THE ROLE OF EDUTAINMENT IN E-LEARNING:
AN EMPIRICAL STUDY

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An experimental study that investigated the usability aspects that are employed in the multimodal interaction metaphors with edutainment fundamentals in the presentation of the learning content of e-Learning interfaces and the production of empirically derived guidelines for the use of these metaphors in the software engineering process.

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بسم الله الرحمن الرحيم

In the Name of Allah, the Most Compassionate, the Most Merciful

DEDICATION

I dedicate this thesis to the most precious persons in my life - my parents, my wife and soul-mate, and my dear, beautiful daughters, Fatema and Tamedort, the two roses of my life.

Khaled Ayad

ABSTRACT

Impersonal, non-face-to-face contact and text-based interfaces, in the e-Learning segment, present major problems that are encountered by learners, since they are out on vital personal interactions and useful feedback messages, as well as on real-time information about their learning performance. This research programme suggests a multimodal, combined with an edutainment approach, which is expected to improve the communications between users and e-Learning systems.

This thesis empirically investigates users' effectiveness; efficiency and satisfaction, in order to determine the influence of edutainment, (e.g. amusing speech and facial expressions), combined with multimodal metaphors, (e.g. speech, earcon, avatar, etc.), within e-Learning environments. Besides text, speech, visual, and earcon modalities, avatars are incorporated to offer a visual and listening realm, in online learning.

The methodology used for this research project comprises a literature review, as well as three experimental platforms. The initial experiment serves as a first step towards investigating the feasibility of completing all the tasks and objectives in the research project, outlined above. The remaining two experiments explore, further, the role of edutainment in enhancing e-Learning user interfaces. The overall challenge is to enhance user-interface usability; to improve the presentation of learning, in e-Learning systems; to improve user enjoyment; to enhance interactivity and learning performance; and, also, to

contribute in developing guidelines for multimodal involvement, in the context of edutainment.

The results of the experiments presented in this thesis show an improvement in user enjoyment, through satisfaction measurements. In the first experiment, the enjoyment level increased by 11%, in the Edutainment (E) platform, compared to the Non-edutainment (NE) interface. In the second experiment, the Game-Based Learning (GBL) interface obtained 14% greater enhancement than the Virtual Class (VC) interface and 20.85% more than the Storytelling interface; whereas, the percentage obtained by the game incorporated with avatars increased by an extra 3%, compared with the other platforms, in the third experiment.

In addition, improvement in both user performance and learning retention were detected through effective and efficiency measurements. In the first experiment, there was no significant difference between mean values of time, for both conditions (E) & (NE) which were not found to be significant, when tested using T-test. In the second experiment, the time spent in condition (GBL) was higher by 7-10 seconds, than in the other conditions. In the third experiment, the mean values of the time taken by the users, in all conditions, were comparable, with an average of 22.8%.

With regards to effectiveness, the findings of the first experiment showed, generally, that the mean correct answer for condition (E) was higher by 20%, than the mean for condition (NE). Users in condition (GBL) performed better than the users in the other conditions, in the second experiment. The percentage of correct answers, in the second experiment, was higher by 20% and by 34.7%, in condition (GBL), than in the (VC) and (ST), respectively. Finally, a set of empirically derived guidelines was produced for the design of usable multimodal e-Learning and edutainment interfaces.

LIST OF PUBLICATIONS

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LIST OF ACRONYMS

2D, 3D	2 Dimensional, 3 Dimensional
AIDS	Acquired immune deficiency syndrome
AIF	Audio Interchange File Format
ANOVA	Analysis Of Variance
AVI	Audio Video Interleave
CAT	Cell-division Achievement Test
CCT	Cell-division Concept Test
CH1, CH2	Chapter 1, Chapter 2
E	Edutainment
GBL	Game-Based Learning
GUI	Graphical User Interface
H#	Hypothesis
HCI	Human-Computer Interaction
HHCI	Human- Human- Computer Interaction
HIV	Human Immunodeficiency Virus
ICT	Information and Communications Technology
ISO	International Standards Organisation
IT	Information Technology
LMS	Learning Management Systems
LO	Learning Objects
MBA	Master of Business Administration
NE	Non-edutainment
OS	Operating System
PC	Personal Computer
Q#	Question
RCLL	Recall
RCN	Recognition
S#	Statement
SPSS	Statistical Package for the Social Sciences
ST	Storytelling
SUE	Systematic Usability Evaluation
SUS	System Usability Scale
T#	Tasks
TE	Text +Earcon
TS	Text + Speech
TSE	Text + Speech + Earcon
TSEA	Text + Speech + Earcon + Avatar
U#	Users
VC	Virtual Class
WAV	Waveform Audio File Format

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Chapter 1

Introduction

1.1 Introduction

One of the major problems encountered by learners using current e-Learning systems is the lack of personal interaction and useful feedback messages, as well as real time information on their learning performance, due to the absence of multimodal metaphors that are available [1, 2]. Another key criticism of current e-Learning systems is that they tend to present insufficient information, thus forcing students to navigate, too quickly, to less text-based and more interactive sites [3]. On the other hand, background literature determines that, to obtain a good result and higher quality thinking, e-Learning systems must provide the users with a challenging environment that enables them to process the new information involved, and to create a bridge with the experiences which they have already acquired [4]. This is why different approaches and strategies should be adopted and applied, in order to prompt the online learner's curiosity to discover and process the information, in depth. In addition, increased concerns about pedagogical issues, such as the number of poor e-Learning systems, in existence, are forcing instructional developers to rethink the possible solutions available to this problem. One interesting and potential solution suggested is that traditional educational standards and teaching techniques that were commonly used in the classrooms should be applied to the online learning environment, whereas other experts did not agree, resulting in the development of new guidelines designed to supersede the more traditional approach [4]. Therefore, this research programme advocates a multimodal, combined with an edutainment approach, which, it is anticipated, could resolve these types of problems. Moreover, this approach to e-Learning could change and improve communications between the users and the e-Learning systems. As well as the use of text, speech, visual assistances, and earcon modalities, avatars or realistic representations of people are other important modalities which could be incorporated to offer a visual and listening realm, thus bridging the gap which exists, in the online learning environment. In fact, studies that process the impact of the integration of multimodal features of educational interfaces and enhance the usability of the e-Learning systems are wide-ranging. In this context, most of the studies are focussed on finding an effective way to combine modalities and to reduce the redundancy involved in different types of web based interfaces. Different models, such as earcons, speech and even avatars were tested and they produced effective results and helped to improve the usability of interfaces and users' performance [5-7]. Conversely, studies that combine multimodal metaphors with entertainment features expressed to users by avatar are few.

This thesis empirically investigates users' effectiveness; efficiency and satisfaction, in order to determine the influence of edutainment, combined with multimodal metaphors within e-Learning environments. The main aim is to enhance user-interface usability; to improve the learning experience, in e-Learning systems; and, also, to contribute in developing guidelines for multimodal involvement, in the context of edutainment.

1.2 Aims

The overall aim of this research is to investigate the role and impact of edutainment, using multimodal metaphors, on the usability and learning performance, within the e-Learning interface. The entertainment features are represented by single multimodal, (e.g. speech only), or a combination of modalities, such as natural recorded speech with avatars, and game-type activity, within the e-Learning context. The study also investigates the enjoyment level that users attained, during online lessons that were presented to them by multimodal interaction metaphors, through amusing messages, engaging facial expressions, body-language gestures, and measures the reflection of this positive feeling on their performance. This research thesis also aims to contribute to the development of guidelines for multimodal involvement, in the context of edutainment, in e-Learning interfaces. This objective was accomplished through the following sub-aims:

Aim 1: to investigate and compare multimodal e-Learning interfaces with a typical text-based learning situation, in order to evaluate the implications on the usability of such interfaces, (in terms of efficiency, effectiveness, memorability, user satisfaction) and the learning performance of e-Learning interfaces;

Aim 2: to investigate the role of individual multimodal metaphors, either separately, simultaneously, or in combinations as amusing communication metaphors, to present learning materials in an e-Learning interface; and

Aim 3: to produce a set of empirically derived guidelines for the design and implementation of e-Learning interfaces.

1.3 Objectives

In order to achieve the aims outlined in the previous section, three different experimental studies were developed from scratch. The first study empirically investigated the usability and learning performance of two experimental interfaces: (i) a typical e-Learning (NE), based on text and graphic modalities; and (ii) a multimodal e-Learning system (E) which incorporated a combination of graphics, recorded speech and a facially expressive speaking avatar. The usability of these two environments was analysed by one dependent group of users. Furthermore, task type and complexity were considered as being a supplementary aim for evaluating the usability attributes measured on user performance. In the second study, three experimental interfaces were evaluated, each of which introduced learning materials, in three different presentation forms: Virtual Classroom (VC) consisting of teachers and students represented by avatars with amusing facial expressions and body gestures; implementation of Game-Based Learning (GBL) with the aid of earcons; and Storytelling (ST) enriched with graphical and animated diagrams. The third study focuses on evaluating the usability and the learning performance of the four games, independently, by means of one group of users, to establish which interface is the most attractive, throughout the student's response to each interface. The first game was presented with Text and Speech, only (TS); the second game involved Text and Earcons, only (TE); while the third game included Text, Speech and Earcons (TSE); and, finally, an all-inclusive game with Text, Speech, Earcons and Avatar (TSEA) was presented. In addition to the usability aspects, (efficiency, effectiveness and user satisfaction), an extra measurement, namely memorability and interface preference was introduced, to support the experiment's main usability factors in evaluating user reaction to the experimental interfaces.

1.4 Hypothesis

Many usability criteria have been developed to assist designers in producing a usable e-Learning system that offers substantial learning content, rather than merely a confusing interface. Examples of key considerations for the usability of e-Learning systems include [8]:

- ease of learning: how the site enhances the learning curve;
- efficiency of use: how quickly a person can locate specific portions of information, using the navigation system as an example;
- ease of memory recall: the ability of the learner to remember how to carry out a particular task;
- error rate: the number of errors should be small, and should be manageable when they do occur, thus not discouraging the user from continuing with the learning process; and
- satisfaction: the user should enjoy achieving any given task.

In a broader learning context, there are many ways of obtaining information. The most common research methods include: literature surveys, research experiments, talking with people, on a one-to-one basis, focus groups, personal interviews, telephone surveys, mail surveys, email surveys, and internet surveys. However, the methodology deemed appropriate for this research project comprises a literature survey, as well as three experimental platforms; the next section will describe the methodology followed, in greater detail.

Based on the usability criteria, described above, the overall hypotheses have been stated to compare the metrics that will be measured, in this experimental study, and are as follows:

The use of multimodal interaction metaphors, combined with edutainment features were shown to enhance interface usability by 5%, (in terms of efficiency, effectiveness, user satisfaction and memorability) and to improve user enjoyment, as well as interactivity and learning performance by 5%, compared with the text based interfaces examined, during the research.

1.5 Methodology

The first experiment serves as a first step towards investigating the feasibility of completing all the tasks and objectives in the research project, outlined above. The remaining two experiments further investigate the role of edutainment in enhancing e-Learning user interfaces.

The methodology used for this research project comprises a literature review and three experimental platforms. The initial experiment serves as a first step towards investigating the feasibility of completing all the tasks and subsequent experiments, in a similar manner. The remaining two experiments explore, further, the role of edutainment in enhancing e-Learning user interfaces. These experiments were carried out mainly in the research laboratories, at the University of Bradford. The data collection procedure was based on the experimental observations and questionnaires. The study measurements produced two types of data: objective data, which resulted from the observation method and which were used to measure effectiveness and efficiency; and subjective data, which resulted from the questionnaire and were used to rate user satisfaction. To ensure accuracy, the platforms were developed and equipped with a built-in system capable of collecting the data, automatically, upon the completion of each task; for example, the time spent is displayed, automatically, which, in turn, helped measure efficiency, with greater precision. This also applied to the data relating to effectiveness, where the accuracy of users' answers was obtained and the total number of successfully answered questions for each user was counted by the system. The users who participated in the study were mostly students of a high educational level, (e.g. Masters and PhD students), and were of different ages, backgrounds and gender. The majority of the users had no relevant experience, indicating that they would rely, exclusively, on the communicated learning information provided, in order to answer the required questions. To avoid any familiarity with the topic and the interface sampling in the experiments, a random rotation technique was applied, between platforms, in all the research experiments, and also, in terms of the lessons examined. The findings were analysed and discussed, which helped in answering the research questions set. The outcome reported significant differences between platforms, in general, and clearly established the role played by avatars, along with the enjoyment features, which helped in capturing the users' visual attention, where learning/assimilating information was concerned. In addition, a statistical analysis was conducted using a range of tests, such as T-test and ANOVA, which supported this variance. The main experimental findings were drawn, empirically, to produce guidelines that could be used for the design of further practical e-Learning applications, while also contributing towards enriching the existing research literature in the fields of multimodal interaction, e-Learning and edutainment.

1.6 Thesis Contribution

This thesis contributes to the research literature, by proposing specific solutions to the problems mentioned, previously, using multimodal attributes, such as earcons, recorded speech, and avatars as tools to facilitate the learning process and the assimilation of content, in combination with edutainment attributes, in e-Learning interfaces. The experimental results demonstrated that:

1. The multimodal features investigated, in this research, assisted with improving the usability and enjoyment, as well as users' learning performance, when utilised to communicate the incorporated learning material; this can be considered as one of the various attributes capable of compensating for the lack of face-to-face contact with the teacher, in e-Learning interfaces.
2. The presence of an avatar or talking to a virtual human, in e-Learning situations, along with the associated cognitive factors and edutainment, increased the users' interest and sense of engagement, and is deemed to be the main contributing factor, highlighted during the thesis, which increased user motivation and retention, while, at the same time, improving concentration, thus leading to a marked improvement in cognitive achievement and reasoning skills.

3. The thesis also contributed to producing guideline rules that could, potentially, benefit the designers of future e-Learning interfaces, in the context of modern learning, through the edutainment medium.

1.7 Thesis Structure

This thesis comprises six chapters and three appendices. The following illustration (Figure 1) concludes the study.

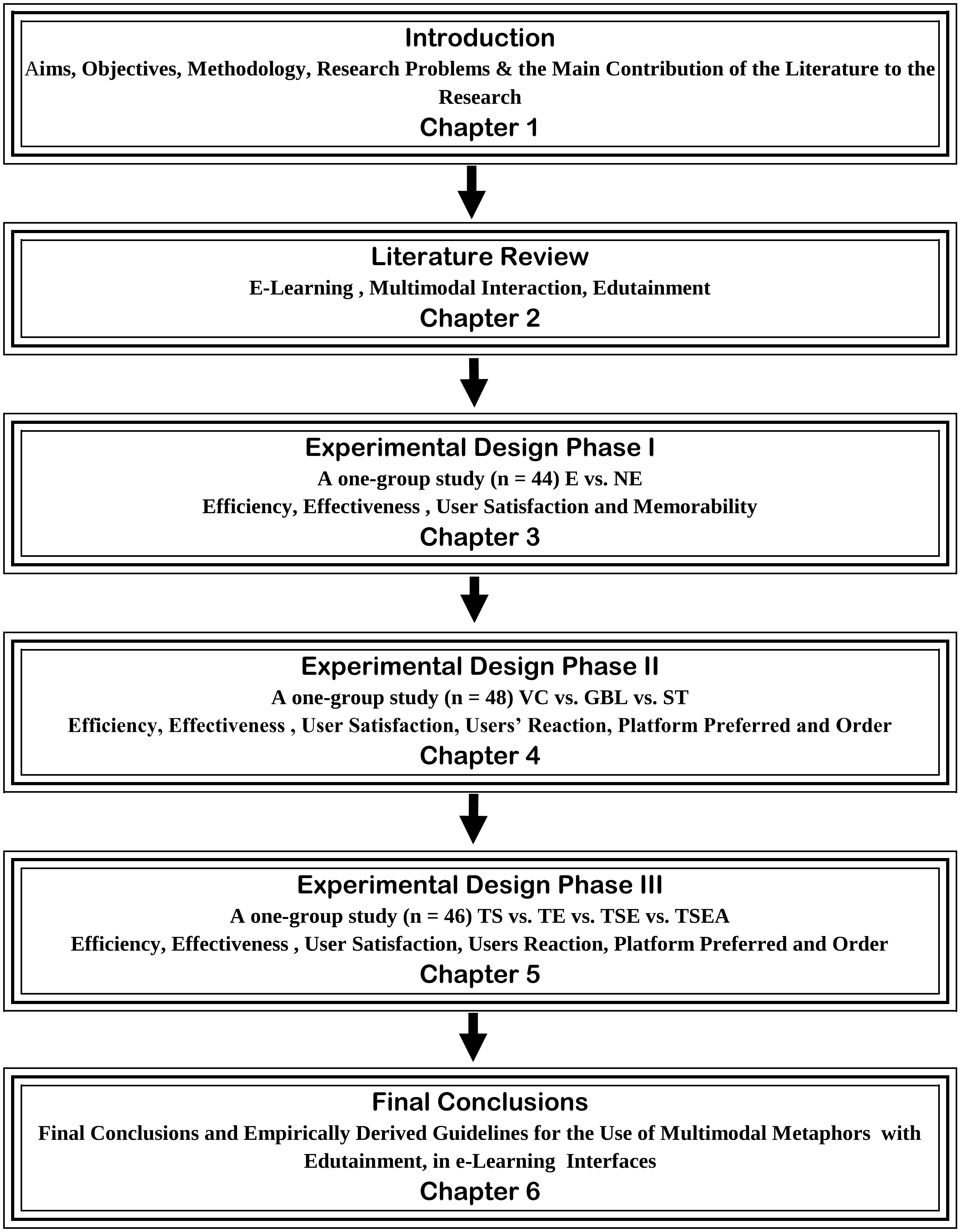


Figure 1 Structure and Experimental Phases Undertaken in This Research Thesis.

Chapter 2

Literature Review: E-Learning, Multimodality and Edutainment

2.1 Introduction

The Literature Review is one of the research methods used to learn from earlier theories and to highlight limitations in previous research. This Literature Review covers several aspects, such as defining the key terms and the terminology used, during the research; as well as identifying prominent studies, models, case studies, and critical points of current knowledge. In addition, this section provides a theoretical basis for the research and helps to determine the nature of the research. Moreover, it identifies the gap in the existing research, which this work aims to bridge, and establishes the critical link between the available literature and this current piece of research, thus producing a rationale or justification for the study. Furthermore, the Literature Review ensures that the research has not been conducted, in the past, while, at the same time, illustrating how the topic has been studied, previously, and helping to refine, refocus or even modify the subject or add to the understanding and knowledge extant of the field. In this research, the focus will be on the analysis of the theoretical, practical and experimental work carried out on the multimodal interface interaction of e-Learning systems and the edutainment field.

This chapter provides a broad background and overview of the significant theories explored by the researcher, that are aimed at supporting the objectives of this thesis and comprises three main sections: the first section reviews current e-Learning technology and the relationship between e-Learning and multimedia systems, supported by a short discussion on the meaning of learning, from several different perspectives, including learning styles, student preferences and apagogical issues, etc.; the second part expands on multimodality and its impact on the learning and e-Learning process; and the third section focuses on edutainment which implies a combination of education, entertainment and science fundamentals.

2.2 E-Learning

Modernisation changes in social structures have also affected the way of learning. The traditional classroom has moved to accommodate the rapid growth in Information and Communications Technology (ICT). This resulted in an accelerated improvement in educational technology and increased the demand for e-Learning. The growth of e-Learning market has been shown to be rapidly increasing since the early years of e-Learning developments. Firms began using learning technologies to deliver more training about 8.8 percent in 2000 [9]. Moreover it has been expected that e-Learning market will be worth €40 billion by 2012 [10].

2.3 E-Learning Definition

Basically, Google provides thousands of pages related to the “definition of e-Learning”. These definitions ranging from the specific: “e-Learning is the delivery of interactive, multimedia tutorials via the Internet.” to “e-Learning is the process of combining content with support and community” and to “e-Learning is the delivery of training anywhere and at any time [11, 12]. Before presenting a sample of e-Learning definition there are other terms frequently interchanged with e-Learning in the literature to say basically the same thing, for example, terms that are often used include [13]: Online learning - Online education - Distance education - Distance learning - Technology based training - Web based training - Computer-based training (generally thought of as learning from a CD-ROM).

Dublin [14] said that the term “e-Learning ” is a replacement of the term “web based learning “ , since both are utilizing the internet to deliver the computer based training materials. In 2001, ASTD expanded the definition of e-Learning as “e-Learning is instructional content or learning experiences delivered or enabled by electronic technology... that is designed to increase workers’ knowledge and skills, so they can be more productive, find and keep high quality jobs, advance in their careers, and have a positive impact on the success of their employees, their families and their communities.” [9]. The e-Learning definitions has been developed further by many industry specialists by the end of 2002, to accommodate the advances of technology as, “The use of technologies to create, distribute and deliver valuable data, information, learning and knowledge to improve on-the-job and organizational performance, and individual development.” [14]. The International Institute for Software Technology in 2005 [15], described the field as “e-Learning represents the awarding of nationally and internationally recognised university degrees, college diplomas or training certificates to students who spend all or some of their study period in front of computer screens. E-Learning includes online learning, web-based training, virtual universities and classrooms, digital collaboration and technology assisted distance learning”. Another definition stated by [16] in 2006 says “e-Learning is defined by the programme itself as Learning facilitated and supported through the use of information and communications technologies (ICT)”. Karlovcec, Skala and Saina [17] gave more details about e-Learning , they said “ Probably the best explanation would be that e-Learning is a method of using the multimedia and Internet in function to improve the quality of learning by enabling the access to distance sources & services and distance collaboration and communication”. [18] defined it as, “[T]he use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance”.

2.4 Common Properties of E-Learning

Following these samples of definition, it can be concluded that e-Learning field is characterised by these common properties [13, 18]:

The e-Learning platforms completely rely on computer as well as Internet, intranet, database systems and applications that enables students to control their learning easily. People can learn anywhere and anytime i.e. learning can take place wherever there is a computer and Internet access, availability of knowledge materials to the academic community and to students even after graduation to help them improve their knowledge. The e-Learning system offers individualised instruction and treats the student as a solver of the problem; furthermore it simulates real life situations, thus making education interactive and exciting and it enables the student to test the knowledge and, if needed, to get help from the adviser**.**

2.5 Benefits and Limitations of E-Learning

In fact, the number of advantages and disadvantages reported here depends on many resources accessible.

2.5.1 Benefits of E-Learning

2.5.1.1 Accessibility

One of the main advantages is the ability of the student to access a range of resource materials, and give control to students regardless of time and place. For example, in case the student is not able to attend the class for any reason (sometimes long time), the student will lose the opportunity to succeed in a particular subject or in all of them. For this reason and others, the student can follow the lesson, make all his duties and take the necessary examinations as well by using e-Learning facilities to run with his classmates which is accessible 24 hours of day, 7 days a week (asynchronous). Moreover, providing access to a range of resources and materials, which may not otherwise be available or accessible: for example, graphics, sound, animation, and multimedia. What is more, e-Learning provides context sensitive help (Electronic performance support systems) to computer users and helps them complete tasks on-the-fly [13, 17].

2.5.1.2 Cost and Time

This issue is very significant for the student who usually has limited financial resource and also for the lecturers to reduce their expenses of various materials, such as books, notepads and other materials. Besides that, it also eliminates expenses and mobility time from home where they live to the location where they have to attend the classes. By using computers and internet, e-Learning reduces and saves a lot of money, time and geographical constraints to the organizations and students as well, considering that both the student and the educational institute have to buy the computer once, which they will use it throughout all of their study, alternatively the student can use or follow the course in the lab at the educational institute, which is supporting the economic reuse of high quality and expensive resources. These properties foster self-paced learning whereby students can learn at the rate they prefer [13, 17].

2.5.1.3 Collaboration with Multi Channel Communication

E-Learning allows an increasing chance to the students to interact with each other, and provides immediate and frequent feedback, from the tutor, and from the students themselves through computer assisted assessment. E-Learning encourages collaboration between students through multi channels of communication (Emails, messenger, voice chat, video conference….) for solving their problems, and discussing more freely with the tutor any time anywhere. Besides, e-Learning permits instructors to develop materials using the world-wide resources of the Web. So it will enhance the knowledge of the Internet that will help learners and tutors throughout their careers [13, 17].

2.5.1.4 Responsibility and Dynamism

Students are more responsible for choosing, managing, sorting, organising, controlling their materials than the traditional approach of learning. E-Learning encourages students to take responsibility for their learning and success by building self-knowledge and self-confidence. The students first have to decide (what, when, how, where) the appropriate time to gain access to the information (in non linear way of learning), choose materials by themselves that fits to them, and after that they can organise, sort and arrange the information in a way that is easy to learn. In addition, there is no need to ask the lecturer to copy the materials or to ask the classmates their help as all the information is available online up to date (just-in-time access to timely information), which will reduce administrative load and will release more time for other activates. Moreover students are free, even allowed, to transform, personalise and customise learning materials. E-Learning gives them control over the learning process and make it dynamic. On the other hand, the lecturer can retain records of discussion which allows for later reference through the use of threaded discussion on bulletin boards [13, 17].

2.5.2 Limitations and Challenges of E-Learning

E-Learning is not, however, the end for every learner's need. It does have limitations as well. The next few subsections discuss some of the most representative limitations:

2.5.2.1 Reliance on Human Support

E-Learning is still dependent on help from either the course materials or the software. On the other hand, users of e-Learning especially students under 16 years old are supervised only by parents or other adults and not by a teacher. Therefore, it lacks sometimes the proper teaching method and style [19, 20].

2.5.2.2 Distraction

Due to the availability and easy access to applications on the web, such as browsing sports information or accessing online news, the chance of the learner being distracted is very high [20].

2.5.2.3 Technology Dependent

The e-Learning service depends on the user's machine specifications and the Internet speed to transfer the course materials in a timely way. Moreover it requires adequate computer skills to deal with e-Learning applications and this could frustrate novice ICT learners [20].

2.5.2.4 Material Incompatibility

Presence of many operating systems (for example, the Apple, Macintosh and the Windows PC) and the lack of standards could be another limitation. Since some materials designed for one particular system will not function properly on another one [20].

2.5.2.5 Unsuitable for Certain Types of Learners

Unlike traditional learning, e-Learning requires a high level of self motivation and time management to take full advantage of the medium. Therefore some learners cannot afford this new style of learning and consequently e-Learning will not help them to learn effectively [21].

2.5.2.6 Expensive

Implementing an e-Learning service is very expensive and the cost of production of online training materials is very high as well. Furthermore significant costs need to be invested in course setup and in keeping maintenance [19].

2.5.2.7 No Match for Face-to-Face Teaching

The lack of face to face communication is one of the important challenges faced by e-Learning industry. Although users are meeting electronically, this communication does not necessarily provide a good match for face to face discussion. The lack of physical interaction means the absence of facial expressions and body gestures that could be used to convey important verbal messages [20].

2.5.2.8 Disabilities

E-Learning might not answer the needs of students with visual or physical impairments [13].

2.5.2.9 Pedagogically Unsound

E-Learning does not offer a pedagogically enhancing learning environment, due to lack of physical interaction between students and their teacher [21, 22].

