SEECS), NUST, Islamabad.

As a requirement of MS degree he/she is intending to conduct a research in an educational setting under the supervision of Dr Muhammad Muddassir Malik

The proposed title of his/her research is "**Measuring effect of interactive physics learning application on student engagement of secondary school students**"

The expected duration of the research intervention and data collection would be from

19th May 2015 to 9th June 2015

It is, hereby, requested you to allow him/her to conduct research in your esteemed institution.

Should you require any further information, please do not hesitate to contact the research candidate at email address: 14msitehkhan@seecs.edu.pk and telephone number: 0322-5025337 or SEECS office at 051-90852196

Your permission to conduct this study will be highly appreciated.

Yours sincerely,

SEECS Office

NUST, Sector H-12

Islamabad