The benefits and limitations of e-Learning mentioned above vary depending on program goals, target audience and organizational infrastructure and culture. Although limitations to e-Learning are rapidly growing parallel with advances in ICT as a form of training delivery, most recent researches are finding that the clear benefits to e-Learning will guarantee it a role in their overall learning strategy, especially when considering alternatives to the lack of face to face problems .

2.6 Online Learning Personalisation

To considering learning differences among students, an understanding of psychological factors is essential so that, it enables people to learn online effectively [23]. This can be accomplished by promoting the educator to understand the way by which each learner acquires, retains ,retrieves information and considers factors involved such as culture which has a significant effect in deciding a person's preference [24]. According to an experimental study conducted to compare the dereferences between traditional learning (face-to-face) with e-Learning, in terms of gender, age, learning preferences and styles, media familiarity, effectiveness of tasks, course effectiveness, test grades, and final grades by using two sections of the same course, the study concluded that there were no significant differences between learning preferences and styles including grades between the two groups. The study confirmed that the same various learning activities could be used effectively for both online and face-to-face learner [25].

Several learning style theories were developed, based on [26] where there are two ways for people to perceive the world *sensation* and *intuition*. Sensation is the way people observes and gathers data through the senses, whereas intuition happens indirectly subconsciously, by accessing memory, speculating and imagining. Everyone uses these two types of perceptions frequently, but most people prefer one way more than another.

In summary, and regardless of the various categorizations in literature and of the complexity of learning the fact, and based on some studies such as [27], people tend to extract and retain more information from visual representation than from written or spoken words. Moreover visual learners learn better if they see and hear words at the same time. Some learners prefer working within groups while others succeed in a competitive learning environment that provides detailed tasks and assignments. On the contrary some learners enjoy the use of learning to accomplish personal goals, as they are interested in exploring new types of experience despite the risk encountered [25]. However, considering the different learning styles of learners, the instructional design and teaching strategies by the e-Learning developer will result in enhancing their motivation and performance [28].

2.7 Human Memory Constraints

Human memory system can be described as specific neural networks that support specific mnemonic processes such as record, retain, and retrieval experience [29, 30]. Baddeley classified human memory into three levels, sensory memory, short-term memory and long-term memory [31]. The sensory memory retains primary information which is gathered through sensory channels for a few seconds. Short-term memory which is also referred to as working memory, can keep hold of small amount of information active for up to 20-30 seconds [32]. In contrast, long-term memory is capable of storing a large amount of information over a longer time [31]. Due to the restrictions of both sensory memory and short-term memory in terms of capacity and duration, the stored information is kept on for a limited time before being forgotten or transferred to long-term memory.

These are two specific cognitive processing theories which should be taken into account when the design of instructional multimedia and multimodal e-Learning systems are considered. These are Dual Coding Theory and Cognitive Load Theory [26, 33]. Both theories focus on the short-term working memory capacity. Since humans integrate information (auditory, visual….) from different sensory modalities simultaneously and interpreted into one meaningful experience, this affects the ability of memory to process the information [26, 33].

2.7.1 Cognitive Load Theory

As the working memory has only a limited capacity, it is likely for the learner to experience a cognitive overload in working memory, when large amounts of information are presented to him at one time. Consequently this will result in dispersion of direction and focus of the learner. This is based on the assumption that a learner has limited processing capacity and only finite cognitive resources [26]. As a result of this limitation, learning instructions should be designed taking in mind the capability of the working memory to process the instruction [34].

2.7.2 Dual Coding Theory

This theory assumes that the short-term memory or working memory consists of two distinct systems or sub-storage areas, verbal and non-verbal. Verbal system processes spoken information, whereas non-verbal system is responsible for processing visual information (image and text). One solution suggested by cognitive psychologists to increase the capacity of working memory available is to make these processing areas work simultaneously; thus it will decrease the cognitive load [35]. The assumption of integrating verbal and non-verbal systems is also referred as the “Modality Effect”, which can be seen as a subset of Dual Coding Theory [35]. As a result combining spoken words with graphical elements will exploit the short term memory resources, allowing processing interchange between various systems and therefore enhancing the learning process [26, 36].

2.8 Desirable Pedagogical Principles of an E-Learning Environment

Creative and affective teaching need to overcome the existing limitation of existing systems of e-Learning because many of the current learning technologies are invented and designed by technicians or engineers, whose backgrounds are only technical with little or no experience of underlying educational goals. Those commercial products are time consuming and lack of educational principle [37]. Vrasidas in his article [38] and dependent on the National Centre for Educational Statistics report, argued that during the 1998 Fall, only 6% of teachers actually taught online classes; therefore the author referred that to lack of pedagogical principles in e-Learning environment. Meaning that these exists a lack of skills needed to design and teach online classes, a lack of support, training, and help needed for planning online instruction and a lack of face-to-face contact and many other principle. Therefore there are essential pedagogical principles that must be carefully considered to provide good practice of teaching. Pedagogical principles include different aspects of the learning process that can be adapted from traditional learning to fit e-Learning process, since these principles have been built from the good practice of teaching since ages [39].

Several researches and articles have addressed the use of e-Learning technology to develop education qualitatively, such as [37-43]. Neuhauser [41] and Govindasamy [39] argued that pedagogical principles have not been included during e-Learning development and attempted to provide clear evidence that it can be used to extend the pedagogical principles that have been used in traditional classrooms to accommodate the advances in e-Learning, in addition to recommending the integration of these principle into Learning Management

Systems (LMS), which is a software designed to automate the administration process of teaching and learning.

A good quality e-Learning systems must include pedagogical attributes such as; teaching or interaction style, grade level, mastery level, and prerequisites where applicable [39, 44]. Govindasamy [39] recommended some pedagogical principles that should be incorporated to every e-Learning environment, based on the original pedagogical principles. These attributes are as follows:

2.8.1 Developing Content

The contents of e-Learning should comprise small controllable pieces of information, which are known as Learning Objects (LO). This will enable learners and any other developer to reuse or update any units easily.

2.8.2 Storing and Managing Content

After completion of LOs chunks, each LOs piece must be stored and classified according to the indexed categories that let learners and instructors to access and modify any particular unit of information "just-in-time learning". Moreover, each LOs portion must be tagged with metadata, such as name, author, date, job, skill, version and date last revised [44]. This metadata will provide great assistance during the process of searching and positioning a particular LO.

2.8.3 Student Support

In this part, the developers must predict all types of problems occurrence which online students are more likely to encounter and provide the prober solution in advance in order to introduce the necessary support on time.

2.8.4 Assessment

There are two types of assessment that should be used to assess the e-Learning students, *Summative* and *Formative* assessment. The summative assessment is used "to grade students to demonstrate students' achievement and it involves making a final judgment of the students' achievement relative to the predetermined objectives", whereas formative assessment is used as "a diagnostic tool for students and teachers to identify and improve areas of weakness".

Other pedagogical aspects recommended by Clark, R. [45] were seven principles integrating cognitive and emotional components of learning, that will provide a greater outcome when it is integrated and makes e-Learning more effective, to create a better experience for the learners. These are meaningful skills to keep things light such as emotional engagement, connected concepts, elaborated examples, pragmatic practice and refined reflection.

A different categorisation of learning principles suggested by Vrasidas [38] for effective online learning and the respective need for LMS support include: Learner-Centred, engaged and active, constructive, situated and contextual, social and collaborative, reflective, and requiring prompt feedback.

One more article suggested other patterns that can help in improving students' reaction to e-Learning, firstly by varying the types of content, and secondly by creating interactions that engage the attention, providing immediate feedback and encouraging interaction with other e-learners and an e-instructor [46].

In conclusion, and based on above literature, e-Learning can incorporate, adopt and extend traditional pedagogical elements that are considered as different learning styles, that make learning a new material, a new process or a new program more entertaining. Making learning more interesting is what makes it more effective. In fact, not every type of training can be turned into e-training, but many could be implemented with excellent results [46]. This can be accomplished with the collaboration of researchers, educators, and computer scientists to determine the ways that technologies can facilitate teaching and learning and carry out research that can point the way to improve the development of such technologies [38].

2.9 Usability of E-Learning

Usability is a measure of how easy a system is to use. Usability could be considered the fundamental base in human-computer interaction (HCI) because it is concerned with the quality of user interface that facilitates useful interaction [47]. The International Standards Organisation (ISO) [48, 49] defines usability as: "*The extent to which a product can be* *used by specified users to* achieve specified goals with effectiveness, efficiency and satisfaction in a specified context". Effectiveness is defined as the "accuracy and completeness with which users achieve specified goals" while efficiency is the "resources expended in relation to the accuracy and completeness with which users achieve goals" and satisfaction is the "freedom from discomfort, and positive attitudes towards the user of the product". This ease of use is required to any interaction between human and machine. In e-Learning applications, the usability can be considered an important issue that promises its success. The learner will suffer and will spend much time to be familiar with the system in terms of system functions and learning contents, if an e-Learning system is not usable enough. Wastage of more time than expected will decrease the users' overall retention and disconnect the sequences of ideas and new concepts being learnt Moreover, an unusable system interface may enforce people to avoid it and search for another satisfied interface that offers fast, enjoyable and more interactive ideas [50, 51]. Moreover, the issue of technology has also a direct effect on the ease of learning if the user has to use different hardware and software equipments, which, however can be possibly resolved by a suitable customization of access procedures [51]. Furthermore, and as mentioned in Section 2.5, besides the usability feature, another essential factor to take note of that enhances usability is the pedagogical principle which should be incorporated to obtain a suitable, attractive and engaging e-Learning system with the aim of supporting the learner and providing an easy and beneficial learning environment, rather than a pure experience in advanced technology [50, 51]. Indeed, many usability criteria have been developed to assist designers to produce a usable e-Learning system that offers learning content rather than confusing interface. An example of key considerations of usability of e-Learning systems includes [8]:

- ease of learning: how the site enhances the learning curve.
- efficiency of use: how quickly a person can locate specific portion of information using the navigation system as an example.
- ease of remembrance: the ability of the learner to remember how to carry out a particular task.
- error: the number of errors should be small, and it should be manageable when they occur and do not discontinue the user completely.
- satisfaction: the user should enjoy achieving a given task.

Additionally one of the approaches that are adopted by many researchers is *User-Centred Design.* This approach has been proven to be effective in providing usable interfaces [52]. In this methodology the users are required to incorporate with the development team from the very beginning of the planning stage. This will provide a good mechanism to discover any errors or usability problems before the final version is completed. Moreover user-centered approach benefits the designers as regards the reduction of completing time, effort savings and offer of more satisfactions required to meet the users' specifications. The philosophy of user-centered design is:

- Analyze users and task;
- Design and implement the system iteratively through prototypes of increasing complexity;

- Evaluate design choices and prototypes with users.

Alternatively Ardito, C., et al. [53] in their paper identified specific usability attributes for e-Learning systems. The study investigated empirically after observing a group of students during their interaction with e-Learning system in a real situation. The study results in some problems that the students encountered, which are:

- Disorientation and difficulty to proceed.
- Lack of mechanism to highlight both the lesson structure and the high priority topic.
- Difficulty to search the educational materials.
- Frustration when the student has to start from the beginning due to network failure and his/her tiredness during a prolonged interaction with the system.

Based on these usability problems, the authors suggested Systematic Usability Evaluation (SUE) approach which targeted to separate the platform usability problems and usability e-Learning module problems. They classified the results of the study into three categories of problems; Presentation (80%), Orientation (95%), and Functionalities (60%), each of which involves detailed problems. Overall the study concluded that e-Learning usability is a very complex issue and the quality of an educational module, when provided through a platform, suffers the quality of the tools provided by the platform itself.

2.10 Entertainment and Fun as Aspects of Web Usability

Recently, philosophers and psychologists' arguments in the area of effective learning and HCI demonstrated that humour or entertainment is one of many important factors that help in developing improved usability [54, 55], hence learning [56-58]. And when students enjoy more in the class, learning outcome increases. Nevertheless humour is part of the various aspects of our life, and it's without doubt necessary for many of us. Therefore humour should be an issue of future multimodal interfaces, especially in the area of education [59, 60]. In this way e-Learning as a new learning medium can engage students in an individualised environment where they can explore and learn concept and content to meet their specific needs [59, 61, 62].

Furthermore, e-Learning is not only an educational issue but also a complex experience that involves various domains such as social, emotional, psychological, and other related areas [63]. Many e-Learning systems still present insufficient information, forcing students to navigate too quickly to less text-based and more interactive sites [3]. Online learners today require more than mere information; they need to fill the gap missing in e-Learning systems, an environment similar to that experienced in traditional learning, to interact with someone who could represent their teacher, and to feel that they are in a classroom learning from other students, experiencing enjoyment during their learning, emotionally involved with the lesson and the instructor and learning from the teacher's facial expressions, gestures, hand movements and other activities that can convey the message [64].

In summary the experience or entertainment has a direct implication for usability evaluation as well as learning development. As a result, modern students, both those who are digitally experienced and those who are new to this field, should be entertained and educated to achieve a better learning performance.

2.11 Multimodality

Recently, the relationship between computers and humans has increased as well as enhanced through what is called a computer as an 'Agent'. Software agents have the ability to interact with users via spoken natural language commands with the capability of moving, sensing their environment and performing specific functions [65]. Moreover, it offers an easy and enjoyable environment that enables users to work with difficulty of a variety of applications. Besides interacting with humans via natural language requests, it understands the logic behind the service, and it can also direct the users to specific pieces of information and capture it from the vast amount of knowledge efficiently. In general it has enhanced the interaction between human users and made the environment more natural and more accessible for all by organising multimodal inputs such as audio, speech, handwriting, keyboarding and other input modes and generating a multimodal response such as speech, text, graphics, audio files, and animation. These modalities are extensions to the traditional text and graphical user interface (GUI) and include gestures, speech, tactile and haptic interfaces, as well as interfaces based on eye-tracking. Examples of advanced computer agents are Sony AIBO, and Honda's humanoid ASIMO [65, 66].

2.11.1 Terminological Differences between Medium, Modality, Multimedia and Multimodality

Multimodality is the simultaneous use of several sensory modalities together by which humans receive information, which facilitates a useful interaction paradigm between users and interfaces and enables natural [67, 68]. These modalities could be tactile, visual, auditory, etc. It also requires the use of at least two response modalities to present information (e.g. verbal, manual activity) [69]. Medium is a material object (diagram or a text) used for presenting information, and it can be stored and communicated through physical carriers including computer input/output devices (sounds, movements, screen, microphone, speaker, and pointer). Modality refers to the use of a medium, or a channel of communication (human senses e.g. visual, tactile, etc.) as a means to express and convey information [67]. On the other hand, multimedia and multimodality can be seen as two different realities. While multimedia systems deal with the presentation of information, it keeps data received through several input media, and presents it to the user through a set of suitable output media. Multimodal user interfaces are able to understand multimodal commands from the human that are formulated using several modalities and then interpret and regenerate information presented to users by various media (e.g. generating system messages and responses) [52, 67]. In other words, the main distinction between multimedia and multimodal user interfaces can be referred to the system's input and output capabilities [70]. While multimodal user interface accepts multiple inputs and presents multiple outputs, such as using speech together with pen-based gestures, multimedia user interface can support multiple outputs only, e.g. text with audio only. As a result, multimedia research can be considered as a subset of multimodal research [70].

2.11.2 Multimodal Systems Interaction

According to human cognition research, the assumption of a combination of multimodal information in human already exists, and this can happen by processing all raw input data, obtained by visual, auditory, olfactory and tactile sensations, and then process in the brain which controls and coordinates the information flow to produce perceivable cognitive responses and actions. Multimodality is the natural way to human to communicate unconsciously using all different information and using different channels every day. For example, human can speak, write, listen and move simultaneously [65, 69]. On the other hand, the majority of the computer system developers concentrate on sight sense only to convey the information; therefore this may confuse the users and distract their retention due to the overloading on the visual channel during the interaction [70].

2.11.3 Why Multimodality

These multimodal metaphors can enhance the interaction between human and machine by linking together more than one channel to convey different information [71] and this consequently decreases the working memory capacity [72]. This flexible environment will enable the flexible use of input and output modes to interact with computers, depending on the setting: speech, gesture, gaze, pen, touch, movement [68]. Moreover and in the case of e-Learning, a successful multimodal interaction should overcome the problems that the users face while they interact with e-Learning systems and are able to focus on the content of the information provided rather than the technology itself. On the other hand the users could build their experience of interacting with technology into an integrated one that would focus on learning only [70]. Furthermore the multimodal nature in human-human interaction can help to make computer to human and human to environment interaction more natural [52] and could get over the lack of face-to-face communication problem in computer user interfaces [73, 74], and avoid misunderstanding that occur sometimes to the lack for nonverbal feedback like in email communication [68]. What is more, spoken utterances are usually not clear without any contribution by a pointing gesture or a shared visual input [68]. Therefore the nonverbal activities like postures, gestures, facial expressions help to add richer meaning to human to human messages. Also, the multimodal interaction provides the facilitates for presenting the similar information using different channels [71], which give the users an alternative choice to interact with the computer application utilising the most appropriate type of interaction that fits to their abilities, preferences and needs [75]. In addition to that, the different combinations of models such as earcons, speech and even avatars after an examination found to have given effective results and helped to improve the usability of interfaces and users performance [5, 6, 76-80]. Finally, multimodal metaphors can help disabled people to communicate with such interface more easily and better than before [52].

2.11.4 Multimodal Computer Interface

Multimodal computer interfaces are those that combine more than one interaction modality to incorporate different human senses to facilitate human-computer interaction [52]. Multimodal interface metaphors can be classified into several metaphors that are briefly reviewed in the next few sections:

2.11.4.1 Visual Metaphor

Jaimes defines visual literacy as the ability to 'read' interprets, and understands information presented in pictorial or graphic images". Aristotle stated that, "without image, thinking is impossible", Poet Simonides said, "Words are the images of things". On the other hand, Jaimes noted also that much of the research reported supports the importance of visual metaphor strategies in teaching and the production of great results. In e-Learning courses, students mainly interact with e-book or computer screens that lack visual references, which in turn makes the learning not sufficient enough [81]. In fact visualization helps to make sense of the data that may have been previously meaningless; therefore a great deal of information is better presented visually rather than verbally [81]. As a result of incorporating visual metaphors, studies such as [5, 6, 78, 80] noticed a great enhancement on the usability of systems in general and e-Learning in particular which offered easier interaction between the user and the system; bearing in mind that crowding interfaces with many graphical and textual information might confuse the users and disconnect their attention. Alternatively the addition of auditory metaphors to virtual stimulus, could contribute to decrease the load on the visual channel in receiving the information being captured [26]. The advantage of the auditory information is that it can be caught from all sides regardless of the direction of body or head giving the other sensory chance to obtain extra information (e.g. visual) [71], while the users, in visual interaction, need to focus their sight towards the graphical representation or output device. For example, satellite navigation system uses both visual and auditory aids; this auditory channel helps the driver to concentrate on the road on many occasions where there is need to drive carefully using the visual sense (Round about for example), thus preventing many accidents that might happen.

2.11.5 Auditory Metaphors

2.11.5.1 Speech Metaphor

Speech can be considered as multimodal in nature since people can use speech naturally with non verbal cues such as facial expression, eye/gaze, and lip movements to provide easy human to human understanding [81]. Moreover visual and audio channels can be also simultaneous with speech, for example, people can hear the sound while they see the lip and tongue movements. Similarly the tactile channel is also a speech medium since blind people use their touch sense to recognise spoken or written language using, for example, the Braille or the Tadoma methods. Multimodal speech systems (or audio-visual speech systems) in fact mimic this human to human communication by connecting together automatic speech recognition with other non verbal cues (hand movement) and by bonding non verbal cues with speech synthesis to produce meaningful multimodal output. Speech sounds can be categorised into natural speech and synthesised speech [81]. Natural speech is normal human spoken speech recorded by special software as digital files and when played, it provides natural human like interaction with computer systems [81]. The drawback of speech is that it requires to be pre-recorded, manipulated and saved as digital files before use; therefore by an increasing size of these files, a large storage space is required, as a result recorded speech is not effective in those systems that need long spoken expressions [81] but they can provide strong communication effectively when used in short spoken messages [82]. Synthetic speech on the other hand, is an imitation of human speech created by speech synthesisers using two different techniques, concatenation or synthesis by role [83]. In concatenation technique, the speech messages are formed by connecting pre-recorded parts of human voices after being stored in a database system, whereas in the second technique, which is also referred to as formant speech, it is based on creating the speech sounds artificially using phoneme generation rules and therefore can be used to produce speech in run-time [84]. These speech synthesiser methods can provide a faster and more flexible solution for the creation of high quality speech sounds; it is not recommended due to the unnatural sounds generated and therefore natural recorded speech is preferred and could provide more required communication [85].

2.11.5.2 Non-Speech Metaphors

Non-speech sound is a multimodal interaction metaphor that has been implicated in Human-Computer Interaction that can contribute to enhance users' performance as well as the usability of interfaces. Brewster argued that speech has some limitation in presenting information due to the serial nature which makes it slow. Alternatively non-speech audio is faster and attractive and can be easily understood with the presence of adequate training [86]. Non-speech metaphor modalities currently available can be categorised according Benoit and his colleges [87] to non-speech inputs and non-speech outputs. Non-speech inputs comprise Pointing and Gestures pointing, 2D gestures and 3D gestures, Characters and Handwriting, Eye/Gaze, Lip Movement and Keyboard and Mouse. On the other hand Non-speech output modalities include Text, Image Data, Sound and Earcons. Earcons and auditory icons will be discussed in detail in the following subsections because they were used in this research to enhance the usability of the edutainment interfaces.

2.11.5.2.1 Earcons

Earcons is defined by Tuuri et al as “nonverbal audio messages used in the user-computer interface to provide information to the user about some computer object, operation, or interaction”. Computer objects meant in this paradigm are files, menus, and prompts, whereas editing, compiling, and executing are examples of operations. Editing a file is an example of an interaction between an object and an operation [88]. Earcons as non-speech sounds are mainly created from short series of musical notes [88] to express complex information. Mustonen classified these earcons to one-element (simple) or a compound. One-element earcons is a compound of single note and a single pitch. Conversely, compound one can be integrated with different combinations of sets of simple earcons. Sound attributes such as rhythm, pitch, timbre, dynamics, tempo, and intensity, can be adjusted to be used to construct different types of earcons [89]. This provides several ways to express the different information when incorporating earcons in user interfaces, which requires users to remember the meaning, associated with each earcons [90].

Earcons have been examined in many different areas and confirmed that it can provide realistic communication in computer interfaces [91]. An example of graphical components enhanced by attaching the earcons in user interfaces is scrollbars [92], menus, buttons, and tool palettes [93]. Additionally, earcons have been used to provide auditory feedback and clearly overcome the usability problems that emerged by using graphical widgets such as ‘kangarooing’ with the thumb wheel of scroll bar and ‘slipping of’ with buttons, by contributing to decrease the task completion time, error rate, error recovery time as well as mental workload without bothering the users [91]. Furthermore, earcons have been utilised in the software development process to communicate auditory messages associated with coding, execution and debugging of the program and provides faster information about variable values, compilation errors, their types and locations in the code [91, 94]. The other benefits associated with earcons are that, it helped visually impaired users to access graphical representations [95], spreadsheets [96] and numerical data tables [97] and allow them to illustrate two dimensions of line graphs [98]. In fact several computer applications were potentially enhanced by the incorporation of earcons resulting in improvement in its usability. Examples of these applications are stock control systems [99], knowledge management systems [100], email browsing [79, 101] and search engines [6].

2.11.5.2.2 Auditory Icons

There is an increasing demand of research that suggests incorporating non-speech sounds (earcons and auditory icons) to graphical interfaces to reduce the visual workload which affects the users' performance [94]. Auditory icons are non-speech that uses sounds from everyday events to add valuable functionality to computer interfaces [88]. They are designed merely to convey information when the user eyes are occupied with another process allowing him/her to listen to computer events without the need for using their visual channel [88].

A number of systems have utilised the potential for auditory icons to convey useful information about computer events. SonicFinder [102], is one of the systems in which auditory icons have been developed and used. It records environmental sounds that could be utilised to represent interface objects, operations and attributes along with visual feedback. For instance, when the user selects a specific file, the icon representing that file is highlighted, accompanied by sound as a result of hitting that file where the frequency of the sound depends on the file size being communicated. On the other hand an auditory icon has been also successfully shared with speech and earcons to enhance the interaction with mobile telephony [103]. A vital advantage of auditory icons is that, it could communicate more than one piece of information using a single sound. For example, the intensity of the various single sounds could give an indication to the user of both the process of the receiving and the size of the arriving message [94]. Additionally the user can easily recognise and remember these sounds and can provide a natural mapping with the delivered data [94]. On the other hand, these mappings are on many occasions difficult to establish [104]. This can be seen clearly in SonicFinder [102] where copying for example had no corresponding environmental sound. Instead, it was replaced by pouring a fluid auditory icon. Another possible disadvantage of auditory icons is that, using a sound derived from the same source such as hammering with walking without doubt confuses the user [105].

In summary, each of the earcons and the auditory icons has advantages and limitations. But earcon is more suitable since it can represent any object, action or interaction more effectively [104]. At the same time, the limitation of earcons is that it's more abstract i.e. it does not express meaningful association with the data it represents [104]. This requires the users to learn this association from scratch to be able to remember its representation easily [52, 106]. Finally and as Brewster [107] recommended, enriching the computer interface by all of earcons and auditory icons could be the best option which has been confirmed by many experimental studies [108, 109].

2.11.6 Audio-Visual Metaphors

2.11.6.1 Avatar

An avatar is an additional multimodal interaction attribute that could engage both visual and auditory human senses. It is a computer-generated synthetic character created to mimic real life behavioral qualities when interacting with other users of avatars virtually [110-112]. Avatars have the capability to transmit verbal and non-verbal cues [113]. In verbal messages the user uses speech with written messages but in nonverbal one the message can be received by facial expressions and body gestures [74]. The word avatar comes from the

Sanskrit language [114] and can be translated as God's Incarnation on Earth. In the virtual reality community, avatars are 3D humanoid characters inhabiting virtual space, with varying degrees of animation and behavioral abilities. Avatars typically represent humans who visit the space virtually. Each visitor controls their avatar and is aware of other visitors' avatars and their actions. The avatar moves and gestures in the mirror as the experimental subject moves and gestures in the physical room [7, 114].

McLaughlin et al. categorised avatars in terms of form to be abstract, realistic and naturalistic. Abstract avatars or symbolic avatars usually represent the real users to remain completely unknown. This type is not recommended, since it does not provide a user friendly environment that enriches user experience expected from multimodal communication [115]. An avatar compound in Microsoft's office application is an example of this type which is targeted to provide helpful information to users when they organise their documents [113]. Realistic avatars on the other hand provide a real demonstration of human beings created that represents still images or video sequences captured from users and had been applied in many cases such as virtual reality games, computer movies and teleconferences and also has been recommended for entertainment purpose [116]. The problem of this category refers to hardware requirements and cost to adopt this technology [117]. Consequently work is in progress to enhance the computer hardware in terms of high performance graphics and speed of cartoon-like and human-like synthesised faces for use in computer applications [117]. The naturalistic avatars however are humanoid i.e. they look like real humans but it is not accurate enough and commonly employed in collaborative virtual environments to embody the users [76]. Virtual environments that are implementing avatars enable the users to interact with each other in a virtual world regardless of their locations [118] and provide them with the sense of presence and participation in social computer-mediated activities [119]. Avatars move or gesture in two or three dimensional world, talk to each other and represents any kind of conversation it might occur between humans in the real world whether it was serious or funny. Avatars or Virtual worlds have been used in many environments such as teaching languages and architectural design [120], entertainment, edutainment, e-Learning, simulation and e-commerce, console games, multimodal applications, or even teleconferencing environments. That is because of realistically offered that provides high level of realism in an interactive environment [121] and also it has been successfully improved the social interaction among students [120].

An avatar facial expression gives a more realistic interaction in human computer interfaces when it synchronized in a normal manner in terms of jaw, lips, teeth and tongue so that the produced speech is suitably articulated [122]. Expressing emotions, feelings, and linguistic information could be extracted easily from human face. Fabri et al. [123] argued that avatars can express and display easily and effectively the simple human six universal facial features such as happiness, sadness , anger ,surprise, panic, disgusting and neutral in the interfaces and they found that the users identified these features accurately even when communicated with incomplete facial appearance [124]. Fabri et al. [7, 125] in another study compared two versions of instant virtual messengers, one is used expressive avatar (Animated 3D character) to entertain two users during their discussion where as the avatar was absent in the other one. The study showed that the emotionally expressive avatar had some positive effect on participants' experience and senses of presence were enhanced users' engagement by creating a more enjoyable experience during collaborating while chatting. In another study, facial expression has been used to treat people who suffer from the autistic disease, and the study found that this autistic users have the ability to interact and understand the different facial expression provided to them by avatars [7, 126] but due to considerable differences in social abilities of those patients, different treatments are required to different users mainly with severe autism users [127]. Additionally and besides the facial expressions, humans are using body gestures to send non-verbally messages such as movements of body, head and hands to express what would like to say as complement to speech channel and sometimes as substitution to speech [82, 128]. Indeed there several cultures and traditions affect the way people use their body to express things, but most of the human body gestures have common interpretation over the world. Moving head from side to side for example indicates to negation whereas nodding is a sign of agreement, while thumb-up provides dissimilar meaning in different countries. A number of studies with the aim of inspecting the role of facial expressions and body gesture through avatars in enhancing the interfaces in general have been carried out by many researchers and resulted in significant outcomes. In one empirical study accomplished by Gazepidis and Rigas [74], users were satisfied with like a talking virtual salesman with facial expressions and body gesture interface than text based presentation in e-commerce interfaces. Further to this study Rigas and Gazepidis [82, 129] [82, 129] found that users preferred some facial expressions and body gestures more than others. Among a set of 13 expressions and 9 gestures examined in both the absence and presence of interactive context, the most positively viewed expressions by users help them in enhancing users' attitude and in remembering the information being trained [129] while were, happy, interested, amazed, neutral, positively surprised and thinking, and the gestures: open palms, head up, chin stroking, hands clenching and hand steepling. Another experimental study used positive (happy, amazed and positively surprised), and negative (sad, tired and disgusted) and neutral (neutral and thinking) facial expressions which confirmed the role of avatar in stimulating the users memory as well as increasing usability [90, 130]. Embedment of human-like expressions and body gestures in users' interfaces could improve users' perceptions towards avatars. Cowell and Stanny [131] argued that representing human facial expressions and gestures by avatars will improve the users attitude and increase trust towards interface agents. In addition many studies evaluated single facial expression such as happy mode and gaze and they provided an evidence of its positive influence on users' emotions. For example Gong [132] tested the happy appearance mode and it was found to be helpful in enhancing users feelings, retention and pleasure. As result numerous guidelines have been developed in order to benefit more from the advantage of combining multimodal metaphors in Human Computer Interaction. A range of these guidelines was specified to assist interface developers in the designing and implementing of earcons [7, 128, 129], other researchers recommended another criteria that serve as guidelines for a combinations of different multimodal metaphors such as speech in the company of avatars [129], speech, earcons and auditory icons [6, 135], and earcons grouped with speech [136]. Finally general guidelines were introduced to offer guidance for the design of multimodal user interfaces [71, 137].

2.11.7 Multimodality is the Solution for Lack of Face to Face Contact in E-Learning

Impersonal, non-face-to-face contact and text-based interfaces, in the e-learning segment, present major problems that are encountered by learners, since they are missing out on vital personal interactions and useful feedback messages, as well as on real-time information about their learning performance [138]. Moreover to obtain higher effectiveness in catching the attention of the learner and enhancing their attitude to online learning, creativity and innovation are required to enhance the mechanism of the way the educational materials are delivered [120]. Many e-Learning systems still present insufficient information, forcing students to navigate too quickly to less text-based and more interactive sites [3, 139]. Online learners today require more than mere information; they need to fill the gap missing in e-Learning systems, an environment similar to that experienced in traditional learning, to interact with someone who could represent their teacher, to feel that they are in a classroom learning from other students, to experience enjoyment during their learning, to get emotionally involved with the lesson, the instructor and the learning from the teacher's facial expressions, gestures, hand movements and other activities that can convey the [64, 140]. E-Learning is not only an educational issue but also a complex experience that involves various domains such as social, emotional, psychological, and other related areas [63]. Therefore multimodal features such as earcons, speech and particularly avatars can be considered as one of various attributes providing substitution for lack of face to face contact with the teacher in e-Learning. The presence of an avatar or talking to a virtual human, for example, in e-Learning, with associated cognitive factors, might make the learning more amusing, increase users interest, motivation, and retention, and at the same time improve a higher order of thinking and reasoning skills [138]. Furthermore interesting possibilities can be offered by avatar world for online learning, collaboration, discovering new environments and attracting learners to keep progressing. Both the educator and the students can also build their own virtual worlds. This creates a sense of realism that is often absent from distance learning, which has been considered a benefit of educational three dimensional virtual worlds [141].

2.12 Edutainment

The term edutainment is a mixture or marriage of the two expressions "education" and "entertainment". Edutainment adapt multimedia interaction methods to produce educational learning materials in some kind of entertaining forms [141] and bring natural emotion into education [142]. Besides edutainment, the phrase *infotainment* also emerged as a result of the development of interactive multimedia in the late 1980s. Another concept appearing with edutainment is what they called *technotainment*. This concept *technotainment* does not use as much as edutainment and infotainment, but also was created to describe specific types of educational materials that are proposed to educate as well as to amuse users [141]. However as edutainment, infotainment and technotainment are a combination of entertainment and education, this integration is mainly to create a motivating and successful environment for learning [141, 143]. As a new medium, edutainment has many definitions. One of the edutainment comprehensive definition is described by Savidis [56] as "*pleasure or positive experiences that a learner hopefully desires. The pleasure can result not only from the entertaining and interesting content itself, but also from the entertaining and* *interesting content itself, and also from the satisfaction of getting problems solved especially in games*". From the definition, it is obvious that the term edutainment includes several types of activates and actions; they could be physical or mental actions, where the feeling of pleasure depends on situation and circumstances where they happen and with whom they differ in terms of the age and the educational level of people. In reality it is kinds of positive feeling people get from interaction with many objects in this world with whatever motivation. It might be from solving a problem or reading a novel or riding a bicycle or even talking to someone or playing specific game [141, 143]. Therefore whatever is the motivator, the important thing is to experience good feeling and continue this feeling which is more important to build a general idea and process information effectively [144]. However the challenge is how to create edutainment programmes that balance the contents of education and entertainment materials. In other words, the edutainment productions should not be neither too entertaining nor too tough [145].

As edutainment is a technique used to teach specific knowledge through the entertaining medium, it should be designed so that it can convey information as natural as possible. Various groups in the United States and the United Kingdom have used edutainment to address such health and social issues as substance abuse, immunisation, teenage pregnancy, HIV / AIDS, and cancer [146-148]. Animals, African Safari, and Hawaii are examples of good edutainment programmes [149]. Edutainment had been also implemented in games software including all types of electronic games like computer games, console games, portable and handheld games. Many programs on TV that submit effective educational subjects via entertainment means for children as Sesame Street could be classified as edutainment [141]. Another example is a simulation game designed to teach basic business concepts and encourage entrepreneurship called *Hot Shot Business* which begins with a high-level discussion of the experience and goes on to describe how the educational content is presented to the player as the game progresses. Examples of websites that educate and entertain at the same time are Learn2.com, Serious Game, Simulearn, Games2train, MBA Games, and HowStuffWorks.com [150].

2.12.1 A short History of Edutainment Term

The first who used the term *edutainment* is Robert Heyman, this was in 1973 to supply the National Geographic Society the documentary materials. Moreover, in 1975 it was used again by Dr. Chris Daniels when he was preparing to launch his Millennium Project, which has changed its name later to The Elysian World Project [146] In 1983 edutainment utilised to provide a description of the games package for the Oric 1 and Spectrum Microcomputers in the UK. "Arcade edutainment" is a term employed to advertise this package which has been available in "Your Computer" magazine since 1983. *Electronic Arts* and *Seven Cities of Gold* computer games are other examples that are described as edutainment products during 1984. It is also the name of a popular radio show in Knoxville TN, "The Edutainment Hip Hop Show" [146].

2.12.2 Types of Edutainment

Edutainment can be considered as another choice that should replace traditional learning. Indeed, edutainment can be classified based on the purpose and content, target group and contents of the material [151]:

2.12.2.1 Purpose and Content

This type of edutainment is designed to help students in schools and educational institutions in their studies and it is communicated in forms of conversation or story. The other subset of this type is the illustration and simulation of virtually the information given to users to improve their experiences or skills.

2.12.2.2 Target Group

This category consists of two main forms:

- Motivation-oriented: The target in this model is to motivate users with the identical interest despite their age, backgrounds and knowledge.
- Age-oriented: The edutainment material is designed to fit the users' age.

2.12.2.3 Contents of the Material

This third classification is intended to give specific programmes such as school-TV programs, games, and game tools to groups of users.

2.12.3 Edutainment and E-Learning Interfaces

The main target to any educational instructors is to attract and prompt the learner. This is essential in e-Learning where students and instructors are invisible to each other [4]. Background literature determines that, to obtain good result and higher quality thinking, e-Learning systems must provide users with a challenging environment that enables them to process new information given and creates a bridge with the experience they have already acquired [4, 143]. Edutainment programs that include computer games and interesting TV programs are mainly designed for the educational use. Therefore it can provide learning to people whether they are in systematic educational organisations or unsystematic learning on a daily basis life contexts [151]. Educational institutions today are obliged to comply with globalisation. Learners, on the other hand, are required to pursue the development of digital technology to become a part of modern society. This new means of information flow has changed learners' attitude to online educational resources [152]. Online learners today require more than mere information; they need to fill the gap missing in e-Learning systems, an environment similar to that experienced in traditional learning, to interact with someone who could represent their teacher, to feel that they are in a classroom learning from other students, experiencing enjoyment during their learning, emotionally involved with the lesson and the instructor and learning from the teacher's facial expressions, gestures, hand movements and other activities that can convey the message [140]. Countless studies from various disciplines, such as human-computer interaction (HCI) and social and cognitive psychology, demonstrate that students' attitude and emotions have a very important effect on student behaviour in online learning [140, 153-156]. Therefore, e-

Learning as a field of recent concern brings as much change to instructors as it does to students, requiring a new set of skills that replace traditional practices. In fact, many e-Learning systems (Interfaces) still present insufficient information, forcing students to navigate too quickly to less text-based and more interactive sites. Considering the problem of e-Learning, many researchers are [58-60,156-158] concerned about the role of multimodals and entertainment in improving learning through e-Learning interface. On the other hand, a number of studies have been conducted to investigate the role of entertainment and positive emotions to enhance learning [140, 159-161]. One work by Lin, A.C.H. and S.D. Gregor [160] has investigated museum websites that present educational materials. These websites are designed to provide the general public with educational materials through enjoyment. In this study five people participated, from the field of museum-website design experts in Taiwan. The approach used in this study was descriptive-qualitative and was based on semi-structured in-depth interviews and expert interviews as the primary method. The study derived five development guidelines for the design of learning through enjoyment in museum websites and noted a number of aspects, including: 1) the adoption of multimedia and interactive technologies; 2) consideration of the characteristics of self-directed learning; 3) the importance of qualified staff and adequate financial support; 4) identifying a target audience; and 5) the importance of making information more sharable. Although these findings are targeted at museum websites, they can be applied generally to e-Learning systems.

In another study made by Kara, Y. and S. Yesilyurt [161], the target was to explore the influence of tutorial and edutainment design of educational software programs that present the topic of ‘‘cell division’’ on student achievements, misconceptions and attitudes. The cell-division achievement test (CAT), cell-division concept test (CCT) and biology attitude scale (BAS) were applied at the beginning and at the end of the research. A total of 72 students took part in the study (age range 14-15 years). The users were distributed randomly in three groups within three ninth-grade classes of a public secondary school. Two were experimental groups and one was the control group. In each group there were 24 students. Users in all groups had knowledge about computers, but had no experience of learning with CAT. The control group practised a traditional teaching method, while the experimental groups were educated through computer-based learning. The study showed increases in general achievement in CAT for the experimental groups. Students understood the general functions of mitosis and meiosis easily since instructional software programs were obvious and effective. In addition, the study discovered that misconception in the experimental groups is not entirely eliminated even after the treatment. Nevertheless the study confirmed that using edutainment software program noticeably alters students' attitudes towards biology materials.

2.12.4 Humour as Edutainment Attribute Recommended to Enhance Human-Computer Interaction

A human-computer interface is the attempt to mimic human-human communication. In human-human communication especially in learning, students were interacting emotionally either with each other or with their instructor in a way that minimises the formal relationships. While in a web based learning these emotions are not present or sometimes absent with many types of e-Learning environments [162]. Researchers on the other hand have articulated that humour strengthens students' performance in learning environment combined with amusement features. This mostly happens online where there are users in front of unadulterated educational screens [163]. In anyway humour is one of the pedagogical factors that have been used in classroom by teachers to obtain better performance and to decrease the sensation of boring especially in scientific subjects [164]. Humour has been used in this era again by educational designers in many projects to overcome the problem of poor web based text [3, 140, 153, 156, 160]. Furthermore philosophers and psychologists' arguments in the area of effective learning and HCI demonstrated that humour or entertainment is one of many important factors that help in developing improved learning. Accordingly students' performance increases in a learning environment combined with amusement features, and when students enjoy more in the class learning outcome increases. Nevertheless humour is part of various aspects of our life, and it's without doubt necessary for many of us. Therefore humour should be an issue of future multimodal interfaces, especially in the area of education [59, 60]. In this way e-Learning as a new learning medium can engage students in an individualised environment where they can explore and learn concept and content to meet their specific needs [58, 59, 61, 62].

2.12.5 Digital Storytelling as Enjoyable and Effective Learning Medium

Stories relate to old customs that are used by people in most of the cultures worldwide to spread the knowledge in daily base and could be considered as one of important techniques that expresses individuals' events and complex affairs [165-167]. Moreover the majority of individuals at some time in their life are experiencing and enjoying storytelling in one form or another, whether it was vocally or text based narrative [165, 167]. A story can be defined as "*a narrative of an event chain told or written in prose or verse*" [165]. Stories in education could be one of many skills for improving school success and as Banaszewski argued according to Bob Barton and David Booth (1990) *"Stories do things to people. We know that things happen when they read or hear stories, that any theory about the place of story in schools has to begin with this fact."* [168]. On the other hand, to enable people to pay much more attention to what has been told, the information must be put into an interesting or exciting manner [167]. Since most people get pleasure from reading and listening to stories, using it in delivering information by computers can facilitate communication and speed up organizational change, stimulate innovation and convey knowledge and reduce the memory workload which is preferable from the viewpoint of human computer interfaces [165, 167].

With technology growth and arrival of the digital era, storytelling received a new medium and opened a big new market that provides development of new applications and systems [167]. Digital Storytelling, as a means of conveying information to people, can be used in many different and useful ways especially in the edutainment aspect of the learning medium, of teaching students different subjects [167, 169]. In addition it can offer new ways of learning not just for children, but even for older people and students with different culture and backgrounds [167]. Digital storytelling is defined as "*the practice of combining personal narrative with multimedia (images, audio and text) to produce a short* *autobiographical movie*". An example of popular TV programs targeted to children to learn by means of stories is Sesame Street [166, 167, 169] have articulated that, conveying knowledge to students using stories increases the students' attention and acquirement and enhance the overall users' experience in social and cognitive skills. On the other hand not much experiment has been made to prove this idea. One study still working in progress by Heiden [169], used digital storytelling in academic teaching within the computer science department, employed hypermedia and virtual reality topics as base for background research. The objective of this study was to investigate the role of storytelling activity within the context of a Hypermedia Novel (HyMN) as edutainment self conducted learning compared to traditional lecture and practice courses. The HyMN approach incorporates different user tasks like receptor, author, and publisher in one medium; enabling personalised as well as distributed story reception and storytelling. Participants, with a number of 16 test subjects and a single course over one term with 8 hours per week, stated their opinion regarding traditional and digital storytelling. The study concluded that the digital storytelling approach can be a supplement to traditional academic teaching approaches or in other words it works similar to traditional academic teaching, in terms of user's motivation and achievement [169].

2.12.6 Games as Edutainment Feature

As mentioned above the edutainment comprises many activities that include games or playing games. The game definitions are varied and they can be seen from many angles, but all definitions are consider free time and entertainment as important elements of the game

[170]. The historian Johann Heuzinga, argued that the game "represents the quality of action, different from ordinary life". That means the game covers a very wide action of human activities which have been an essential aspect of humankind for thousands of years [170]. This is proved by Archaeologists these days when they discovered the entire kit of instruments that have been used from 3000 BC. in China a game called "Wej-qi" was also found around 2000 BC [171]. Recently the noun game with the emerging of computer technology and the Internet, automatically refers to computer games or electronic games [170, 171]. Computer (Electronic) Games are defined by Mortensen [172] as:

"Form of computer art with built-in and quantitative definitions of success and failure, in which participants (players), put up with formal and predefined set of rules for the progression of a game session, make decisions in the pursuit of a clear and meaningful goal".

The electronic games include a wide range of games that can be played on TVs, computers, mobiles, even in specific machines used in public places, but the term computer game on the other hand differs, since it can be played by computers only [171]. The first computer game was created in 1962 at Massachusetts Institute of Technology and called Spacewar [173]. Many studies such as [144, 174-176] determined that the game must have and show an obvious and meaningful objective. Khine, M. and I. Saleh [174] in their study which has been conducted for the Entertainment Software Association predicted that both computer and video game products will be raise significantly in the next few years in terms of sales due to strong demand by users, and they also asked the users about the reasons behind this demand, when their answers were that it was mainly fun they experienced which was estimated at about 78%, whereas challenging attribute got 72%, social interaction 42% and finally 36% entertainment value for the money [174]. In terms of gender and frequency of game play, a research made by Fromme [177] showed that 55% of boys and 29% of girls are playing games regularly, while 40% of boys and 51% of girls play infrequently and the remaining had no strong feeling and do not play at all. Furthermore it has been found that adult boys spend more time playing computer and video games more than that of girls years ago, but girls and most children now play more and it is difficult to find today, specifically in America where a child does not experience at least one type of computer or video games [178]. Play associated with educational games or Digital Game-Based Learning, is another important aspect that can be used to enhance the achievement and motivation for today's generation of learners and interaction between users and e-Learning systems [179]. The role of play in increasing motivation and stimulating curiosity has been proved by many studies and experiments. Play games enable the player to acquire motor skills, improve memory, visualisation and problem solving [180]. Playing games offers the learner a completely free medium of making mistakes and provides them with a range of attempts which are assisting in embedded the information in the learners' memory permanently [181].

Prensky [139, 182] discussed that the learners today have changed and are different from their parents and from all earlier generation; they are described as Digital Natives, and Digital Immigrants due to increased usage of new technology. This has changed and enhanced children's brains, enabling them to accomplish multiple tasks at the same time and also to grasp wide types of information, to speed up the decision making process and experience collaboration and social interaction worldwide. This is also confirmed by Twidale, M., X. Wang, and D. Hinn, [183] in their studies which have been conducted on informal learning in human-human computer interaction (HHCI). In conclusion and in addition to pleasure and challenge that the gamers experience, playing games may stimulate the users to enhance their participation and contribute towards the achievement of educational objectives [139, 184].

2.12.7 Future of Learning through Gaming Medium

Learning through gaming machine will increase in the future leading to the replacement of traditional academic disciplines. This will occur not only for children in primary or secondary education, but also for learners in higher and advanced stages, with the result that and the game developer will attempt to push and improve their products with reasonable cost. Microsoft and U.S. Military are examples of organisations that provide support to people and educationalists to learn through gaming environments [139]. “Games-to-Teach” is game funded by Microsoft to enable users understand physics and environmental science that can be used in X-Box and Pocket PC. LucasArts is another example that encourages the teacher to learn how to use the games to teach critical thinking [139]. Therefore the target that developers must concentrate on the development of excellent games that engage the user and let the player discover new structures bearing in mind the pedagogical factors associated with different types of game design.

2.13 Summary

In summary, the chapter shows that e-Learning , in terms of the process of conveying information to the learner, typically relies heavily on textual materials forcing students to navigate, too quickly, to less text-based and more interactive sites [3, 139]. Moreover, the absence of inter-personal face-to-face contact in the e-Learning segment is another problem encountered by e-learners using this process, since they miss out on the personal interactions and useful feedback messages, as well as on real-time information on their learning performance [138]. This dependency on one modality, as a means of attracting students is no longer effective, because it lacks important elements that should be incorporated, if high quality results are to be obtained. The literature referred to, in this chapter, emphasises that significant advances have already been made, with improvements in modality integration and the development of other techniques in user interfaces; earcons, speech and even avatars are examples of features examined, in this research, and which have been shown to deliver effective results and to help improve the usability of interfaces and user-performance [5, 6, 74, 76, 78-80, 90, 108, 185, 186]. Moreover, understanding the multimodal nature of human-to-human interaction can help to make computer-to-human and human-to-environment interaction appear more natural [52] and could overcome the lack of face-to-face communication problems associated with computer user interfaces [74]; it could also help to avoid the types of misunderstandings that typically occur, due to the lack of non-verbal feedback [68]. In order to achieve greater effectiveness in gaining (and retaining) the learners' attention and to improve their attitude to online learning, creativity and innovation are required to enhance the mechanism underpinning the educational materials being delivered [120]. In this context, the research suggested a number of guiding principles targeted at improving the methods used to hold the learners' attention. Examples of these principles include giving prompt feedback, developing reciprocity and co-operation among students, and using active learning techniques [187]. Interestingly, these guiding principles did not consider entertainment as one of the potential dimensions that could help engage the students' attention and stimulate their cognitive interaction and memory recall. A number of theoretical cognitive and psychological studies have emphasised the role of entertainment and the pedagogical factors which can complement the learning process, indicating that humour and a sense of engagement actually increases students' performance, in a learning environment, combined with amusing and engaging features [188].

Therefore, humour or entertainment should be an issue for future multimodal interfaces, especially in the area of education [56]. This approach to the e-Learning process is expected to be more effective when incorporated with multimodal features, such as earcons, speech and particularly avatars, which can be considered as one of various attributes providing substitution for lack of face-to-face contact with the teacher, in e-Learning situations. The presence of an avatar or a "talking" virtual human, in e-Learning scenarios, with consideration to associated cognitive factors, has the potential to make the e-Learning process more amusing, increase users' interest, motivation, and retention and, at the same time, develop improved thinking patterns and reasoning skills [138, 189]. This creates a sense of realism that is often absent in distance learning, and which has been shown to be a major benefit of educational three dimensional virtual worlds [141].

Besides the use of avatars and other integrated metaphors as a means of enhancing usability and providing entertainment features in e-Learning situations, the chapter also reviews the scope offered by a fun-driven environment and the use of educational games as another subset of edutainment activities with the potential to provide motivation and amusement, in e-Learning interfaces. The review found that play associated with educational games or Digital Game-Based Learning is another important aspect that can be used to enhance achievement and motivation for today's generation of learners and the interaction between users and e-Learning systems [179]. The role of play in increasing motivation and stimulating curiosity has been proved by many studies and experiments. Fun-focussed games enable the player to acquire motor skills, improve memory recall, visualisation and problem solving, etc. Crucially, playing games offers the learner a flexible medium for making mistakes and provides them with a wide range of options which have been shown to help embed the information in the learner's memory, permanently [181].

However, this research thesis, empirically investigated the role of edutainment applied in the form of multimodal attributes, such as earcons, speech, and avatars, as a tool to represent the entertainment attributes, in an e-Learning framework. The main aim is to enhance user-interface usability, in e-Learning systems, through an entertainment-driven learning process and, essentially, by experiencing learning through the medium of game-play, in order to explore the influence of edutainment on helping improve levels of learner concentration. In particular, three main experimental interfaces (platforms) were implemented, in this research, each of which was integrated with a combination of different multimodal features, which included: text, earcons, speech, and avatars. The aim was to measure effectiveness, efficiency and user satisfaction, but also to evaluate levels of memory retention and to assess the educational value associated with certain aspects of edutainment. The results obtained from the experimental studies are compared and discussed, in the next three chapters, in order to produce empirically derived conclusions as to which platform examined is preferable as a standard for e-Learning applications.

Chapter 3

Role of Edutainment in e-Learning Interfaces

3.1 Introduction

As a member of the Innovative Interactive Systems team, De Montfort University, this group study is concerned with the impact of multimodal metaphors on enhancing online interfaces, in different areas, such as e-Learning, e-commerce, e-noting, e-news and e-feedback. Furthermore, this research also addresses another area, namely, Edutainment within an e-Learning framework, utilising the same multimodal metaphors that other research groups have used. The idea is to verify how a multimodal feature is sufficiently flexible to cope with diverse areas, with differing goals for online interface usage. This chapter describes the first set of experiments which investigated the role of edutainment in a multimodal e-Learning context. The experiment is an attempt to answer, empirically, whether or not incorporation of multimodal metaphors, such as speech, and earcons enriched with an avatar (the main character used to convey the entertainment message), is capable of improving online user-performance and information retention. The experiment evaluated the usability features of two interfaces; one, an edutainment interface using an avatar (with a human-like appearance) to convey various entertainment aspects; and the other, a non-edutainment (typical e-Learning interface). The usability of these two environments was analysed by a single group, with 42 users. User-efficiency, effectiveness, and satisfaction levels were assessed, under a controlled environment. The outcomes of the experiment showed an improvement in learning with the edutainment interface, compared with the standard version.

3.2 Aims

The aim of this experiment was to:

1. to inspect the benefits of integration of various modalities represented by natural recorded speech, earcons, and virtual avatars within e-Learning framework.
2. to investigate the enjoyment level that users attained during online lessons that were presented to them by avatars through amusing messages, amusing facial expressions, body gesture, and the reflection of this positive feeling on their performance.
3. to measure user efficiency, effectiveness and satisfaction of a multimodal e-Learning interface (E) compared to a typical text one (NE).
4. to perform extra measurements such as memorability and interface preference to support the experiment's main usability factors in evaluating the user reaction to the experimental interfaces provided.

5. to evaluate users in terms of tasks type and complexity in each platform.

3.3 Objectives

This study had three main objectives. The first objective was to measure efficiency of the two interfaces for each task by measuring the time spent by users to perform the task provided. The second objective was to compute effectiveness by counting the number of errors and the number of correct tasks during and after the experiment for each task as well. The last objective was to calculate user satisfaction scale in each of the two examined e-Learning environments.

3.4 Hypothesis

Many usability criteria have been developed to assist designers to produce a usable e-Learning system that offers learning content rather than confusing interface. An example of key considerations of usability of e-Learning systems includes [8]:

- ease of learning: how the site enhances the learning curve.
- efficiency of use: how quickly a person can locate specific portion of information using the navigation system as an example.
- ease of remembrance: the ability of the learner to remember how to carry out a particular task.
- error: the number of errors should be small, and it should be manageable when they occur and do not discontinue the user completely.

- satisfaction: the user should enjoy achieving a given task.

In order to measure the learnability of E and NE, a set of 7 hypotheses has been stated to compare the metrics that will be measured in this experiment in terms of efficiency, effectiveness and satisfaction. These hypotheses are:

H1: The E interface will be more efficient than the NE in terms of the time spent by users to complete the required tasks.

H2: The E interface will be more efficient than the NE as the task complexity increased.

H3: The E interface will be more efficient than the NE for performing both recall and recognition-type tasks.

H4: The E interface will be more effective than the NE in terms of the percentage of correct answers answered by users.

H5: The E interface will be more effective than the NE in terms of the percentage of tasks successfully completed by users.

H6: The users of the E interface will outperform NE users in terms of the successfully completed recall and recognition-type tasks.

H7: The users of the E interface will be more satisfied than the NE users.

3.5 Design of Experimental Platforms

To verify the proposed hypothesis, two interfaces have been designed and developed according to guidelines for the design of multimodal information presentation, [71] and multimodal user interface [190] were followed. For example the multimodal output was used to widen the bandwidth of information [71, 191]. Also, graphical displays, speech, and non-speech sounds were combined to obtain an effective transfer of information [190] where speech can be used to transmit short messages and non-speech to supplement other interaction modalities. One group of users tested the first multimodal e-Learning platform (Speech, avatar) which encompassed edutainment (E) elements and served as an experimental group. The second interface was non-edutainment (NE) interface (text with graphics) to serve as a control group. Everything in both interfaces is similar in terms of contents and number of tasks but differs in the means of presenting the information or material. Please refer to Table 1 for weight into the features incorporated in both interfaces.

3.5.1 Learning Material

The subject matter examined as e-Learning content was Human Computer Interaction (HCI). Considering that HCI as subject matter is mainly theoretical, the learner needs something to watch and listen to in order to improve his imagination and engagement. This can be done by entertaining users through incorporating some kind of amusing elements such as amusing messages, facial expressions, and body gestures besides essential multimodals such as textual and graphical metaphors. An example of the subject matter examined can be found in Appendix A-2.

3.5.2 Edutainment Platform (E)

The main modality used in the edutainment platform to introduce the edutainment aspects is Avatar (sound and human-like expressions) with text and graphics as additional modality displayed simultaneously on the screen. The avatar expressions utilised in this experiment were selected to attract and increase user interest usually used in everyday life to express human feelings and emotions [74, 90, 192]. The plan is to use the avatar to read to the user the subject matter and to entertain the learner at the same time through amusing messages, some expressions and short messages as feedback especially in exercises where the user in stressful condition (Figures: 2 A, B, C, D, E, and F). Each page designed divided carefully to two parts to avoid overlapping between contents, so the user can easily distinguish the screen.

The right section shows a text compound on the black background, with font size for title 24 and 14 for the plain text. The avatar occupied the left side of the screen be dressed in dark colours such as blue and dark grey on white background colour. Under the avatar there is countdown o'clock to show the user the time remaining for the avatar to complete the lesson and a special button to stop the avatar when the user chooses to pause. In addition, at the bottom of the page there are two types of buttons; one type is for navigation forward and backward between cases. The other type which is under the blackboard is for navigation between lessons in one particular case. A third button has been allocated to direct the student's attention to exercises. After the user has finished the training within the specific case, he/she is then examined to test how much he/she has memorised. Basically, the user was asked to answer three recognitions-type and three recall-type questions for each case. These two types of questions were built in the system, rotating them between platforms as well as cases. To let the users interact emotionally with the subject, the edutainment platform is active; the learner should be doing something actively and not watching something passively. The user has to move the mouse pointer above the button labelled "Question One (Q1)", see Figure 2. A, so the text and the avatar appear immediately saying or reading the question to the user, and repeat it as long as the mouse cursor rests over the button.

Immediately after the user has finished reading and listening to the question, the next step is to move the mouse cursor over the remainder buttons labelled (A1, A2, A3…..), see Figure 2.B, within the page to read and listen to the proposed answers. Once the user clicked what he/she believes is the correct answer, an entertaining short message appears as positive or negative feedback. This response was represented by some kind of humorous avatar gesture accompanied with short amusing a speech message, (for example turning a head right and left with saying nonononononon) and text as seen in Figure 2. C. If the answer was correct, the program automatically gave the user the next question (Task).

With the same manner the user could answer the remaining tasks until he/she finished three of them.

Conditions	Features									
	Sound	Text	Graphics	Avatar	Earcons	Gesture	Facial expression	Amusing messages	Normal Feedback	Amusing feedback
E	√	√	√	√	√	√	√	√	√	√
NE	√	√	√						√	

Table 1 Platforms Features, E= Edutainment, NE=Non-Edutainment.

Again the user was prompted to go to the next recall-type questions (short answer question) Figure 2. D. What the user has to do is to read the question and write down the proper word(s) in the particular space given and click on the specific button labelled "Record Answer Button".

After the first question is completed, the user must click on the next button to go to the second short answer question and so on. Another technique of exercise, (see Figure 2. D, E and F) involved the user to move or drag the coloured word (term) in the middle of the screen to the correct position or corresponding shape. The right shape accepts the word and immediately a positive response as in the first type of exercise appears (See Figure 2. E), alternatively, it rejects the word and comes back to the original position with a negative response.

In addition the system is designed to proceed to the next question automatically in case of a correct answer. If not, after three attempts for each question the system precedes the user to go to the next question, considering the result incorrect.

When the user does not perform any action for several seconds (approximately 30 seconds), the program launches a humorous prompt as shown in Figure 2. F, reminding the user by his/her slow act in taking a decision, which is in turn to motivate the user to take faster action. The developed platform also gives users the freedom to interact only when they want to do so, i.e. the learner can play, stop, and go back to a specific point. Additionally learning with this system can potentially become an experience enjoyed by a family or a group of friends. The group can enjoy the social interaction and exchange of ideas enabled by the shared experience.

Moreover, recorded speech messages were used in this study to explain the HCI topic to the students. In comparison with synthesised speech, natural human speech is generally more comprehensible by users. The delivered information explained an introduction to the Human Computer Interaction model with some diagram and illustrations associated with the topic. These sounds were recorded and edited using digital audio editor software called "Audacity" [193].

Finally, besides giving illustrative information, the proposed project tests the skills and knowledge of the learners. It provides learners with hints to make progress, different levels of difficulty, and providing feedback when achieving an intermediate goals or answering correctly or encouragement to think in order to answer correctly. All these are represented by the avatar in many ways and an expression depends on the situation and actions to involve the users or students emotionally with the subject. Both recognitions and recall-type questions designed, presented the text and avatar models together for each question.

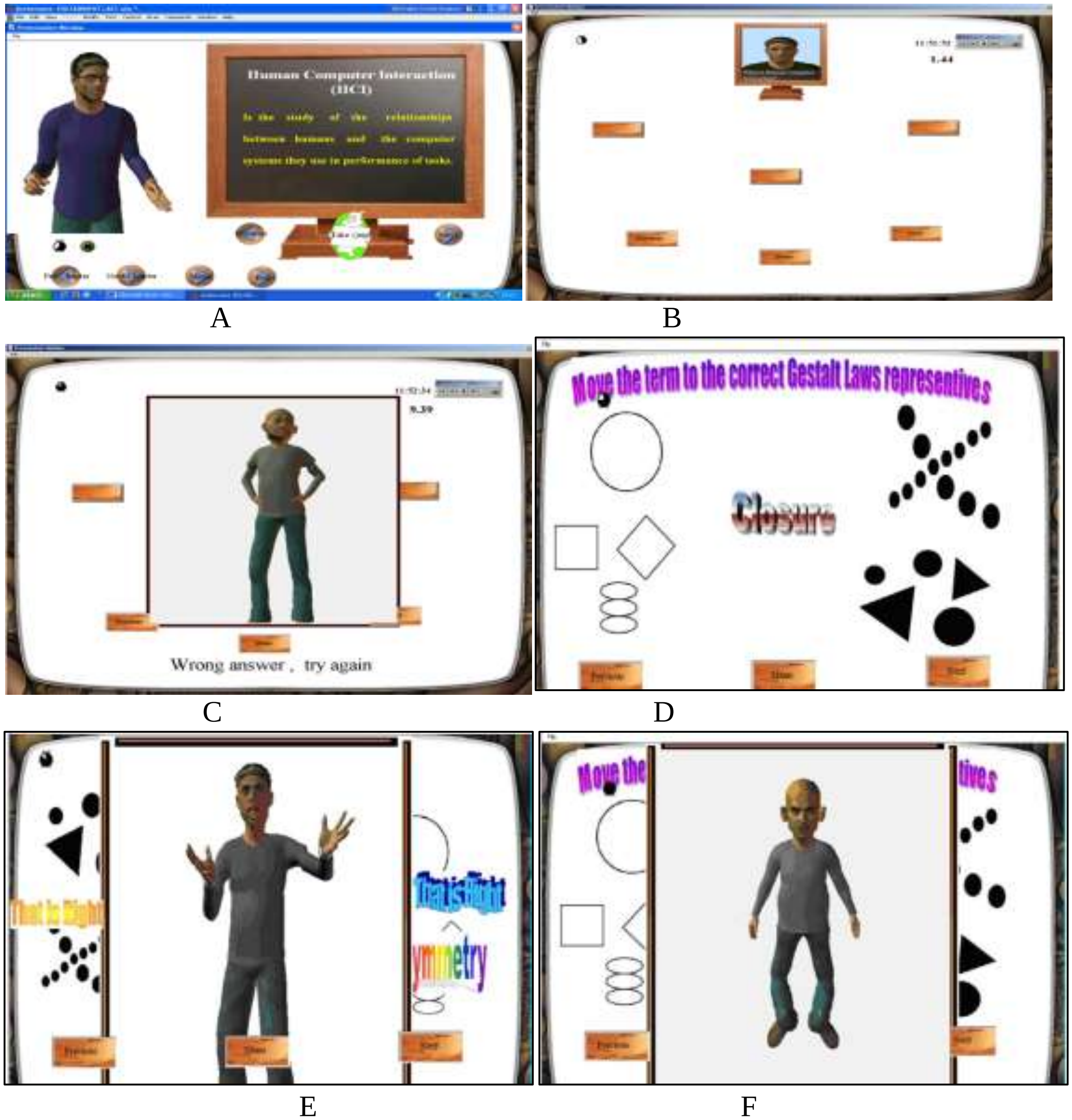


Figure 2 Snapshots of Experimental Platform Using the Edutainment Condition (E) (A): Avatar as Teacher Presenting the Materials to the Student. (B): Example of Exercise in which the Avatar Presenting the Question with the Aid of Text. (C): Example of Negative Feedback. (D): Example of Second Type of Exercise before any Actions from User. (E): Example of Positive Feedback. (F): Snapshot of A Reminder When the User has Taken Slow Action.

3.5.3 Non-Edutainment Platform (NE)

Non-edutainment platform is the text only version. Simply, it is the edutainment platform removed of all the multimodal objects. However still retains the general characteristics of original interface with same feel, look, chapters order, and type of questions.

3.5.4 Tools Used to Implement the Experimental Platforms

This subsection briefly describes the techniques used to develop the multimedia to support both classroom and distance learning activities. The tools used to develop these experimental platforms were:

1. *Audacity sound editor 1.3.5 (beta):* Audacity is used to record speech sounds in this study to explain to the user the learning materials. Audacity is a free, easy-to-use audio editor and recorder for Windows, Mac OS X, GNU/Linux and other operating systems. Audacity was used mainly to record live speech through a microphone or mixer; convert records into WAV sound files; cut, copy, splice or mix sounds together; and change the speed or pitch of a recording according to certain circumstances [193].
2. *Visual Music:* Music synthesis were utilised for the production of earcons used in this study. Visual Music lets you play 128 musical instruments on your PC including Flute, Bagpiper and even whistle. You can even record what you are playing, edit it and save it in a file. If you are not an expert at playing the synthesiser keyboard, it provides you an easy to use scripting language to create music just by telling what key in which instrument you want to play, and the time duration [194].

3. *DAZ Mimic 3.0:* Mimic is a stand-alone application designed to create lip-synchronisation animations. It is used to synchronise the lips with the sound produced by Audacity software. It creates an output file which you can then render in a third-party application such as DAZ Studio or Curious Lab's Poser. You can also generate animations directly from within DAZ Mimic itself. Mimic is an advanced tool that creates and edits facial animations for 3D figures by making them accurately mimic the correct lip movements for a pre-recorded speech segment, allowing figures to “talk” and “sing” during animations. You can either import existing WAV or AIF audio files in any language and let DAZ Mimic do the work for you, or record your own speech using DAZ Mimic’s simple recording studio and a microphone. You can furthermore complete the effect by adding expressions and gestures such as smiles, winks, and nods to transform your figure into a fully expressive speaker [195].

4. *Poser:* Poser has been used for the generation of facially expressive humanoid 3D figures based on the imported Mimic file. Poser is the premiere 3D-character design and animation tool. Artists and animators used to create 3D scenes from a diverse collection of ready-to-use 3D human and animal models quickly and easily using Poser’s intuitive interface. This software has the ability to realistically customise figures and scenes by mapping facial photos to create realistic 3D portraits, growing and styling real spline-based hair, and creating dynamic cloth objects. Poser can also produce stills and animations and can quickly output movies (AVI) and images for use in Web, print, and video projects. In addition, this tool can export posed figures as 3D objects to add life to scenes created in other 3D applications [196].

5. *Authorware:* Both platforms objects are integrated together using this educational software, which is a macromedia product. Authorware is a program that helps to write hypertext or multimedia applications. Authorware is used to create a final application merely by linking together objects, such as a paragraph of text, an illustration, or a speech. By defining the objects' relationships to each other, and by sequencing them in an appropriate order, Authorware produces attractive and useful graphics applications. This authoring system also supports a scripting language for more sophisticated applications [197].
6. *Camtasia studio:* Camtasia is used to capture the visual activity occurring on any portion of the screen as well as capturing the users reactions and responses while the user interacts with the system through a laptop web camera [198]. The recorded portion can be produced as AVI files to be played and reviewed for discovering any usability problem later [199].

3.6 Experimental Platforms Design

Each platform contains two chapters (Case 1, Case 2) and each chapter contains 6 tasks (Questions). Tasks were divided into 2 groups, with the first group consisting of recognition-type questions and the second consisting of recall-type. The level of difficulty gradually increases from Case 1 to Case 2. To avoid any familiarity with the topic and the interface sampling in the experiment, random rotation technique was applied between platforms and also in terms of chapters (Cases). As seen in Table 2, the user may start from

Case 1 in edutainment interface and finish in Case 2 in non-edutainment interface, and the reverse is also possible.

Moreover the tasks also increased in terms of the levels of difficulty (easy-moderate-hard). Table 3 concludes the complexity distribution of tasks in both platforms and Table 4 summarises the tasks instructions executed by each user.

3.7 Variable

A number of variables was identified and defined prior to carrying out experiments. These variables are of three types; independent, dependent and controlled.

3.7.1 Independent Variable

The independent variable in this experiment was the edutainment platform which is represented by avatar with human-like expressions, i.e. the absence or existence of entertaining avatar.

Moreover three levels of question complexity; easy, moderate and difficult complexity has been investigated. This study also explored question-type; ‘recall’ and ‘recognition’ on the usability of the two e-Learning interfaces tested.

Users	Edutainment	Non- Edutainment
10	Case 1 : T1, T2, T3, T4, T5, T6	Case 1 : T1, T2, T3, T4, T5, T6
10	Case 2 : T1, T2, T3, T4, T5, T6	Case 1 : T1, T2, T3, T4, T5, T6
	Non-Edutainment	**Edutainment**
10	Case 1 : T1, T2, T3, T4, T5, T6	Case 2 : T1, T2, T3, T4, T5, T6
10	Case 2 : T1, T2, T3, T4, T5, T6	Case 1 : T1, T2, T3, T4, T5, T6

Table 2 Rotation System.

Tasks Distribution						
Question Type	**Recognition-type Questions**			**Recall-type Questions**		
Complexity level	**Easy**	**Medium**	**Difficult**	**Easy**	**Medium**	**Difficult**
Tasks	T1	T2	T3	T4	T5	T6
No. of Tasks	1	1	1	1	1	1

Table 3 Tasks Complexity Levels.

Task 1	**Multiple Instructions Tasks** 1 Move the mouse cursor over the button **labelled** “Q1” and click to read and listen to the question. 2 Move the mouse cursor over the remaining buttons in the page to read and listen to the answers. 3 Click on correct answer. 4 In case of correct answer, the program will proceed to the next question. **Drag the Term Instructions Tasks** 1 Drag the **coloured** word (Term) in the middle of the page to the right position. 2 Do the same operation if you have answered incorrect. 3 In case of correct answer, the program will proceed to the next question.
Task 2	Repeat the same steps in task 1.
Task 3	Repeat the same steps in task 1
Task 4	Here you will find short answer question, and all you have to do, is to write down the proper word (s) in the space shown and click on the Record Answer Button.
Task 5	Click on the next button to go to the next question, repeat the same steps in task4.
Task 6	Repeat the same steps in tasks 4, 5.

Table 4 Tasks Instructions for Both Platforms.

3.7.2 Dependent Variable

The dependent variable is determined by the time taken by each user, number of correct and completed answers and responses to subject satisfaction statements using the Likert scale (1-5) in both platforms.

3.7.3 Controlled Variable

The variables expected to affect the experimental procedure were controlled. These variables are:

1. Tasks: All users experienced the same number of tasks in each of the platforms.
2. Topic: The topic tested in this experiment was the same in both interface versions, with the same level of difficulty.
3. Awareness of tasks: of the users were aware of the tasks that would be presented to them.
4. Time: Users had time range to complete each specified task in both platforms. Therefore a task completed within the time range would be regarded as successful; otherwise the task would be considered unsuccessful.
5. Interface familiarity: All the users were provided with the same training and were first time users of the tested interface.
6. Consistency: The experimental platforms implemented were examined with the same users on an individual basis with each user. Moreover the same procedure was followed

throughout the process of the experiment as well using the same tools and computer for measurements.

3.8 Platforms Structure

The structure refers to the organisation of the content. Structuring the project forms the core of the design process. The structure reflected the natural order of the content. It generally provided a graphical overview of the project whereas navigation is the way in which the user will move within the structure of the package. Two different structures were used in the construction of both platforms, namely Hierarchy and Linear [200]:

3.8.1 Hierarchy

Hierarchical structure refers to the division of topics into subtopics, the subtopics into sub-subtopics and so on. Users often navigated hierarchies through a series of menus. Figure 3 shows an example of the hierarchical structure (the arrows represent movement up and down the levels of the hierarchy) [200].

3.8.2 Linear

Linear structure refers to programs which can only move from screen to screen. The page-turner is linear, as are most books. Figure 4 represents a linear structure (The arrows represent movement back and forth between the pages) [200].

Both platforms were created using the two types of structures described above. As shown in Figure 5 below, the user can navigate from main menu to sub main menu in a hierarchical way, and from inside chapters (pages) in linear structure. Again the chart uses the hierarchy mode when the user wants to take a quiz.

3.9 Methodology

3.9.1 Users Sampling

The experiment was carried out over a period of 4 weeks in the research laboratories of University of Bradford. Overall 44 volunteers took part in the study dependently; all users used both edutainment (condition E) and non-edutainment (condition NE). The conditions (E and NE) was distributed randomly but was the same for each user. The selection criteria of the users sample were based on their prior knowledge in Human Computer Interaction. In this regard, the majority of the users had no experience indicating that they will rely only on the communicated learning information to answer the required questions. In addition the sample was selected by chance and there was no any arrangement or purposed time with users to conduct the experiment, in other words the chosen users were met accidently within university campus and the majority unaware of what they invited for, until explaining the purpose of the experiment.

3.9.2 Questionnaire and Data Collection

In order to maintain consistency throughout the experiment, the same procedure was followed with both groups of users. The questionnaire consisted of 11 pages with pre-experimental and post-experimental parts (see Appendix A-2). The first page in the pre-experimental section introduced the study and the aim of this experiment, with instructions to fill the questionnaire, followed by a clarification of Likert five-point scale.

The second page presented to user the required information such as age, gender, education level, computer, Internet experience, and e-Learning, avatars knowledge user's obtained. The post-experimental part of the questionnaire was aimed at assessing the user's satisfaction with the tested e-Learning platform. Users responses to this questionnaire were used to calculate the satisfaction score for each user in both the control and the experimental groups. The remaining pages are for the second platform tasks and the feedback is structured in the same manner as in the first part. The last page was reserved for problems, comments and suggestion that the user experienced.

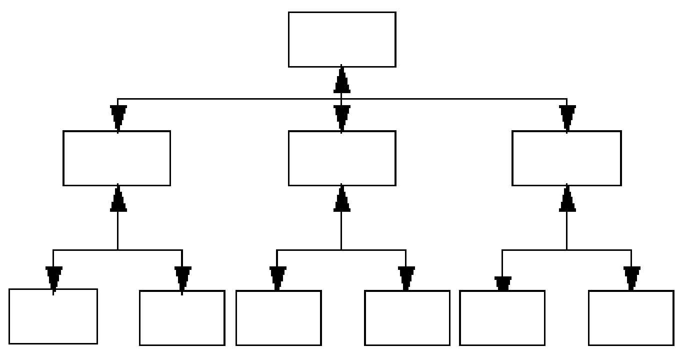


Figure 3 Representation of Hierarchical Structure.

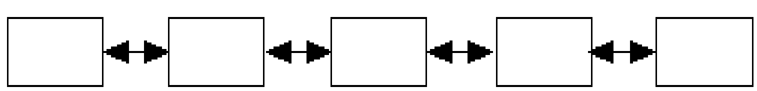


Figure 4 Representation of Linear Structure.

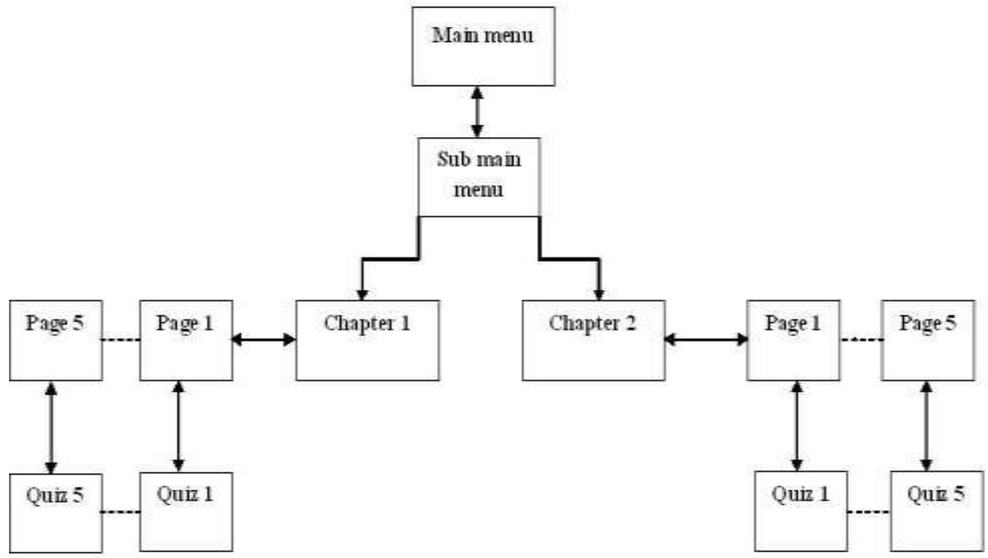


Figure 5 Platform Flowchart.

The data collection procedure was based on the experimental observations and questionnaires. Upon completion of each task, the system automatically displayed the time spent which helped further to measure efficiency. However, in order to collect the data related to effectiveness, the correctness of users' answers was checked and the total number of successfully answered questions was counted for each user.

3.9.3 Pilot Study

A pilot study was arranged and performed with six users:

1. to establish whether the questionnaires were easy to understand.
2. to confirm whether the platforms and instructions were easy to recognise.

3. to validate the experimental procedure and estimate the typical time needed to complete.
4. to identify any other usability issues that were not already picked up during design prototype.
5. to collect any other feedback the pilot users provided.

3.9.3.1 Procedure

Six people took place in the pilot study. All users examined both platforms (condition E), and (condition NE). The experiment was recorded using software called Camtasia studio [199] to be able to review the session and discover any problems that the interface might later develop. Users completed the final questionnaire. They then expressed their comments on aspects of the experiment.

3.9.4 User Feedback

All the six users commented that the cases were relatively long, although they felt the contents were relevant. Additionally, the exercises were difficult to complete. 40 users (90.6%) however agreed that both interfaces were easy to use and enjoyable. With regards to the questionnaire, 42 users (96.5%) commented that it was easy and well organised.

3.9.4.1 Changes Made in Response to Feedback

The changes were made in response to the users' feedback was that, the cases were shortened to avoid overload. Also exercises reviewed and modified to better match contents considering users who were of diverse background.

3.9.5 Pre-Experimental

To minimise confusion and anxiety in users prior to the experimental session given diverse background (Biology, Electrical Engineering); they were informed that the experiments goal was to test the system and not their ability. Furthermore, users were explained the experimental steps to be carried out after reading the instruction of the questionnaire, in order to eliminate any uncertainties. Although the experimental parameters were specified in the questionnaire, the experimenter reminded users of the time limitation and case order.

3.10 Results and Analysis

3.10.1 Users Profiling

Users who participated in this study were 43 (97.7%) males. The mean age was 36 years. Users were generally highly educated, Doctoral degree was 14 users (31.81%), and Masters was 26 users (59.09%), whereas Undergraduates was 4 users (9.09%). In terms of area of study, 22 (50.00%) of users were from computing and informatics background, 6 users (14.00%) were from engineering and the remaining users were from various other areas. Around 40 (90.00%) of users used the computers for more than 10 hours per week and 38 users (86.36%) used the Internet more than 10 hours per week. As users stated in the questionnaire, only 8 (18.18%) of users had excellent knowledge about HCI, 16 users (34.09%) had good knowledge, 9 users (20.45%) had limited knowledge, and 12 users (27.27%) had no knowledge at all. Users with knowledge about e-Learning systems were 19 users (43.18%). Concerning avatar, 25 users (56.81%) had no knowledge, 10 users (22.72%) had limited knowledge, 7 users (15.90%) had good knowledge, and 2 users (4.54%) had excellent knowledge. The frequency of user profiles raw data can be found in Appendix A-3.

3.10.2 Experiment Sessions

Sessions lasted between 20 and 35 minutes with mean time of 27.50 minutes (standard deviation 10.60), including pre-experimental and post- experimental questionnaires. The time was distributed as follow: Users engaged with pre-session questionnaire for approximately 3 minutes, read the tasks for approximately 4 minutes. The user straight away starts with the first platform (E for example) for approximately 10 minutes, upon completion; users have to fill the five-point Likert scale provided in the questionnaire for approximately 4 minutes. This procedure applies also for the second platform. Finally the user ends the experiment with post-questionnaire tasks for about 4 minutes.

3.10.3 Efficiency

The time taken by users to answer the required tasks was used as the measure of efficiency. This measure was considered for both control and experimental groups, for all tasks, cases (chapters) and according to the question-type (recall and recognition). Figure 6 shows the mean values of the time taken by the users in both platforms to accomplish all the required tasks, grouped by the platforms conditions (E) and (NE), tasks conditions (T1,T2,….T6), cases (chapters) condition (ECH1, NECH1,ECH2,NECH2) and questions-type condition (ERCNT,NERCNT,ERCLLT,NERCLLT). The next subsections will consider in details all conditions independently. The raw data for question answering time can be found in Appendix A-4 and A-5.

3.10.3.1 Platforms Condition

Figure 6 illustrates the mean value of time (excluding reading, pre- and post-questionnaire). Condition (E) was 26.52 seconds and condition (NE) was 27.28 seconds. Differences between conditions are not significant. The minimum and maximum time for condition (E) was 15 and 40 seconds, whereas condition (NE) was 14 and 44 seconds.

3.10.3.2 Tasks Conditions

Figure 6 shows the time differences between tasks for both conditions. In fact the time was trivial. This is because the edutainment with multimodal interface such as sound and avatar and video consumed much time when presented. Similar time was spent by users because of absence of other modalities in non-edutainment (text version).

3.10.3.3 Case Condition

Time differences between cases are not significant as well. As shown in Figure 6 the mean time for Case 1 was 26.60 seconds, Case 2 was 27.20 seconds.

3.10.3.4 Questions -Type Condition

The mean time for recognition-type for condition (E) was 16.05 seconds, whereas in condition (NE) was 14.93 seconds. Recall category for condition (E) was 36.99 second and condition (NE) was 39.32 seconds (see Figure 6).

3.10.4 Effectiveness

Effectiveness was measured by calculating the number of correct answer users made, and the number of tasks correctly completed by users.

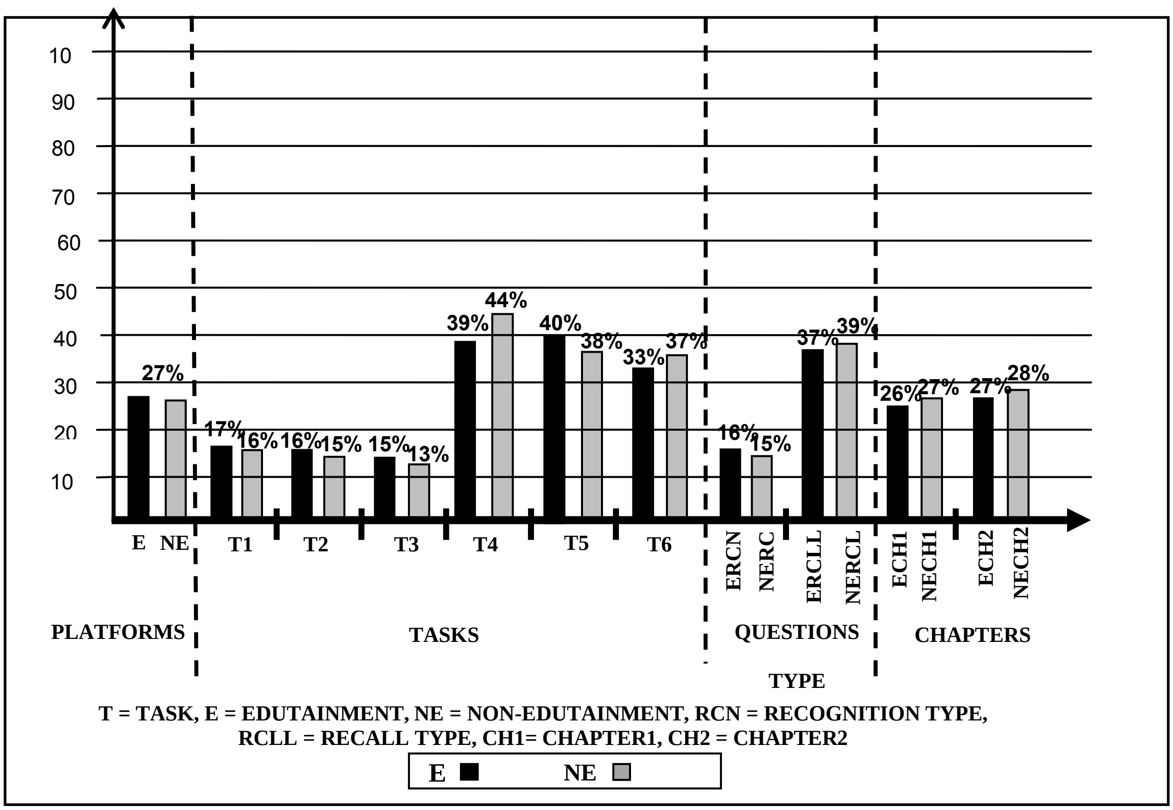


Figure 6 Mean Value of Time for Platforms (E&NE), Tasks, Type of Questions and Case Conditions.

This measure was considered for both control and experimental groups, for all tasks, cases (chapters), and according to the question-type (recall and recognition).

Figure 7 shows the percentage of correct answers for users to accomplish all the required tasks, grouped by the platforms conditions (E) and (NE), tasks conditions (T1,T2,….T6), cases (chapters) condition (ECH1, NECH1,ECH2,NECH2) and questions-type condition (ERCNT,NERCNT,ERCLLT,NERCLLT). The next subsections will consider in details all conditions independently. The raw data for correct answer can be found in Appendix A-4 and A-5.

3.10.4.1 Platforms Condition

Figure 7 shows the mean correct answers for condition (E) was higher than the mean of condition (NE), 63.63% and 43.56% respectively. On the other hand, the number of users completing all tasks in condition (E) was 61.36% compared with 50% on condition (NE) as depicted in Figure 8. Enhancement was noticeable for the performance of users in condition (E), but still the condition (NE) result is acceptable.

3.10.4.2 Tasks Conditions

On the task level, 22.73% of tasks that were given in condition (E) were correct. In contrast, success level in condition (NE) was 13.64%. On the other hand, it was obvious that the correct answers decrease gradually towards recall-type in both conditions. These results are illustrated in Figure 7.

In terms of each task on its own, as shown in Figure 8, 41 (93.18%) of users completed Tasks 1, 2, and 3 in condition (E), and 44 users (100%) in Task 4. 36 users (81%) was for Task 5 and 6 users (13.63%) was for Task 6. Overall, users performed slightly better in the first 4 Tasks. It was slightly lower in condition (NE), 39 users (88.63%) completed Task 1. Tasks 2, 3 were 41 users (93.2%), whereas 36 users (81.81%) for Task 4. Users that completed Tasks 5, 6, were 35 users (79.54%). Overall, users performed better in terms of task completion for the first 3 Tasks.

3.10.4.3 Case Condition

Variation between users performance for both conditions (E & NE) in terms of cases regardless of task type were noticed. Considering the mean value of correct answers for Case 1 (Case 1 for both conditions E & NE), compared with Case 2 (Case 2 for both conditions E & NE) is illustrated in Figure 7. The average for Case 1 was 61.74% and Case 2 was 50.88%. This provides us indication that Case 2 is more difficult than the Case 1.

Regarding completed tasks conditions (E) Case 1 and 2 were 30 users (68.18%) and 22 users (50%). Condition (NE) Case 1 and 2 was 28 users (63.63%) and 16 users (36.36%). Figure 8 shows that Case 2 in both platforms was harder to complete than Case 1.

3.10.4.4 Questions -Type by Condition

Figure 7 also depicts the percentage of correct answers by users for recognition and recall-type questions in both conditions. The mean for condition (E) for recognition-type was

71.76%, whereas in condition (NE) was 61.36%. In contrast, recall-type was significantly low, it was observed in condition (E) 53.78% and condition (NE) 35.60%.

In the main time, as shown in Figure 8, in condition (E) the recognition-type questions completed was 81%, and recall-type 68.18%. Whereas in condition (NE) the recognition-type was 81% and recall-type was 63.63%.

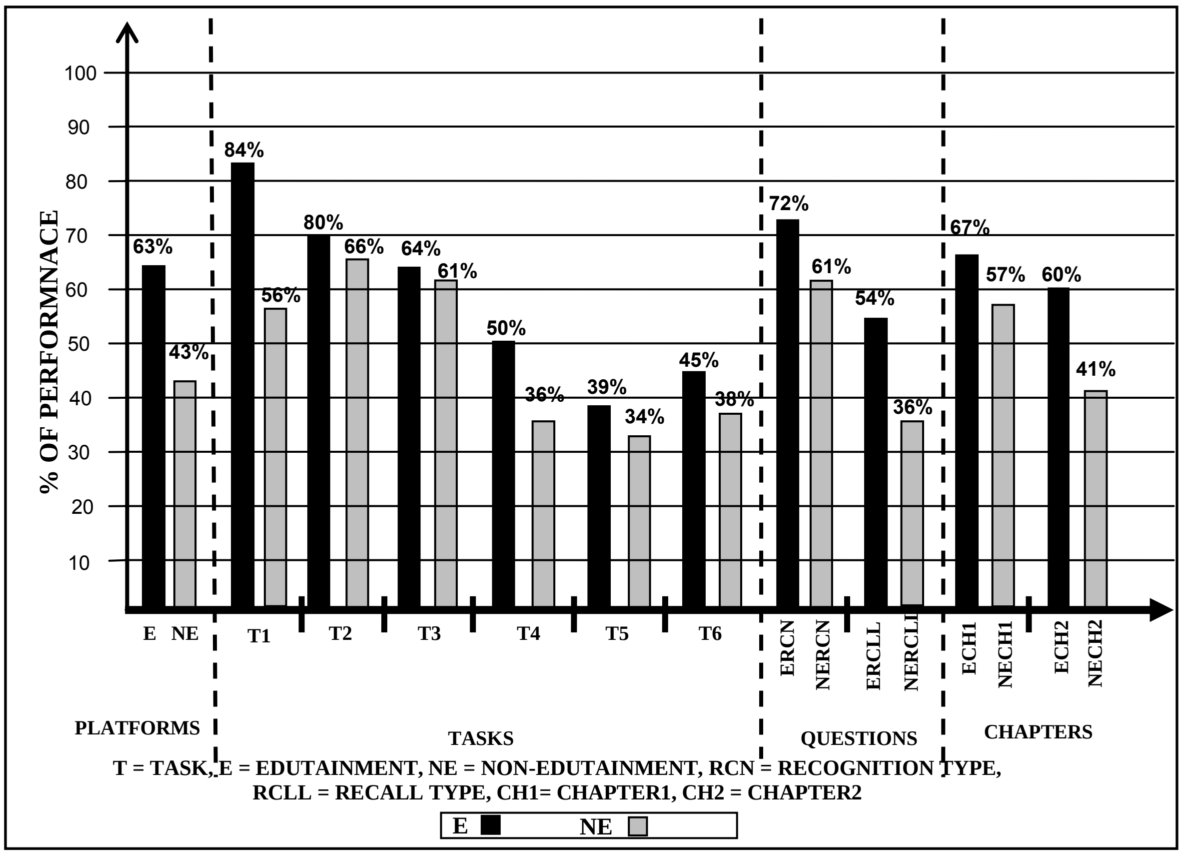


Figure 7 The Percentage of Correct Answers for Platforms (E&NE), Tasks, Type of Questions and Case Conditions.

3.10.5 Satisfactions

User satisfaction was measured in both e-Learning platforms by inviting users to express their opinion to statements provided during the post-experimental questionnaire using five-point Likert scale [201]. The scale consisted of 10 statements related to ease of use, confusion, enjoyment, ease of learning, ease of understanding of the presented information, and overall satisfaction. The five-point Likert scale ranging from 1 (the value of strong disagreement) to 5 (the value of strong agreement) was used for each statement.

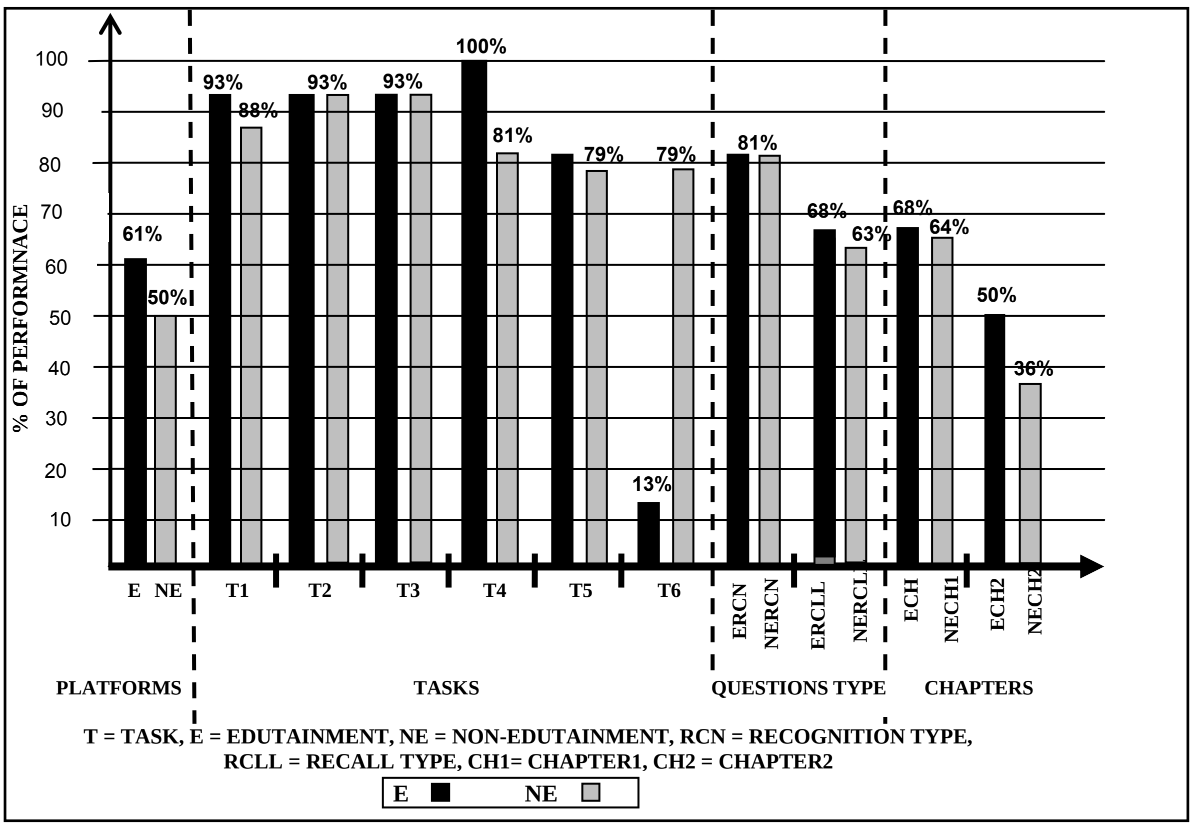


Figure 8 The Percentage of Completion for Both Platforms (E&NE) for Tasks, Type of Question and Case Conditions.

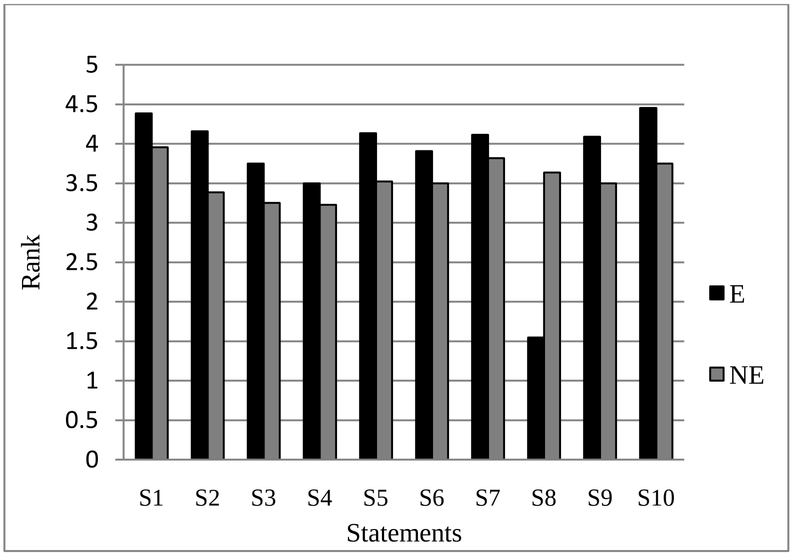
The scoring system followed here is by taking the average score for each statement. This generally results in a positive effect where users liked condition (E) more than condition (NE). The mean score was 4.1 for edutainment (E) platform. In contrast it was less valuable in text oriented platform (NE), it gained only 3.55. Additional analysis has been made for each statement as seen in Figure 9.

Noticeably high ranking was reported by users for condition (E). This can be observed especially in statements such as: “The interface of this system is pleasant”, 4.2 was the mean in condition (E), and 3.3 in condition (NE). In the statement concerning the avatar “I enjoyed the exercises because of Avatar”, condition (E) mean was 4.1, and in condition (NE) the mean was 3.5.

Another significant mean was for the statement “This system is boring”, in condition (E) was 1.5, and 3.6 in condition (NE). Looking at the other 6 remaining general statements, the edutainment (E) interface still ranks greater. This means that users’ satisfaction is significantly improved in condition (E) in comparison with the text version. The satisfaction raw data can be found in Appendix A-6 and A-7.

3.10.6 Memorability

Expressions identification (memorability) of the post-experiment questionnaire was conducted. Users were given 2 expressions as shown in Figure 10 (avatars with facial expressions), and asked to select among options provided to match the correct expression that have experienced in the experiment at session.



S1= I think the interface was easy to use.
S2= The interface of this system is pleasant.
S3= It was easy to answer the exercises.
S4= There have been times while interacting with the system where I felt challenging.
S5= I enjoyed the exercises because of Avatar
S6= The challenge forces me to continue.
S7= People will learn the use of this tool quickly.
S8= This system is boring.S9= I would recommend this system to my colleagues
S10= Overall, I am satisfied with this system.

Figure 9 Mean Users Satisfaction Score in Both Conditions (E &NE).

			
Correct Answer	**Correct Answer**	**Correct Answer**	**Incorrect Answer**

Figure 10 Examples of Avatar Expressions Identification.

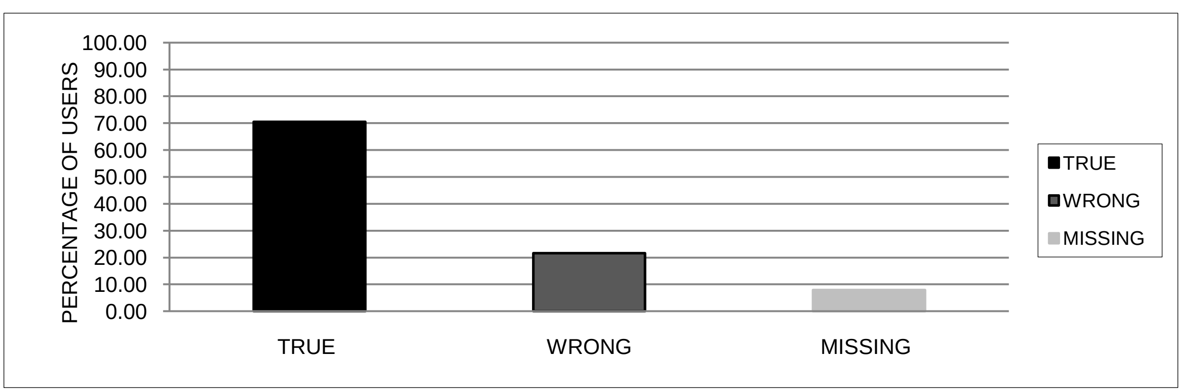


Figure 11 Percentage of Avatar Expression Recognition.

These expressions were used to distinguish between the correct and incorrect answers. For example happy expression usually indicates to correct answer and vice versa.

The feedback depicted that 31 (70%) easily recognised the facial expression provided by the avatar, whereas 10 users (22%) answered incorrectly, and only 3 users (8%) refused to answer (see Figure 11). For the raw data see Appendix A-7 and A-8.

3.10.7 Interfaces Preference

The study provided direct questions that requested from the users in the end of post-questionnaire to articulate the preferred platform experienced. The final results demonstrated that 35 (80%) of users preferred the condition (E) as shown in Figure 12. This was evidence that the role of multimodal metaphors incorporated on the (E) interface has direct and strong effect on the users than the typical one. The raw data for preferred platform can be found in Appendix A-8.

3.10.8 T-Test Results

Since the sample was tested on a dependent group, variations between conditions were compared when tested for the individual factors, using a T-Test: Paired Two Sample for Means with $p<0.05$ P ($T<=t$) one-tail. On the subject of time between platforms T-Test derives $t = -0.43$, 43df, $p = 0.33$, there was no statistical significance at $p<.05$. On the other hand, significance for correct answers between the platforms T-Test derives $t = 2.25$, 43df, $p = 0.14$.

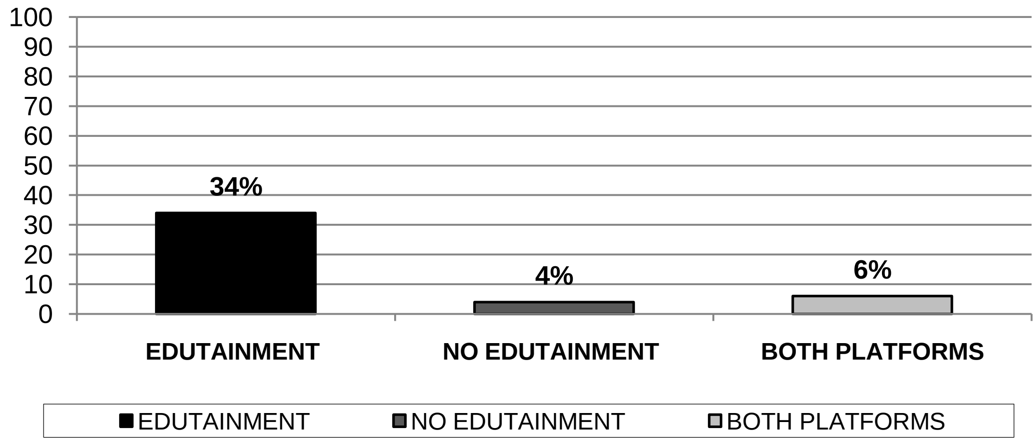


Figure 12 User's Interfaces Preference.

Moreover T-Test conducted on correct answers for each task separately, T-Test found t = 3, 5df, p = 0.15, given that p < .05. Significant results between platforms and in terms of each individual task were noted, therefore rejecting the null hypotheses.

3.11 Discussion

The experiment aimed to establish the overall role of edutainment in multimodal e-Learning systems, and whether it had an impact on users' learning capabilities. Three quantitative factors were identified to describe and explore the concept of edutainment, namely: time, accuracy, and satisfaction scores. The experiment also focussed on factors that could affect the role of multimodal interaction metaphors, such as complexity levels, (easy, moderate and difficult), and the types of questions (memory recall and recognition) involved in the required learning activities. Looking at the three quantitative measures, in general, the experiment produced encouraging results. Furthermore, accuracy levels and satisfaction results showed significantly higher scores, in condition E. The remaining measure, i.e. time, showed no significant differences, in response to the two conditions. The explanation behind these results is explored and discussed, in the following sections:

With respect to the mean value of time, for both conditions E & NE, the differences were found not to be significant, when tested using T-test. As stated above, this means that edutainment comprising multimodal features, such as sound, avatar and video takes longer to present and complete. However, the users also spent the same amount of time on the non-edutainment (text version). This might be explained by the absence of other modalities. Moreover, the satisfaction scores showed that users were less engrossed in the task and had fewer positive feelings, during the text-only version. This was reflected in the relatively long time taken to complete the task.

With regards to complexity, it was anticipated, as stated in H2, that condition E would prove more efficient than condition NE, with an increasing level of complexity. The results of this experiment (refer to Figure 6) showed an increasing difference in answering time, for both platforms, when the required questions (recall and recognition-types) became more difficult, particularly in Tasks 4 and 5. In other words, the more complex the learning material being presented, the greater the benefit of using multimodal metaphors appeared. Conversely, in Tasks 1 and 2 (levels: easy to moderate), the material presented was simple and therefore limited resources were required for the cognitive processing of the material, in question. However, with increasing complexity, more information is delivered, and fewer cognitive resources become available for processing [202]. In this context, Tasks 4 and 6, where the focus was on memory recall, showed that using multimodal metaphors could be beneficial in extending the capacity of working memory to facilitate the processing of both verbal (auditory) and non-verbal (visual) information [203]. Therefore, the experiment results indicated the increasing contribution of multimodal metaphors to user-efficiency, where users of the E platform responded slightly faster to the required difficult evaluation questions, thus supporting H2. This outcome provided evidence of the benefits of incorporating such multimodal metaphors which could influence the complexity level of the information being communicated, in an e-Learning environment.

Concerning the types of questions asked, the third hypothesis predicted that the E condition would prove more efficient for both the memory recall- and recognition-type questions. Overall, the findings indicated that the addition of multimodal metaphors as applied in the E platform contributed, significantly, to memory recall activities, regardless of their complexity. In memory recall questions, users needed to recall, from memory, the information which had been presented to them, and the time taken varied, depending on the complexity of the task. On the other hand, answering the recognition-type questions only required selecting the correct option from the given alternatives; this resulted in reducing the time needed to answer these types of questions, by users in both platforms. Therefore, the multimodal metaphors were shown to contribute more to minimising the time taken for recall-type, than for recognition-type questions. A considerable difference was noted between the two platforms observed for recall-type. Overall, H3 was accepted for recall-type questions, only. Therefore, it can be stated that the effect of the tested multimodal metaphors on response times is limited to memory recall activities, irrespective of the difficulty of the questions, and this can only be of benefit, in high complexity recall tasks.

Although 8 (18.18%) of the users had excellent knowledge of HCI, the mean of correct answers, in general, was satisfactory. Results showed that the variation between conditions, as well as tasks, was significant; with condition E attaining 63.63%, and condition NE, 43.56% (refer to Figure 7). On the complexity level of tasks, condition E scored 22.73%, and condition NE, 13.64%. Additionally, a T-Test confirmed that the difference was statistically significant ($p<0.05$). These positive indications were supported by satisfactory scores, where users achieved more than 4, in the majority of the statements analysed in condition E. All these significant statistics support the users' excellent performance, in condition E. The experiment also reported an encouraging response to the question about whether or not edutainment increased user-attention and performance. These findings confirmed the assumptions made in H4.

It was anticipated that users of platform E would make better progress than users of NE, in terms of the number of questions completed. As shown in Figure 8, condition E proved superior to the NE version, for enhancing users' learning capabilities. Moreover, it would appear that using more than one communication metaphor of a different nature, in the E interface, focussed the users' attention, more effectively, thus improving user levels of concentration. It also assisted users in distinguishing between the different types of information provided by each of these metaphors, as well as enabling them to retain this information, for a longer period of time. This effect can be attributed to multimedia principle [204]; involving other human senses, apart from the visual channel in the interaction process, could assist in extending the capacity of working memory and, as a result, the user's ability to perceive and understand the information presented could also be enhanced. The fact that users, in the experimental group, retained the information communicated, for a longer period of time (compared to the control group), enabled them to attain a significantly higher number of completed answers than their counterparts, in the control group. These findings confirmed the assumptions made in H5.

Decreasing user-effectiveness outcomes were interpreted as being the result of increasing the difficulty level of cases and tasks that had been prepared, with a view to involving the users in a more challenging environment. The mean for Case 1 was 61.74% and Case 2 was 50.88%. Nevertheless, the mean for condition E (recognition type tasks) was 71.76%, and for condition NE, 61.36%. In contrast, percentage outcomes for the recall-type were relatively low, with condition E attaining 53.78%, and condition NE, 35.60%. It is obvious that the results recorded for both question types and, also, in terms of level of difficulty (easy-moderate-hard), were higher for condition E, compared with condition NE, as proposed in Hypotheses 6. The explanation for this phenomenon, noted throughout the experiment, is that the majority of users preferred recognition-type questions, whereas multiple choice questions tended to stimulate their minds to retain information, more easily. On the one hand, whilst some students/users chose not to utilise their memory, while undertaking the tasks, others struggled to remember what they had read concerning the recall-type questions. Furthermore, the effect of incorporating multimodal metaphors, with entertainment attached, was more apparent in the users' answers, in recall-type questions, compared to recognition-type questions. Overall, the experimental group performed significantly better than the control group, for both types of questions.

In general, it was expected that users of platform E would experience greater satisfaction than users of the NE platform, as assumed in Hypotheses 7. Going with this assumption, the multimodal presentation of the learning material, in platform E, has been shown to offer significantly greater satisfaction than the text with graphics, in the NE platform. It seems that using the facially expressive avatar, in a human-like method, in addition to recorded speech and earcons, was interesting and engaging for the users, in the experimental group. Consequently, they articulated a more positive attitude towards the audio-visual communication of the learning material. Both of the tested e-Learning interfaces were simple to use and the information easy to assimilate; neither was confusing nor stressful for the participants; and this is the suggested reason why the results obtained demonstrated a larger difference between both platforms, with regard to these satisfaction features (refer to S1 to S10, in Figure 9). These results were derived from a single group of users presented with both interface versions. However, users in the experimental group may already have had some experience of typical learning interfaces, and this probably served as a comparison between platforms. Meanwhile, users in the experimental group felt that their learning experience was enhanced by the use of multimodal metaphors, especially the avatars with entertaining elements and, therefore, they enjoyed the experiment more than the other version. In addition, users found it easier to identify the learning information, where the topics were presented using avatars, speech, and earcons, respectively.

Considering the platforms, in general, supplementary results indicated that, overall, 31 users (70% of users) easily recognised the facial expressions provided by the avatar, whereas, 10 users (22%) answered, incorrectly; and only 3 users (8%) refused to comment.

Although 25 (56.81%) of the users had no previous knowledge of avatar expressions, it is important to note, here, that these users were able to distinguish, easily, between happy and sad expressions, when introduced, following the submission of right and incorrect answers by the users. The outcome concluded, therefore, that the avatar had succeeded in conveying emotional expressions to the users, effectively. These findings could form the basis for further research into fun-focussed e-Learning systems.

Finally, 36 (80% of users) preferred condition E, when asked for their opinion on the two conditions, regardless of subject matter and whether they had responded, correctly, or not. Indeed, this positive view was based on the fact that, overall, the users enjoyed the edutainment more than the non-edutainment platform and this, in turn, had improved their retention levels and ability to memorise new information. In addition, edutainment stimulated the students' interests, thus facilitating the transfer of knowledge, while simultaneously providing a fun-driven and enjoyable e-Learning environment. Consequently, learners who experienced the edutainment platform reported greater satisfaction with the level of interactivity involved.

Following on from this point, and based on the results and their clarification, this experiment established, to some extent, that the tested multimodal metaphors could significantly contribute to enhancing users' learning performance and the usability of e-Learning interfaces, in general. On the other hand, this result cannot be generalised, as it is restricted to a limited number of users, and the typical mean difference is not large enough. However, when the results for user satisfaction, efficiency and effectiveness are combined together, the argument that users in the experimental group were helped by the multimodal metaphors becomes much stronger. It can, therefore, be deduced that the multimodal e-Learning aid is more likely to result in an enjoyable and satisfying experience for the user. This experience is linked with the ability to complete learning tasks, correctly and quickly. In summary, the overall results of this study point to the importance of the multimodal interaction metaphors tested, in enhancing user-learning performance and the usability of e-Learning interfaces, in terms of efficiency, effectiveness and user satisfaction.

Nevertheless, the resulting outcome did not indicate the specific and individual roles played by each of the multimodal metaphors investigated, in enhancing usability, as well as improving learning performance, in the E condition. To some extent, the results of the experiment could not be considered as sufficient to determine the level of individual enjoyment associated with each specific multimodal metaphor, be it the speaking avatars, recorded speech, amusing messages or the earcons, and how each contributed in the final results. Earlier studies [192, 202, 205] proved that the use of a human-like avatar, as a virtual pedagogical agent, could facilitate the learning process and enhance user-learning performance. However, these studies did not investigate the level of entertainment derived from the amusing facial expressions and body-language that could be incorporated into the avatars, when employed as virtual lecturers. Therefore, the next experiment (as described in Chapter 4) was designed to explore the usability (in terms of efficiency, effectiveness and user satisfaction) and the learning performance of three different modes of utilising e-Learning interfaces, by other types of edutainment environments.

3.12 Summary

This chapter introduced an empirical study for investigating the role of “edutainment”, (recorded speech sounds, earcons and avatars with human-like facial expressions), in education, compared to the use of a “non-edutainment” version (text with graphics), to deliver the same learning material, via Human-Computer Interaction. The usability of these two platforms was measured, in terms of efficiency, effectiveness, and satisfaction by a single group of users. The main aim was to enhance the learning process through actively engaging the users, and employing a multimodality e-Learning system, using an avatar to convey educational materials. First, the results of the experiment presented in this chapter indicated an improvement in user enjoyment and learning retention, as well as creating a more satisfactory user-interface. The application of the analysis of variance between the groups, as defined in the study, further confirmed this supposition. Therefore, it is concluded that the multimodal metaphors tested could, potentially, contribute, significantly, to enhancing user-learning performance and the usability of e-Learning interfaces, in terms of efficiency, effectiveness and user satisfaction. Consequently, the addition of multimodal metaphors is recommended; moreover, the above findings could be taken into account, when designing user interfaces for future e-Learning applications. Additionally, this research also anticipated building an improved interface, with a view to contributing to the development of user usability and learn-ability measurements. In this context, further experimentation will be conducted through sequences of tests designed to overcome usability problems, within edutainment interfaces.

Chapter 4 Comparing Virtual Classroom, Game-Based Learning and Storytelling-Style Teaching in an e-Learning Environment

4.1 Introduction

The outcomes from the first experiment indicated that the use of multimodal metaphors has the potential to enhance user-performance and the usability of the proposed e-Learning system. In particular, incorporating text, graphics and recorded speech, merged with the entertaining facial expressions of avatars, amusing messages, and human-like gestures, proved to be an effective method for engaging and assisting users in their learning process. These outcomes, however, do not clearly portray the role of each of the individual multimodal metaphors, in the obtained enhancement. As the aim of the study was to investigate the overall role of edutainment, which includes several different activities and actions, this experimental phase, therefore, investigated and compared three new interfaces, integrated with different entertainment attributes, in order to identify, further, which specific entertainment activity was best preferred by the group of users.

These three interfaces included: Virtual Classroom, using avatars to represent the teacher-student scenario (VC); Game-Based Learning (GBL); and Storytelling (ST). In addition to textual and graphical communication modalities, natural (and sometimes amusing) recorded speech was used as a common feature, across the three platforms. An earcons attribute was also built into the game, to measure its impact on enhancing the usability of the game, as well as on user-performance. Usability involves the effectiveness and efficiency of, and satisfaction with the product [206]. These principles were measured, empirically, for the first component of usability, which is learn-ability, or, in other words, the ability to complete tasks, from first time use [206]. The remainder of this chapter presents, in more detail, the aims and objectives of the research, the hypotheses, the three experimental platforms, the methods used for the experiment, the final results and a discussion thereof, before moving on to the summary and conclusions.

4.2 Aims

The aim of this empirical experiment was:

1. to investigate the usability of the multimodal metaphors implemented in the different experimental environments.

2. to test three new platforms namely; Virtual classroom (VC), Game-based learning (GBL) and Storytelling (ST).

3. to inspect the role of entertainment features represented by natural recorded speech, avatars, and game activity within an e-Learning context.

4. to examine earcons which was incorporated to help users resolve problems given, both efficiently and quickly.

5. to investigate whether there are significant differences between the three tested environments in terms of efficiency, effectiveness, and satisfaction.

6. to identify the most desirable user interface among the three disparate methods implemented in the three environments and which interface the majority of users were enjoyed mostly.

4.3 Objectives

In order to fulfil the aims provided in the previous section, a list of objectives should be achieved. These objectives are:

1. Construct the hypotheses.

2. Design and build three experimental interfaces, each of which introduces learning materials about Geology, in three different presentation forms; virtual classroom consisting of teachers and students represented by avatars with facial expressions and body gestures, implementing game-based learning with the aid of earcons, and storytelling enriched with graphical and animated diagrams.

3. Design and preparation of questionnaires consisting of a set of satisfaction-testing statements for each platform, which will serve as a measure individual satisfaction after the experimental sessions.

4. Perform the experiment for the three environments using a group of users.

5. Measure the efficiency of each platform by the time users used up to complete the specific tasks.

6. Determine the enhancement on learning performance of users by calculating the percentage of completed tasks users performed successfully.

7. Empirically evaluate each of the three experimental environments using the System Usability Scale (SUS) method.

8. Obtain measurements regarding the use of each platform in terms of use preference.

4.4 Hypothesis

This part determines six hypotheses to be weighed against the metrics that will be measured in this experiment in order to measure usability (efficiency, effectiveness and satisfaction) of VC, GBL and ST platforms dependently (using one group of users) . These hypotheses are:

Hypothesis 1: The efficiency of VC, GBL and ST will be different in terms of time taken to complete the same tasks by users for the first time.

Hypothesis 2: The effectiveness of VC, GBL and ST will be different in terms of number correct answers made and number of tasks completed successfully for the first time.

Hypothesis 3: There will be a difference between the experimental platforms VC, GBL and ST in terms of user's satisfaction.

Hypothesis 4: VC will be more efficient than GBL and ST in terms of shortening task accomplishment time.

Hypothesis 5: VC will be more effective than GBL and ST in terms of reducing frequency of incorrect answers.

Hypothesis 6: VC will be more satisfied than GBL and ST.

4.5 Design of E-Learning Platforms

This section introduces the e-Learning experimental platforms used to empirically investigate a number of multimodal interaction metaphors proposed to enhance the usability of the e-Learning interfaces. These platforms were (1) Virtual class using avatars, (2) Game-based learning and (3) storytelling interfaces. The Virtual class e-Learning platform was built from scratch and designed to utilise speaking avatars with human-like facial expressions and body gestures as well as natural recorded speech with entertaining features in order to offer audio-visual presentation of the learning material, to ensure immersing users' interest in the attractive environment. It is believed according to some studies [82, 90, 157, 192, 207, 208] that using avatars in this manner compensate to a large extent for the traditional face-to-face interaction that typically takes place between a lecturer and his/her students. The game-based learning introduced a Square-Game enriched with earcons as an aided metaphor to enable users to answers game questions as quickly as possible when user prefer using them. The final interface presents the learning materials in a narrative manner (i.e. the system articulates vocally the information with the text as extra channel), associated with pictures, graphs, dynamic diagrams and movies that mimics and disclose the information offered. The multimodal features of the three platforms are depicted in Table 5.

4.5.1 Learning Topic

In the previous experiment the Human Computer Interaction (HCI) was the subject matter tested, therefore due to the suspicion that it might have an effect on the student's performance, since the majority of users were from computer science, to avoid this influence, in this experiment alternative learning materials have been introduced as the e-Learning topic. Therefore in this study three geology lessons circulated between the three platforms, please see Table 6**.** Each lesson kept the same amount of information; this was done by counting the number of words per lesson to ensure that the three lessons are similar and to minimise difficulty of the tasks. In order to guarantee that all experimental platforms had been regularly used for each lesson, these platforms were assigned to the three lessons on a systematic random rotation basis (see Table 7) and for complete lessons, see Appendix B-2.

4.5.2 First Interface Design (Virtual Classroom VC)

This platform employed an expressive avatar with facial expressions as a virtual lecturer (speech and human-like expressions) to introduce the learning materials as well as edutainment aspects. The interface provided additional metaphors such text and graphics displayed concurrently on the screen.

Conditions	Features									
	Sound	**Text**	**Graphics**	**Avatar**	**Earcons**	**Gesture**	**Facial expression**	**Amusing messages**	**Normal Feedback**	**Amusing feedback**
VC	√	√	√	√		√	√	√	√	√
GBL	√	√	√		√			√	√	√
ST	√	√	√					√	√	√

Table 5 The Platforms Multimodal Features.

Learning materials	Interfaces (conditions)	No. of Words
L1 = Lesson 1 (Geology, what is it)	C1=VC= Virtual Classroom represented by Avatar.	455
L2 = Lesson 2 (Geology, Earth cycles)	C2= GBL = Game-Based learning	423
L3 = Lesson 3 (Geology, Earth Properties)	C3= ST = Storytelling	436

Table 6 Learning Materials.

Lesson / Users	L1	L2	L3
U1	C1	C2	C3
U2	C1	C3	C3
U3	C2	C3	C1
U4	C2	C1	C3
U5	C3	C2	C1
U6	C3	C1	C2
.	.	.	.
.	.	.	.
.	.	.	.
U43	C1	C2	C3
U44	C1	C3	C3
U45	C2	C3	C1
U46	C2	C1	C3
U47	C3	C2	C1
U48	C3	C1	C2

Note that as in the table the conditions and learning materials are rotated for the same number of times.

L1&C1= 16 times
C2 = 16 times 48 times & L1
L1&C3= 16 times
L2&C1= 16 times
C2 = 16 times 48 times 2 L1
L2&C3= 16 times
L3&C1= 16 times
C2 = 16 times 48 times 3 L1
L3&C3= 16 times

Table 7 Lessons Random Rotation System.

The way of presenting the information in this interface is similar, to a real classroom environment where the teachers and students interact with each other during the class. This has been done by interchange of questions and answers between the teacher and the students (as represented by avatar), building dialogues and amusing conversations that are expected to increase student the quality of learning. The virtual class is also designed to mimic the real classroom consisting of a teacher, a board, chairs, tables, floor carpet and wall.

The avatars representing the teacher and other students to read to the user the subject matter and entertain the user at the same time with amusing messages, some expressions, and short messages as feedback (sometimes from students as questions or comments). Figure 13 (A), (B) and (C) show example snapshots of the system. The proposed platform provides users with ‘play/stop’ functionality to enable users to interact only when they want to do so, (i.e. a learner can play, stop, and go back to specific point). The lessons are divided into chunks of information, carefully presented as text with a font size of 24 for title, and 14 for the plain text on the blackboard, following screen design guidelines for motivation in interactive multimedia instruction. Also natural speech has been applied together with amusing messages, and the unambiguous feedback about their advance. These combined with the other features of the system make up the necessary learning elements.

The system switches between teacher and student when the talk swaps between them. The avatar is dressed in dark colours such as blue and dark grey in front of light brown board background. Directly under the avatar, is a countdown clock showing the user the time remaining for the avatar's task to be completed, and a special button to stop the avatar if the user chooses to not continue or pause. Also there is an extra button with a different colour and shape, which allows entry into the quiz portion. Time is limited for the user to read or listen for a maximum 1-2 minutes for each segment, measured according to normal reading rate by the developer and according to the avatar's speech length. When the user has completed the listening and reading session, the page automatically navigates to the next page until the user completes all lessons.

4.5.3 Second Interface Design (Game-Based Learning GBL)

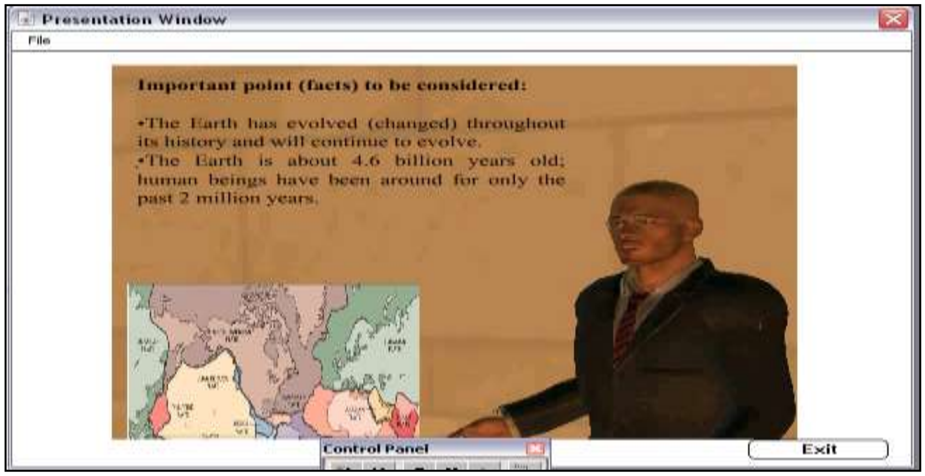
The method used in this platform differs completely from the previous interface; simply the user has to read and listen to specific lesson and directly must go to tasks (questions) designed to be "Square Game" as it composes of squares. This game was implemented by the same software mentioned in the previous chapter [209]. In the early phase, the game appears in the form of 6 squares (boxes), with the main box (rectangular shape) in the top middle of the screen which is allocated for the question. The question appears only when the user shifts the mouse over the box. As the user reads the question, he/she straightaway has to move the pointer over the remaining boxes (6 squares) to find the correct answer which is distributed randomly across the boxes. Besides the text as answer, the game provided earcons to help with answering questions where the user was not sure of the correct answer. The tone used in these earcons was developed using software called *visual music*, by half the tones to two portions. The first half was assigned to the question and the other half assigned to the answer. Therefore to find the correct tone, the user must click on any of the tone buttons that was assigned to each square or answer.

The system automatically proceeds to the next question if the user's answer was right. Otherwise the box disappears and raises the number of boxes to 7 if the user's answer was incorrect, and it continues to increase for so long as the user's answer is still incorrect until it reaches a maximum 9 boxes, prompting the user to go to the next question and then the game starts over again.

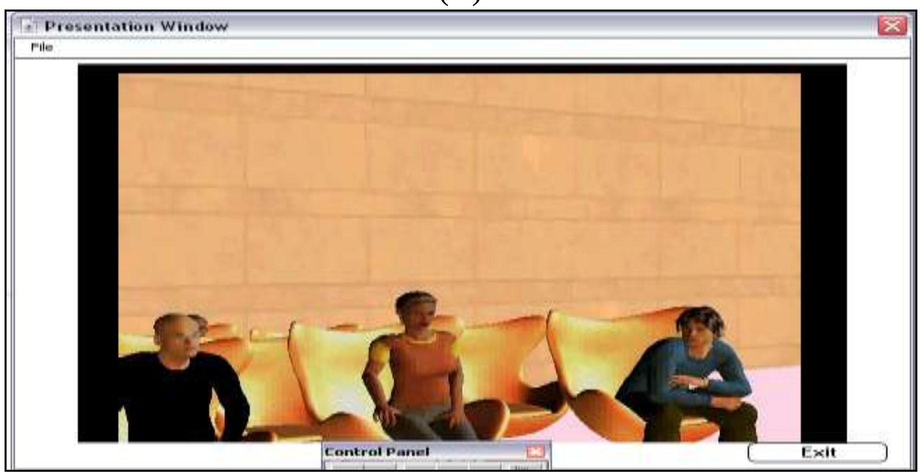
This makes the probability of finding the correct answer low and more difficult and encourages the user to find the answers from the first try; otherwise the chance of getting the answers correct will decrease with the second and third tries. Example of proposed game is shown in Figure 14 (A), (B), (C) and (D).

4.5.4 Third Interface Design (Storytelling ST)

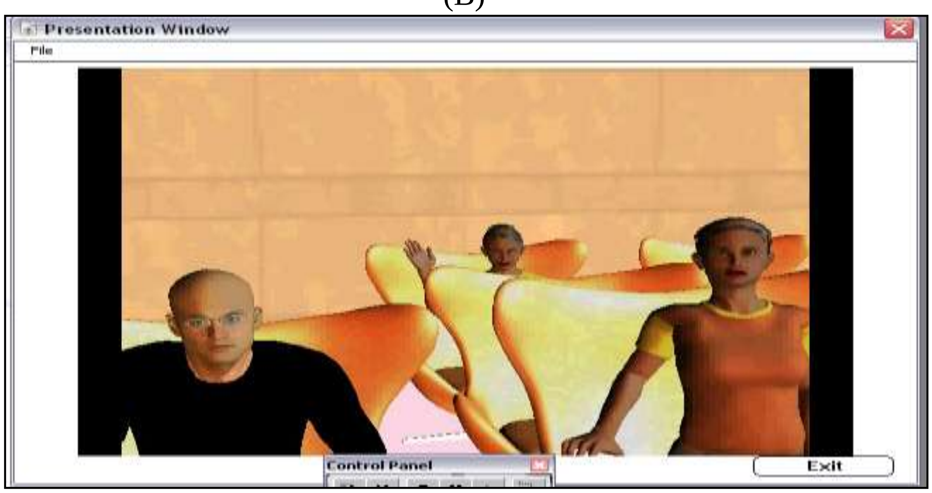
Storytelling as means of conveying information to people is considered these days to be one of the effective methods for teaching different subjects to students. In fact, many researches such as [210] have used storytelling to capture the students' attention. In this experiment storytelling was tested as edutainment interface, used to present science information (Geology) in an interactive way. The system articulates the information vocally with the text as extra channel, associated with pictures, graphs, dynamic diagrams and movies that mimic and disclose the information offered.



(A)



(B)



(C)

Figure 13 Virtual Class (VC) Condition Examples (A) Teacher, (B) Students, (C) Female Students.

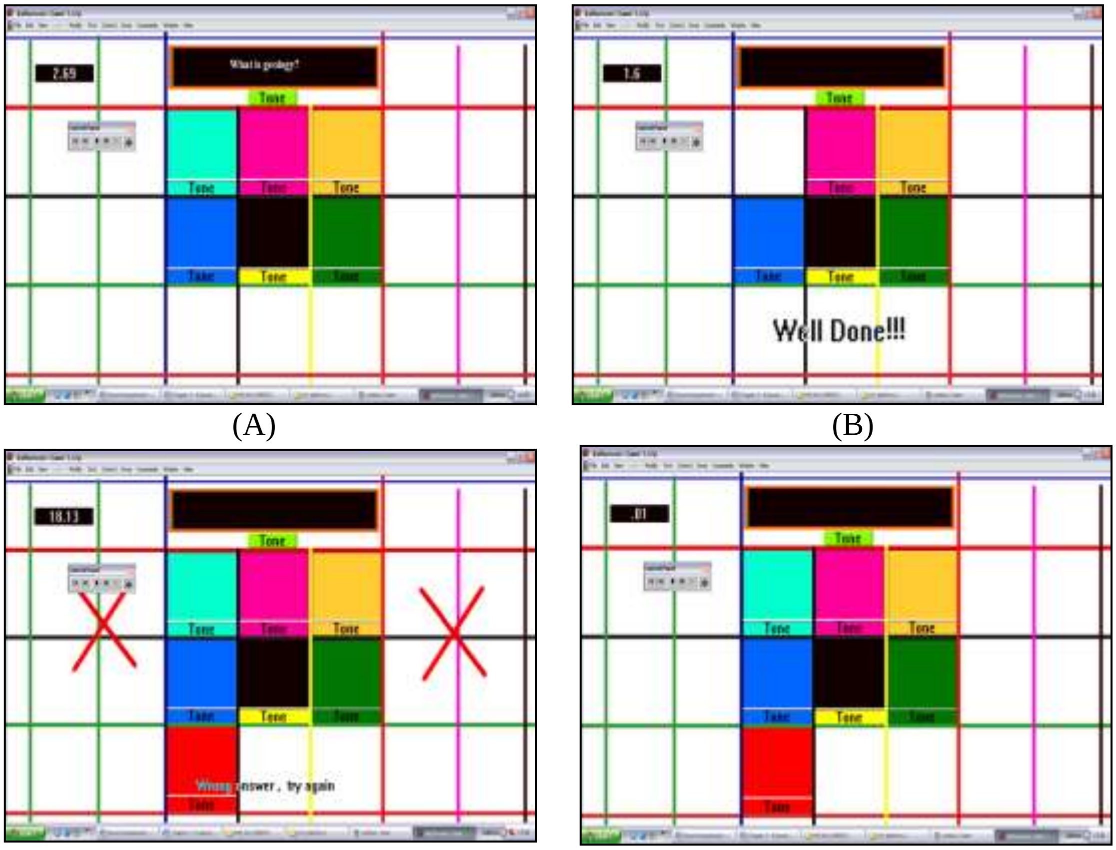
Stories are a powerful mechanism for conveying information. A story can be used for many goals; it might be used to transmit personal expression of emotional, physical and informational aspects that the individual associates with the knowledge, entertainment and even teaching science facts. An excellent narrative should link the objective with the subjective, and the rational with the emotional [165].

In this experiment, in order to present the information and narrate the facts in suitable way, the information was communicated to users through stories that served as an anticipatory set or hook to capture the attention of students and increase their interest and entertainment in exploring new ideas [211].

So this interface is designed to hold one lesson. The lesson is divided into pages, and each page contains some information communicated using speech, text and graphs. Users must press the next button to navigate to the next portion of the information. Additionally, the users were provided with the facility of play, stop and go back to specific point at any time. Figure 15 (A), (B) and (C) demonstrate some example snapshot of this interface.

4.5.5 Execution of Avatars, Earcons and Natural Speech

In addition to Mimic [199], Poser [13], Camtasia Studio [26], Authorware [209] and music software's [193] used for the creation of the first experimental platform (see Section 3.9), other software tools have also been used to develop the sound, earcons and avatar instead of those mentioned.



(A) (B) (C) (D)

Figure 14 (A) The Game in Early Phase (B) The Game When User Answers Right (C) The Game When User Answers Incorrect (D) The Game When User Answers Incorrect and A Box Added.

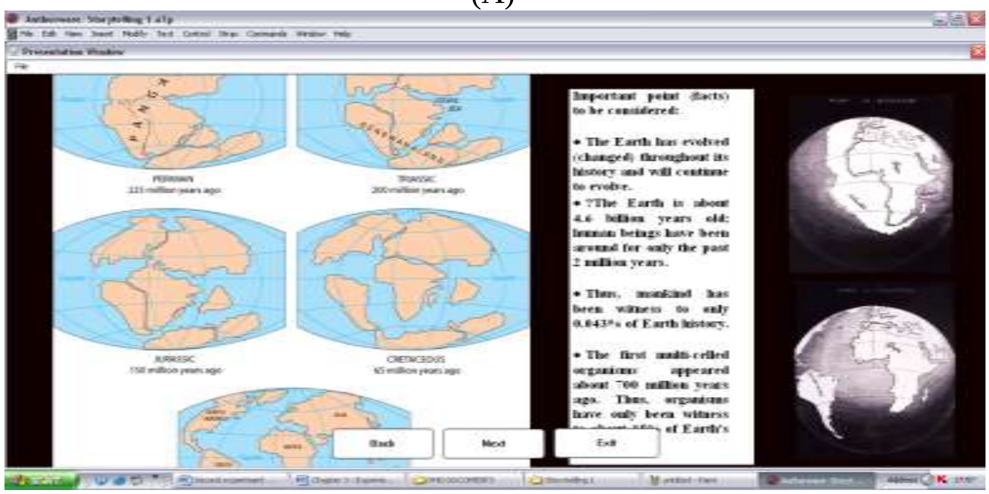
This is because the problem that has been encountered during the development of the first experimental platforms was in generating the AVI files for Poser files. The rendering process was time consuming mainly when the number of frames became bigger; sometimes the device was hanging. In order to resolve this problem, CrazyTalk [212] was used to produce the upper half of the avatar (head and shoulder), as in this experimental interface, head, gaze, and eyes movements were only needed to represent the amusing human expressions. CrazyTalk provides better 3D facial orientation, face profile for all kinds of creatures, enhanced hair mesh for natural head movement, and the new dimension of storytelling with multiple characters.

Moreover Crazytalk allows the transform action of photos and images into talking animated characters and brings them to life with real-time actions; turning any PC into a face animation movie studio. It can animate any kind of image, even doodles, drawings or sketches. Inside CrazyTalk, you can also apply several types of special effects to enrich your animation. With this technology, one can use a mouse or handheld device to create facial animation with solo feature adjustment or full face control with all possible facial controls which enable the developer to make your project faster and more enjoyable.

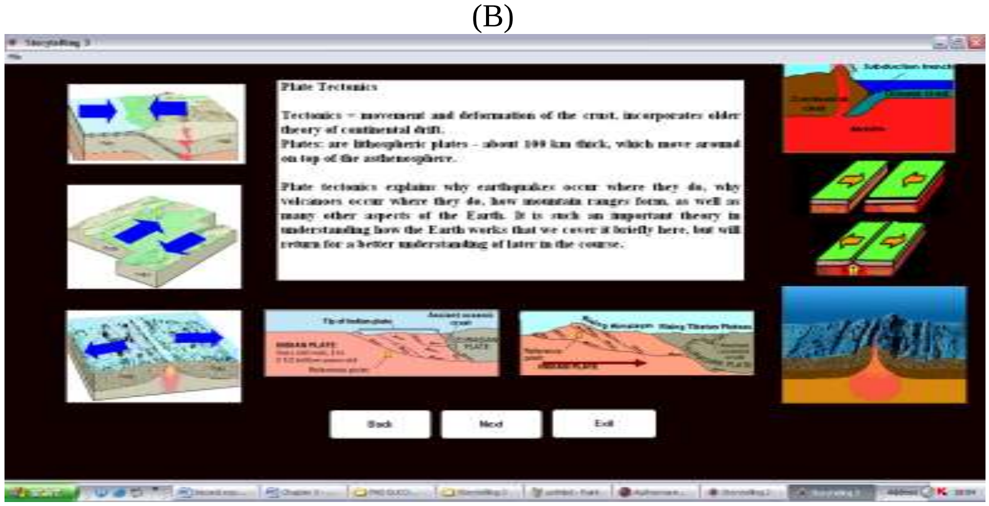
The implementation of earcons metaphor was employed in the game-based learning interface only. Visual Music software [35], Gold Wave [213], and All Sound Recorder [214] were used to create, record, edit and filter the nine earcons sounds, each of which has been utilised to communicate one of the nine different questions designed based on the suggested guidelines [204].

This earcons composed of different instruments available in the software; an example of the instrument used in the experiment, first tone was from Honky-tonk Piano with Octave 4 and Pan 64, the second Rhodes Piano with Octave 4 and Pan 64 as well. The third tone was Tinkle-Bell with Octave 7 and Pan 64, the fourth tone was done by Fiddle with Octave 5 and Pan 64.

(A)



(B)



(C)

Figure 15 The Storytelling (ST) Interface, (A) Example 1, (B) Example 2, (C) Example 3.

By halving the tones to two portions using *Audacity sound editor 1.3.5 (beta)* [87], the first half was allocated to the question and the second half to the answer. Therefore, to find the correct tone, the user must click on any of the tone buttons allocated to each square or answer.

4.5.6 Experimental Design, Variables and Procedure

The technique that has been followed to carry out this experimental investigation was the *within-subject* procedure. Because it minimise the risk of any other external factors that may be influencing user's performance from one treatment to another [215]. Moreover it ensures the contribution of each user in testing all the systems being evaluated. Therefore, one group of users was involved in testing the experimental e-Learning platforms: VC, GBL, and ST. A total of 48 users have taken part in the experiment on an individual basis. Users had to select whether they liked any of the interfaces and also had to rate them through questionnaires that were provided. All the three interfaces were demonstrated in a random order to avoid the effect of any other factors. The controlled, dependent and independent variables of this experimental study were identified. These variables can be seen in Table 8.

4.5.7 Experiment Tasks

The systems provided 6 tasks (Questions) for lesson or interface; all questions could be considered recognition-type (Single, Multiple choices and true-false questions). These questions were built in the system, and each question is considered as one task.

Controlled Variables	1. The tasks were the same for all users. 2. The level of difficulty of the subject matter was the same. 3. The time distribution is same between all tasks. 4. None of the users were aware of the tasks that would be presented to them.
Dependent Variables	1. Time spent 2. Number of correct answers 3. Satisfactions 4. User reaction (smiles, laughs…)
Independent Variables	Learning method proposed with three levels: 1. The virtual class presented to obtain user's opinion 2. The game presented to obtain user's perception 3. The storytelling presented to obtain user's perception.

Table 8 Study Variables.

It is the same for all three platforms in terms of number of questions, questions-type and difficulty level. Nevertheless the system provides the user with 3 tries for every task and is built in with a' clock. A limited time is allocated to complete the task, not more than 60 seconds each. Whatever the user believes to be correct, he has to click on the proper answer to check the response with amusing sounds and text at once, whether it is correct or not.

4.5.8 Questionnaire

The questionnaire consists of a total of 9 pages, the first part of the questionnaire that introduced to users general instruction and personal detail is similar to the one used in the first experiment phase (see section 3.9.2) (see Appendix B-1).

In this phase, the users start with instruction to read lessons which are the same in the three interfaces tested as shown in Table 9. While instructions to execute the tasks itself are same only in platforms VC and ST and differ in platform GBL, Table 10 and 11 shows these instructions respectively.

Beside the standard satisfaction statements, each platform has extra satisfaction statements that stated according to the type of modalities incorporated with that particular platform. In the final page, the users were asked to select the most enjoyable interface and to order them according to their experiences, whereas the second part is allocated for problems that the user experienced and any other comments or suggestion.

4.5.9 Pilot Study

Pilot study was arranged and implemented with six users; all users examined all three conditions (platforms). The experiment was recorded using Camtasia software [26] to be able to review the session and discover any mistakes later and also to record users' facial responses regarding the enjoyment elements incorporated such as smiles, laughs and brow rising. Users completed the final questionnaire in which they expressed their comment on aspects of the experiment.

All users commented that the lessons length were relatively reasonable; they felt the contents were relevant. Additionally, 44 (92.4%) of users stated that the exercise was easy to moderate to answer even for those who did not have not any experience with the subject. Whereas most users agreed that the interface was enjoyable and easy to use, about the questionnaire they mostly commented that it was easy and well organised.

4.5.10 Pre-Experimental

Forty eight users (48) participated in the study, mostly students of high educational level (Master & PhD). Geology is the subject matter that was examined as the e-Learning content. To avoid the user being disordered or becoming anxious, and also because most of the users are from various departments such as Biology, and medicine, it was important to get users relaxed by informing them of the goal of the experiment and encouraging them not to worry whether they have any knowledge about geology or not, and calming them down by telling them that they are not in position of testing his or her ability, but to investigate the differences between the platforms developed. Moreover, explaining to the users orally exactly what he/she has to do after reading the instruction of the questionnaire was also helpful.

Although everything is written clear and simple in the questionnaire but reminding the user about the time limitation, tasks order and answering to specific question by users reduces the possibility of users' falling into any unwanted mistakes. Moreover at the end of pre-experimental tasks, the experimental platforms were introduced by showing a 2-minute video recording that described the components integrated in the interface of each platform, and thus provided all the users with a consistent demonstration of these platforms.

Thereafter, three lessons on Geology were interactively presented using the experimental platforms. These lessons were dependent on each other; therefore the order of presentation was the same for all users (i.e. lesson 1 then lesson 2 then lesson 3). However, each platform was used once with each user presenting one of these lessons. In order to ensure that all experimental platforms had been equally used for each lesson, these platforms were assigned to the three lessons on a random rotation basis (refer to Table 7).

Instructions	1. You will have to read and listen to lesson one which is **Geology , What is it?**, for maximum 5 minutes, where every page designed to give you one section as text, and in the same time you will listen to the avatar all the time to read and explain the lesson . 2. After you have finished reading and listening, you are asked to answer some questions by pressing on the Quiz button:

Table 9 Lessons Instructions.

Tasks	Tasks Instructions
Task 1	Multiple choice questions: chose at least 2 answers that you believe is correct and click on the check answer button to find out the result.
Task 2	Repeat the same steps in task 1.
Task 3	Single choice questions: chose just one answer that you believe is correct and click on the check answer button to find out the result.
Task 4	Repeat the same steps in task 3.
Task 5	True and falls questions: click on the answer (true or falls words) that you believe is correct and click on the check answer button to find out the result.
Task 6	Repeat the same steps in tasks 5.

Table 10 Tasks Instructions for VC and ST Platforms.

Tasks	Tasks Instructions
Task 1	1. Read the question in the top of the page by moving the mouse over the **black rectangular or press** is colored button labeled **Tone** to hear to the sound or tone. 2. After you have finished reading the question move the mouse over 6 any of colored squares or colored button labeled **Tone**, to see the answer or to hear and mach the tone in the question given. 3. Click on the square if you believed it is the correct answer and if you have chosen to answer the question by hearing the tone, still you have to click the square to get the feedback. 4. Do the same operation if you have answered incorrect. 5. If you have answered correct, the program will automatically give you the next question until you have finished all of them.
Tasks 2-6	Repeat the same steps in task 1

Table 11 Tasks Instructions for GBL Platform.

4.5.11 Sampling

For equal distribution of the lessons between the three platforms, six possible substitutions could be achieved by presenting the learning lessons as shown in Table 7, earlier in this chapter. Therefore the number of users should be a multiple of number 6 (12 or 18 or 24 or over). Although using only 6 users could provide system usability evaluation, the contribution of a larger number of users offers more sufficient usability result .Therefore; the test sample consisted of 48 users participating in the experiment individually. All of them were volunteers and they were using the experimental platforms for the first time. The majority, 35 (72.18%) of users were inexperienced in geology, the learning topic presented by the experimental platforms. As mentioned earlier due to the reason that most users who participated 24 users (50%) were from computing background in the first experiment, therefore in selecting geology as learning topic, in this experiment extra care is taken, to avoid any affect in the experimental results. This guaranteed that most probably the target population for this set of experiments participated, having no previous knowledge in answering the required questions. As a consequence of that, the effect of the tested experimental e-Learning platforms on the user's performance will be validated.

4.5.12 Data Collection

The data was collected for the experiment using two methods, these are observations and questionnaires. Observation consists of writing down any notes that could help in collecting the required data in order to measure function learning time, tasks accomplishment time and number of incorrect answers during achievement of each task. In other words, the observation notes helped to collect the data required for measuring efficiency and effectiveness. Regarding the questionnaires, six different kinds were used to collect the data; each questionnaire was used to assess the three environments proposed using the systematic rotation (see Table 7). A user had to read a maximum of one page about a topic in Geology prior to performing each of the required 6 Tasks. In the platforms VC and ST, the first two questions were designed to be single multiple choice (One answer is correct), the second two question was multiple choice (two or more answers are correct), and the two final ones were true-false type. Whereas in the platform GBL, 6 opportunities were allocated for each question and the number of choices increased to 7 or 8 or 9 when the user answered incorrectly. The user would then start performing the task and all actions taken (time, task completion, and incorrect answers) were observed and timed. In addition, the user's responses were recorded using Camtasia studio [26] application to help in computing the number of smiles, laughs, brow rising and other facial expressions. Finally the user had to evaluate a number of post- questionnaire statements. These declarations aimed to measure the level of satisfaction that is provided by the interaction metaphors. This procedure was applied for all the platforms after completing the required tasks.

4.5.13 Users Profiles

This experimental phase involved 48 users; who contributed individually to the experiment. All the users were student volunteers and first time users of the experimental platforms. They were drawn from the age range 18-54, and 46 users (95.83%) were males. The mean age was 36 years with a standard deviation of 25.26%. Users were generally educated to higher level, with 21 (43.75%) of them holding Doctoral degrees, 27 (56.25%) holding Masters Degree and only 1 user (2.08%) were Undergraduates. In terms of area of study, 21 (43.75%) of users were from Computing and Informatics department, and 6 users (12.9%) were from Engineering in general. The remaining users were from other different schools and departments. 47 (99.75%) of the users were using computers for longer than 10 hours weekly; and 44 (91.67%) of the users were using the Internet for longer than 10 hours weekly. In terms of prior experience, only 1 user (2.08%) had an excellent knowledge of Geology, 12 users (25%) had good knowledge, 26 users (54.17%) limited knowledge, and 10 users (18.75%) had no knowledge at all of the subject. Regarding e-Learning, 16 (33.33%) of users were experienced in e-Learning system. And concerning avatar, 21 (43.75%) of the users had no knowledge, 18 users (37.50%) had limited knowledge, 5 users (10.42%) had good knowledge, and 0% was excellent. The frequency for user profiles can be found in Appendix B-3.

4.5.14 Experimental Sessions

The sessions ended between 30 and 45 minutes with mean time of 37.5 minutes (standard deviation 10.60 minutes), including time spent on pre- and post-questionnaire. The time was distributed as follow: users started with pre-session questionnaire for mean 3 minutes, then they read the tasks for mean 4 minutes, and went on to begin platform 1 experiment for mean 8 minutes, followed by first platform feedback questionnaire for mean 2 minutes and there was an equivalent distribution of time with the second and third platforms.

4.6 Results and Analysis

In all, 48 volunteers took part in the study, which lasted over 4 weeks mostly in the Bradford University research laboratory. All users utilised the three lessons and three edutainment conditions. Both conditions and lessons was distributed randomly but was the same for each user. The obtained experimental results were analysed using different parameters including efficiency, effectiveness, satisfaction, memorability, user's responses (number of smiles, laughs….etc) and preference. The existence of significant difference in the users' responses was examined by the Friedman's ANOVA statistical test at $\alpha = .01$ indicating significant difference when p-value was found less than 0.01 (i.e. when $p < 0.01$).

4.6.1 Efficiency

The timing observations collected from the users in the three environments are analysed and compared in this section. This measure was considered between all conditions as well as for each task accomplished, by taking the mean time users spent in each platform. Figure 16 illustrates the mean time (excluding reading, pre- and post-questionnaire) in all conditions. In condition VC the mean time was 14.51 seconds. Condition GBL was 24.67 seconds, and condition ST was 16.99. The time spent in condition GBL was clearly higher than in the other conditions. Moreover the time variations between tasks for the three conditions are high as depicted in Figure 16, especially in condition GBL which was 24.67 seconds as mean. In condition VC the time gradually decreases towards Tasks 6; in Task 1 the time was 19.77 seconds, whereas the time taken was 9.9 seconds in Task 6.

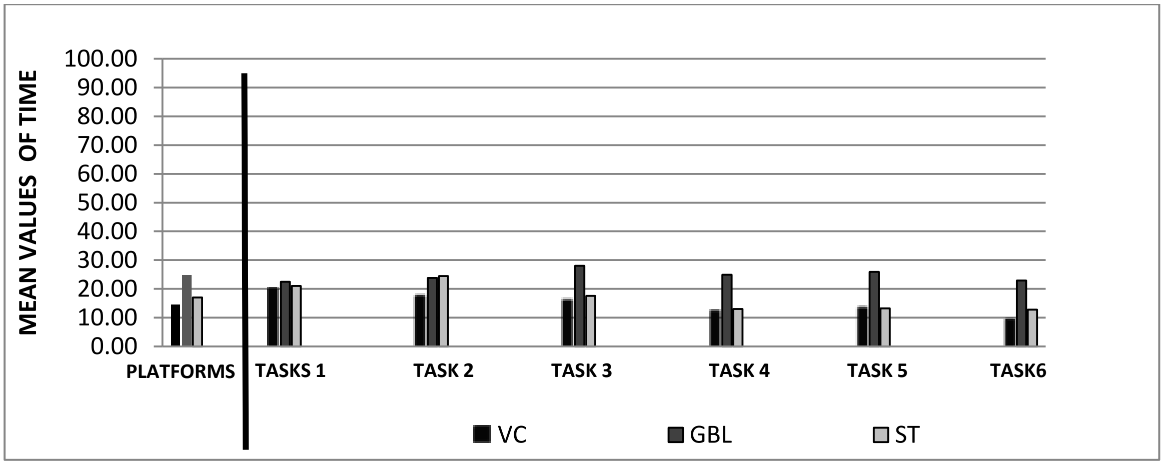


Figure 16 Mean Time for All Platforms and for Each Task.

The same gradual decrease was noticed except in Task 2 which took 24.5 seconds. In condition ST, time taken in Task 1 was 20.05 seconds, whereas the time taken in Task 6 was 12.77 seconds.

Overall, the time spent by users in conditions VC and TS was less compared to the GBL interface and that is because the latter was more complicated than the other interfaces and also due to incorporating additional modalities such as earcons. The raw data for question answering time can be found in Appendix B-4, 5 and 6.

4.6.2 Effectiveness

A mean correct answer has been taken from each condition in order to show in general the user's performance as illustrated in Figure 17. Users in condition GBL performed better than users in the other conditions. The correct answers percentage was the highest 78.82% in condition GBL, and was less in condition VC which had 53.82%, and was even less in condition ST with 44.10%.

Figure 18 depicts the number of correct answers compared to incorrect and missing answers, which was the highest in condition GBL than the other conditions. In condition GBL it was 227, in condition VC it was 155, and in condition ST it was 127. These results indicate that the user's performance is better in condition GBL followed by condition, VC, and finally condition, ST.

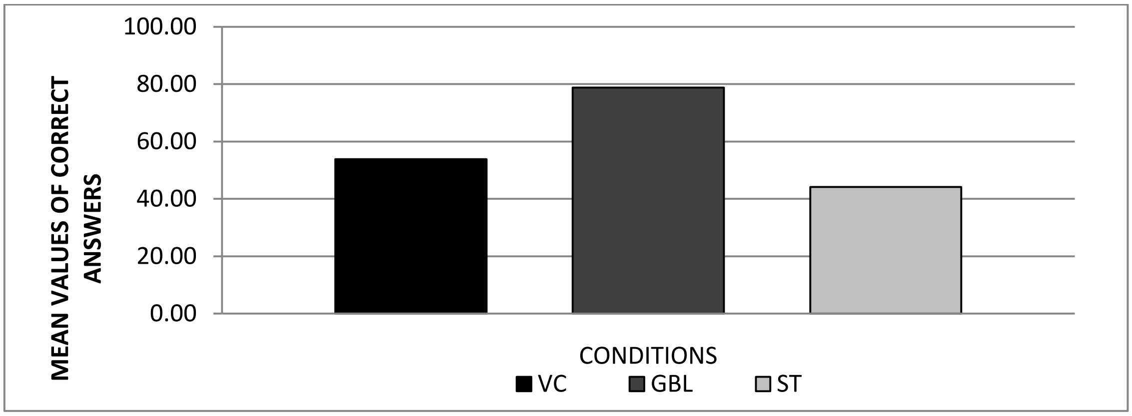


Figure 17 Mean Percentage of Correct Answer for Conditions VC, GBL and ST.

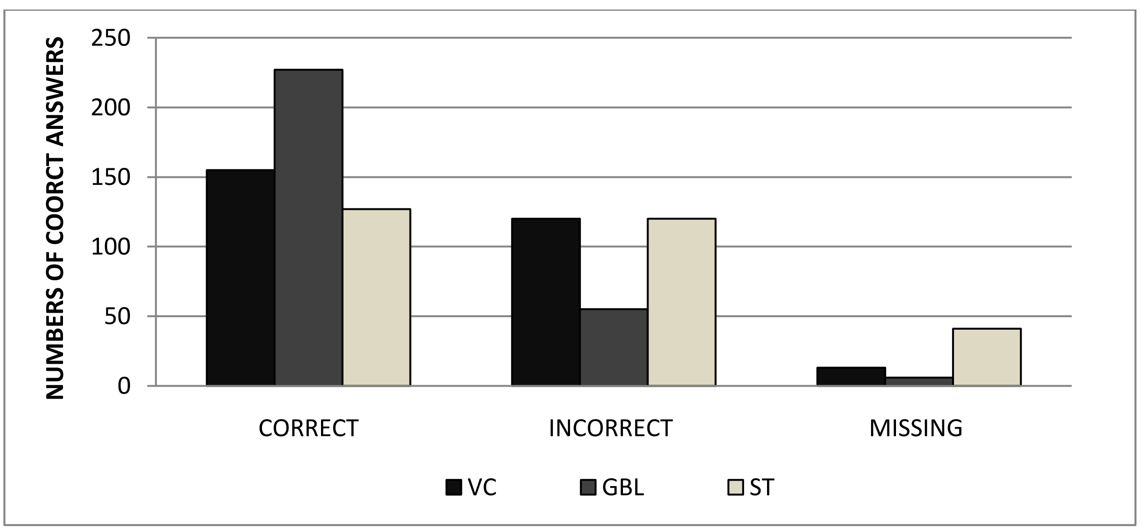


Figure 18 Conditions, VC, GBL and ST Number of Correct, Incorrect and Missing Answers.

On the task level, participant's correct answer in condition GBL was highest in all tasks without exception, compared to the other two conditions. As shown in Figure 19 below, in condition VC there was mean of 53.82% correct answers. In contrast, the result was 78.82% in condition GBL, and 44.10% in condition ST. It is obvious that the percentage of correct answers decreases gradually from condition GBL to VC, and finally ST.

In addition to the percentage of correct answers declared above, the study measured the completion rate for all conditions in general as well as in tasks level. Figure 20 below shows the completion variances in the three platforms.

The completion rate in condition GBL is higher measured up to conditions VC and ST. The percentages were in condition VC 79.86% (38 users), condition GBL 97.9% (47 users) and in condition ST 85.76(41 users).

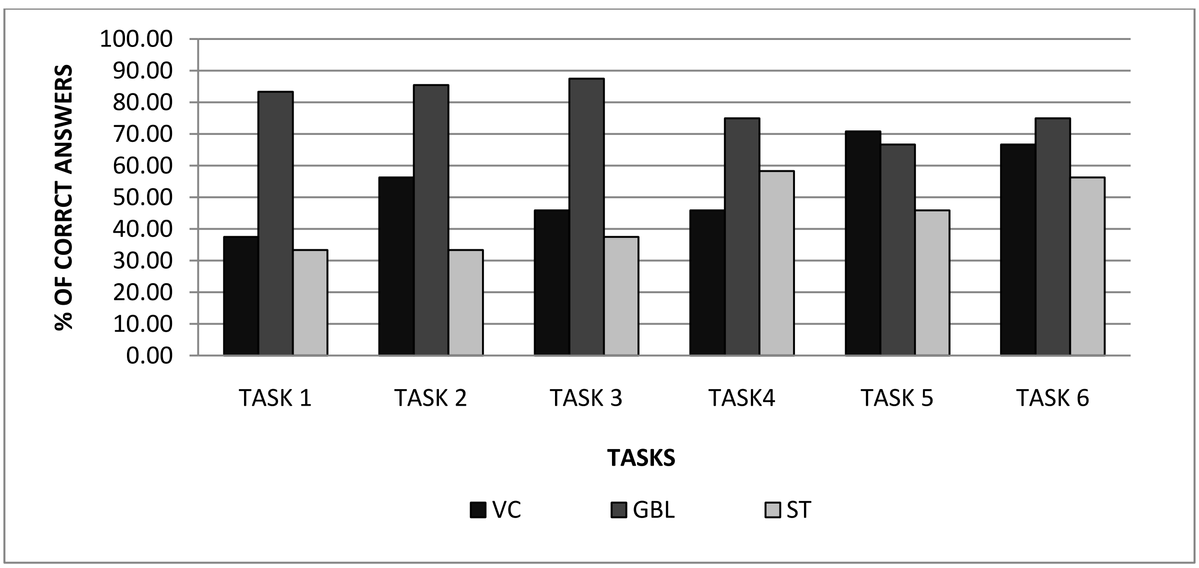


Figure 19 Conditions, VC, GBL and ST Percentage of Correct Answers for Each Task.

On the other hand, 37 (77.08%) of the users in condition VC completed their tasks without any mistake. In condition GBL the percentage rate were 89.6% (43 users), and 45.80% (22 users) in condition ST. This is generally depicted in Figure 21. There is a noticeable enhancement in the performance of students in condition GBL, but results were bad in condition VC, and even of less value in condition ST. In terms of independent task as shown in Figure 22, in condition VC the mean of 94.81% (46 users) students completed Tasks 1, 2, 3 and 4 and the percentage rate is slightly less in Tasks 5 and 6. Overall, users in all three conditions performed slightly better in the first four questions compared to Tasks 4 and 5. But the performance was slightly lower in condition ST where the mean was 79.17% (38 users) especially in Tasks 4, 5 and 6. The raw data for correct answer can be found in Appendix B-4, 5 and 6.

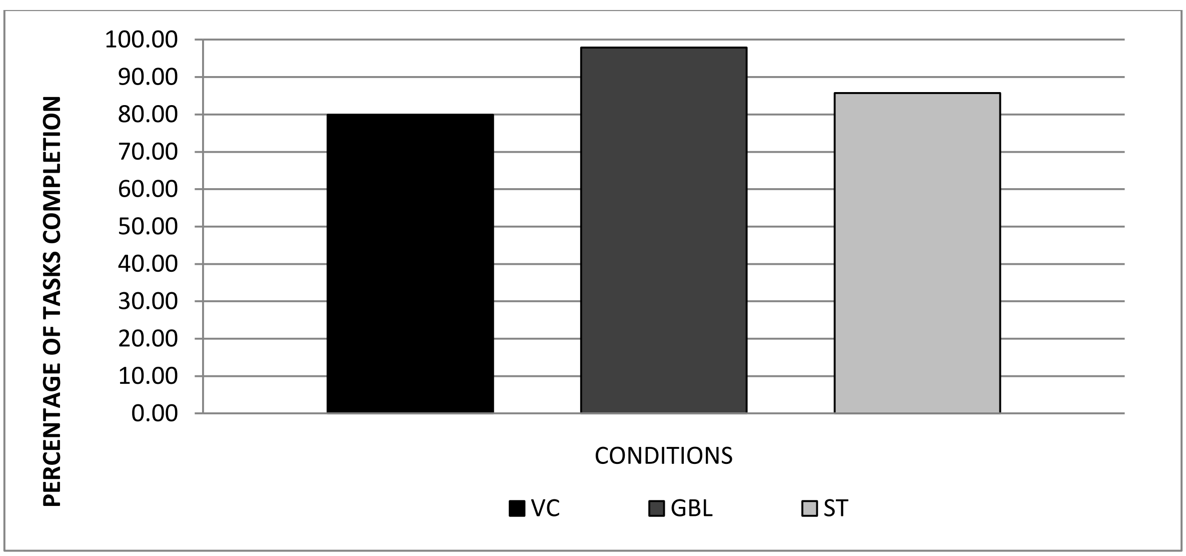


Figure 20 The Percentage of Completion for All Conditions.

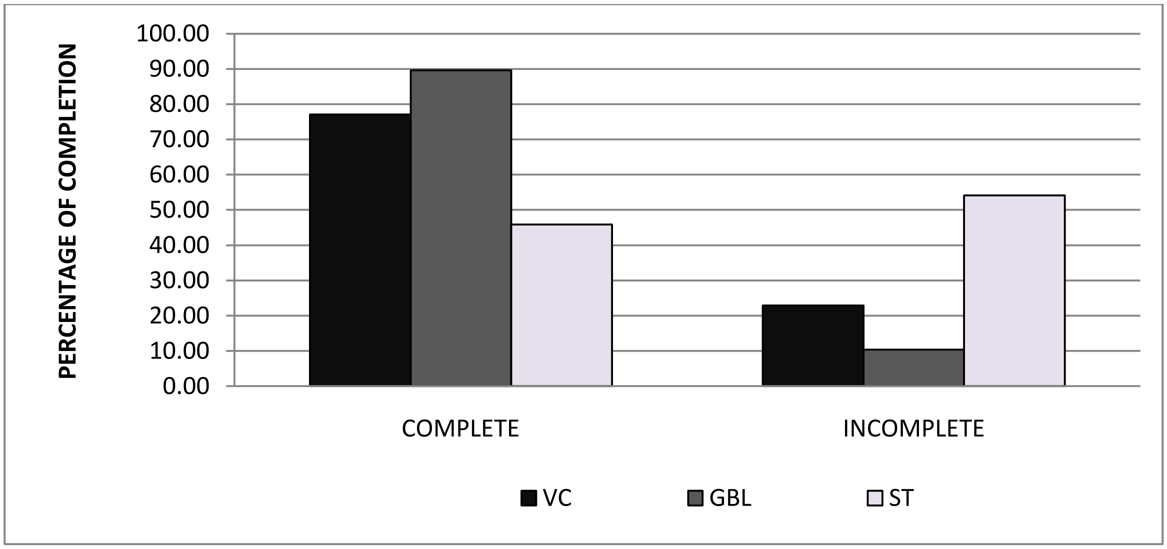


Figure 21 Percentages of Completed and Uncompleted Tasks for All Conditions.

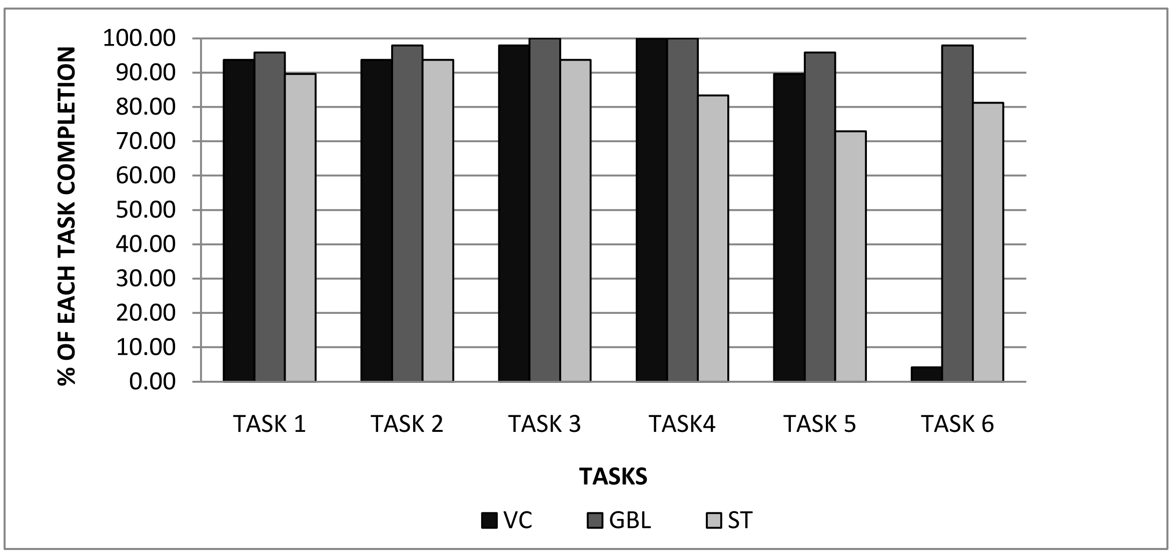


Figure 22 Percentage of Completions for All Conditions for Each Task.

4.6.3 Satisfaction

This measures the user's enjoyment and pleasure and helps with understanding the effect of the multimodal metaphors in improving users' attitudes and feelings after they had experienced the three platforms proposed.

The SUS questionnaire (10 statements) was based on Likert five-point scale [201] and it was used to determine which platform the majority of users enjoyed and were motivated to continue using. In addition to standard statement, the Likert five-point scale is enriched by extra 5 statements that also express the user's opinion scored as normal average for each statement. The five-point Likert scales were structured with 1 representing "strongly disagree" and 5 representing "strongly agree". Moreover the SUS scoring method [201] was adopted to calculate the first ten statements for each user in each interface, whereas occurrence of users' agreement for each statement was accumulated to find out the users level of judgment towards the different edutainment, multimodal aspects and learning experience of the experienced platforms. The results demonstrated that condition VC scored the highest satisfaction rate compared to GBL and ST in terms of the standard satisfaction statements. The mean SUS score calculated for the condition VC was 58.67% compared to 73.08% for GBL and 52.23% for ST. Figure 23 summaries the users' recorded scores for each statement. In addition to standard statement, the additional 5 statements findings was depicted as normal (1-5 scale) mean shown in Figure 24. The results were that in condition VC the mean user score was 3.40 compared to 3.69 for GBL and 3.02 for ST. The overall results showed that users mostly enjoyed the condition GBL more than other conditions in both methods used.

Moreover, the agreement frequency demonstrated by users for each of the SUS statements in each experimental condition has been computed as shown in Figure 25.

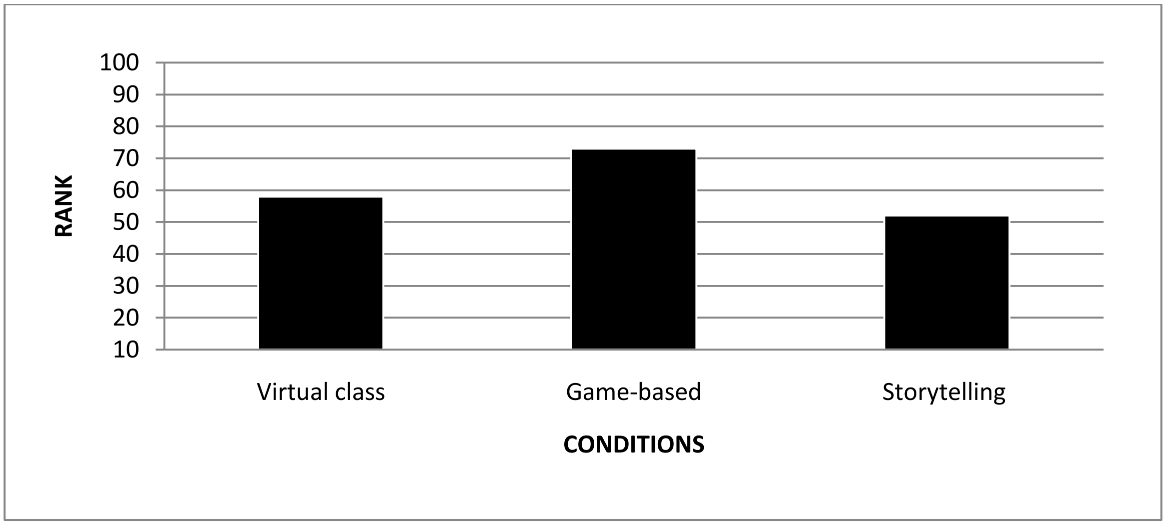


Figure 23 SUS Scale Results.

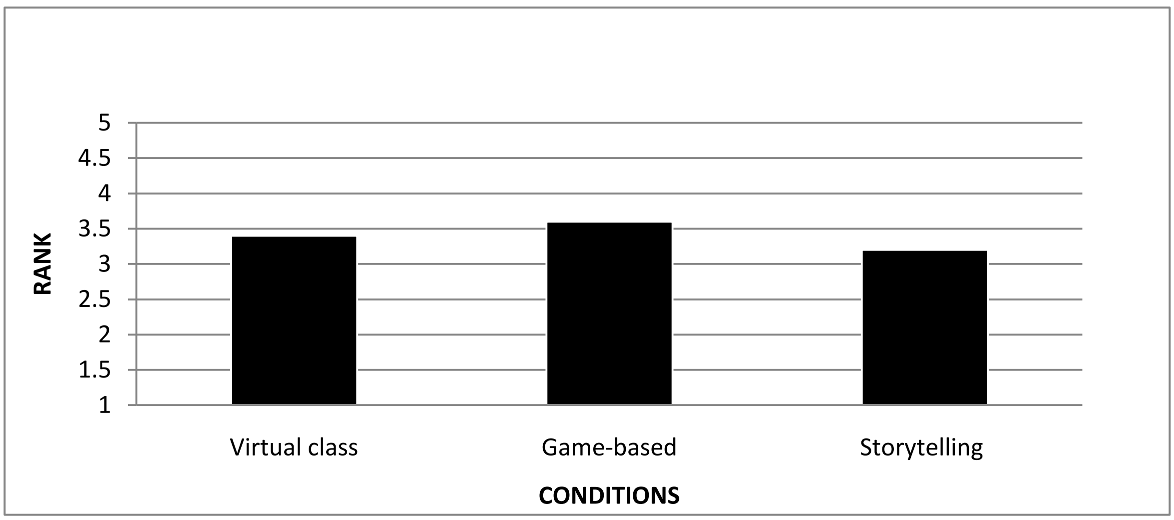


Figure 24 Normal Satisfaction Results.

The figure shows users in the experiment expressed a higher level of agreement in relation to the positive aspects of the tested interface when they interact with the game-based learning interface (GBL). In other words, the users found the GBL *easier to use* (S3), *well integrated* (S5) and *quicker to be learnt* (S7). Also, they *felt confident* (S9) while using it. Therefore, they expressed a stronger interest to use GBL *frequently* (S1). On the contrary, users showed stronger disagreement towards the negative aspects of the GBL platform. More specifically, few users agreed that GBL was *unnecessarily complex* (S2) whereas approximately equal agreement was expressed across the three conditions in terms of the *need for technical support* (S4). Regarding the extent of *inconsistency* in the tested platform (S6) none of the users agreed in condition GBL, 8% disagreed in condition VC whereas 4% disagreed in ST interface. Additionally, 0% of the users agreed that VC and GBL were *cumbersome to use* (S8) compared to 10% for the ST interface. The percentage however was slightly higher for S10; "*I needed to learn a lot of thing before I could get going with the system"*, with 10% for VC and 31% for ST and 0% for GBL. In summary, it can be said that game-based learning (GBL) in e-Learning interfaces is more satisfactory than avatar facial expressions and storytelling technique.

In addition to the SUS statements, S11 to S15 were included to obtain users views about their learning experience and interface components as well as the incorporated multimodal features. These added statements investigated "*how to extend learning material is easy"* (S11), whether "*questions and answers presented during the interfaces helped students to grasp the lesson more easily"* (S12), and (S3) was three different statements presented according to the interface the user experienced. In GBL interface the statement was shaped as follows: "*In my opinion the Game is excellent tool to learn from",* in VC interface it was *"discussion between student and teacher made it easier to me follow and understand the lesson*", and in ST the statement was *"Storytelling interface helped me answering the quiz more easily".*

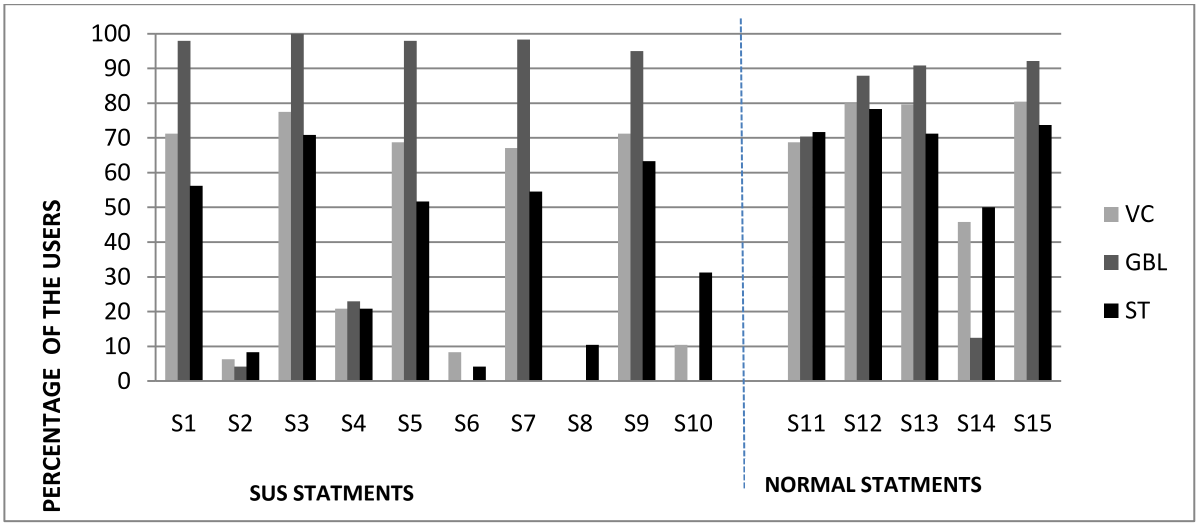


Figure 25 Frequency of User's Agreement for Each SUS Statement in the Experimental Conditions.

Also, statements (S14) asked users to rate the platforms in terms of *"boring experience they acquire and if they felt sleepy"*. The last statement was aimed at evaluating *overall the* user's *satisfaction* (S15). The user's agreement levels for these statements are illustrated in figure 25. It can be seen that when the VC and GBL conditions has been experienced, users showed a stronger agreement with respect to most of the added statements.

In other words, users using the GBL felt more excited and interested about the presented lessons and the way of asking and answering questions simulated in this platform enhanced their understanding further. Furthermore, play let users enjoy more and encouraged them to pay more attention, in addition to the ease in pursuing the presented learning material. Overall, users were more satisfied and gained more enriching learning experience with the implementation of the GBL presentation mode. The raw data of user's responses to the satisfaction questionnaire can be found in Appendix B-7, 8 and 9.

4.6.4 Users Responses

The experiment traced and recorded the user's reaction for each interface via Toshiba laptop built-in webcam with Camtasia software where the users executed the experiment. Movies produced by the software were analyzed and converted in forms of numerical data. The criteria adopted from [216] to measure the user's positive and negative reactions such as smile, laugh, expressing vocally, and other features.

This has been done without informing the user that there is a webcam recording his actions against the practiced interfaces to avoid any confusion that some users might experience when they feels that they are behind the camera. The records are kept confidential after extracting the information required. Figure 26 concludes the users reactions results were the smile feature obtained the highest total number of 374 in condition VC and 194 in condition GBL, whereas only 8 in condition ST. Moreover, the second high feature in the figure was laugh. In condition VC there were 51 laughs, in GBL condition there were 49 laughs, and none at all in condition ST. Hand touching a face is featured foremost in condition ST. The other face features were very rare in condition VC, and appeared at some point in small numbers in conditions GBL and ST. Users responses Raw Data can be found in Appendix B-10, 11 and 12.

4.6.5 Interfaces Preference

It is a good idea to support and enrich the results documented by adding up single statement in the end of the questionnaire to let users choose the best interface that they experienced.

Figure 27 displays the user's preference to each condition, were condition GBL was the platform most chosen, followed by condition VC and condition ST was lowest in the graph. The raw data for interface preference can be found in Appendix B-13.

4.6.6 Interfaces Preference Order

Users were required to order the interface according to their preference, that is to place number 1 or 2 or 3 in the box provided in the questionnaire where number 1 represents the best interface experienced by the user, and numbers 2 and 3 respectively represent the second and third best interfaces experienced. The results showed that the GBL interface gained the highest mean 58.33% (28 users) of user's choice, whereas 25% (12 users) of users chose condition VC and 16.67% preferred condition ST. These results are shown in Figure 27. The raw data for interface preference order can be found in Appendix B-14.

4.6.7 Users' Comments and Suggestions

Users' comments and suggestions all concerned the lessons presented. Given the majority of students participating had limited knowledge about the Geology topic; users suggested if that attending the presentations for the learning material more than once could provide more flexibility. Allowing users to repeat the lessons many times was ignored in the design of the experimental interfaces as that would invalidate the results.

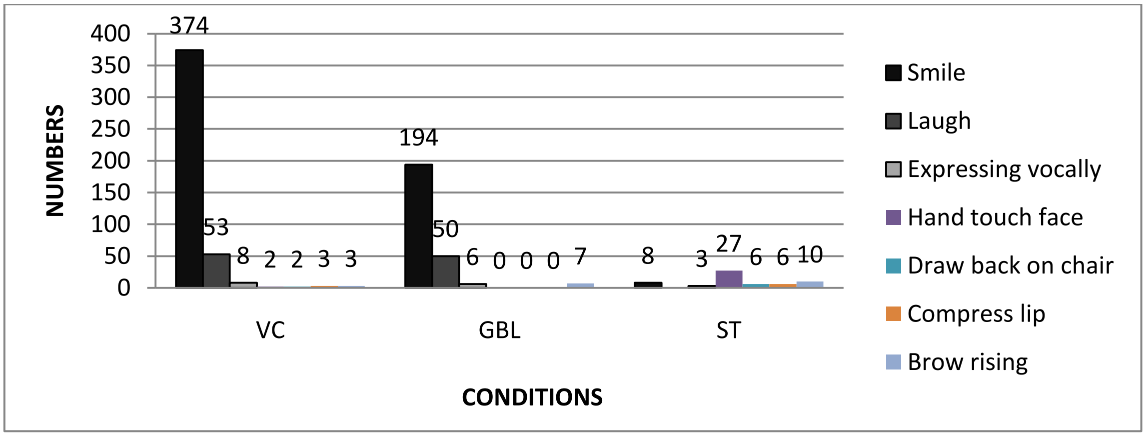


Figure 26   Number of Users' Reactions.

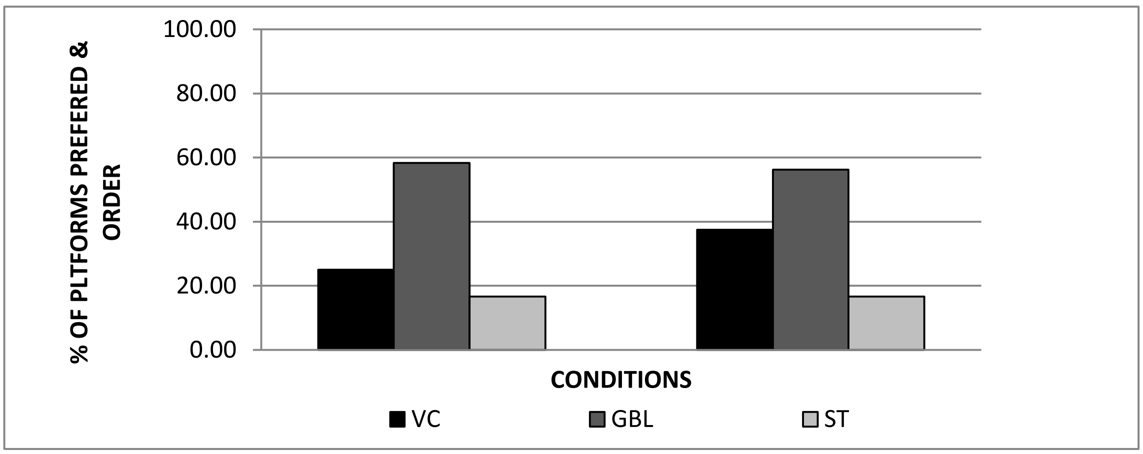


Figure 27 Users Interface Preference.

4.6.8 ANOVA Test

Based on the type of data and independent and dependent variables applied in this experiment, the proper test found and suggested by [215] is One-way repeated measures ANOVA designed to compare how *a within-subjects* experimental group performs in three or more experimental conditions. The ANOVA compares whether the mean of any of the individual experimental conditions differs significantly from the total mean across the experimental conditions.

4.6.8.1 Normality Test

Statistical methods are based on various underlying assumptions. One common assumption is that a random variable is normally distributed. In many statistical analyses, normality is often conveniently assumed without any empirical evidence or test. But normality is critical in many statistical methods. When this assumption is violated, interpretation and inference may not be reliable or valid. Therefore before going with ANOVA test, normality test has been done using SPSS software to analyse the time and correctness data in this experiment, and the Table 12 below concludes the test results. In Kolmogorov-Smirnova distribution the VC was, $D(288) = 0.10$, $P < .05$, appears to be non-normal, were in the GBL, $D(288) = >.04$, $P<.05$, appeared normal distributed, and in storytelling $D(288) = .09$, $P<.05$, came out non-normal. The other column in the table results Shapiro-Wilk test and showed that all conditions were significantly non-normal, $D(288) = 0.0$, $p<.05$. Based on the fact that the Shapiro-Wilk test yields more accurate statistics than the Kolmogorov-Smirnova test, the final conclusion stated here is that all three variables are significantly non-normally distributed and non parametric test (Friedman test) should be conducted to compare and find out the differences in conditions.

Furthermore the normality test has been conducted on the number of incorrect answers data as summarized in Table 13 below. The Kolmogorov-Smirnova distribution showed that the V.Class was, $D(288) = 0.36$, $P< .05$, appeared to be non-normal, were in the Game, D

(288) = >.48, P<.05, appeared also non-normal distributed, and in storytelling D (288) = .35, P<.05, came out non-normal. The other column in the table results Shapiro-Wilk test showed that all conditions significantly were non-normal D (288) = 0.0, p<.05. Therefore all three variables are significantly non-normally distributed and non parametric test (Friedman test) should be conducted to compare and find out the differences in the conditions as well.

4.6.8.2 Friedman's ANOVA Test

Friedman's ANOVA test is used for testing differences between conditions when there are more than two conditions and the same users have been used in all conditions, which is the similar with this experiment situation. Also the Friedman test is based on the fact that the samples should be randomly taken and independently of each other. Therefore this test has been conducted to the time for the three conditions using the SPSS statistics software and the output of the result is shown in the Table 14.

Test Result:

The null hypotheses stated as follow:

H_0 = there is no difference between the means of time of the three conditions.

$\mu_1 = \mu_2 = \mu_3$

H_1 = there is a difference between the means of time of the three conditions.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
V.Class	.104	288	.000	.954	288	.000
Game	.048	288	.200*	.979	288	.000
Storytelling	.094	288	.000	.948	288	.000

a. Lilliefors Significance Correction

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

Table 12 Test of Normality for Time.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
V.class	.364	288	.000	.711	288	.000
Game	.482	288	.000	.499	288	.000
Storytelling	.350	288	.000	.724	288	.000

Lilliefors Significance Correction

Table 13 Test of Normality for Correct Answer.

Since p-value = 0.00 ≤ 0.01 = α, the null hypothesis rejected, and we can say that at the α = 0.01 level of significance, there exists enough evidence to conclude that there is a difference in the true mean time recorded in the rate of the three experimental conditions and the treatment conditions used were effective.

In addition, Friedman's ANOVA test has been conducted to the number of incorrect answers for the three conditions using the SPSS statistics software and the output of the result is shown in the Table 15.

Ranks

	Mean Rank
V.Class	1.66
Game	2.46
Storytelling	1.88

Test Statistics[a]

N	288.000
Chi-Square	98.590
Df	2.000
Asymp. Sig.	.000
Exact Sig.	.000
Point Probability	.000

a. Friedman Test

Table 14 Friedman's ANOVA Test Results for Time.

Test Result:

The null hypotheses stated as follow:

H0 = there are no differences between the means of the incorrect answers in the three conditions.

$\mu 1 = \mu 2 = \mu 3$

H1 = there are differences between the means of the incorrect answers in three conditions.

Ranks

	Mean Rank
V.class	2.09
Storytelling	2.14
Game	1.77

Test Statistics[a]

N	288.000
Chi-Square	43.022
Df	2.000
Asymp. Sig.	.000
Exact Sig.	.000
Point Probability	.000

a. Friedman Test

Table 15 Friedman's ANOVA Test Results for Incorrect Answers.

Since p-value = 0.00 ≤ 0.01 = α, the null hypothesis rejected, and we can say that at the α = 0.01 level of significance, there exists enough evidence to conclude that there is a difference in the true mean incorrect answers recorded in rate for the three experimental conditions and the treatment conditions used were effective.

4.6.8.3 Post Hoc Tests for Friedman's ANOVA

4.6.8.3.1 Wilcoxon Signed-Rank Test

To see if there is significant difference in learning time using different training methods, Friedman's ANOVA employed compared whether the mean of any of the individual experimental conditions differs significantly from the aggregate mean across the experimental conditions, but this test did not give an indication of which condition is significantly the best. In other words, the target of the study is to know the condition in which the user performs significantly better in comparison with others. Wilcoxon signed-rank test is based on the differences between scores in the two conditions to be compared. Once these differences have been calculated they are ranked, but the sign of the difference (positive or negative) is assigned to the rank. Therefore in this experiment each two conditions have been tested separately, since three conditions are examined here, so the comparison distribution was as follow:

- Condition VC with condition GBL
- Condition GBL with condition ST
- Condition VC with condition ST

The output from the test is shown in Table 16. The first table tells us about the positive and negative ranks. Whereas the positive rank indicates the time spent by users is more compared to the other condition, the negative rank shows the opposite. The first outcome between game and virtual class were 219 out of 288 positive or users spend more time in game than in the virtual class, whereas in storytelling – game comparison, 86 of the 288 users , their score was greater in storytelling than in the game. In the storytelling with virtual class correlation, 166 of the 288 users make use of grater time in storytelling than in the virtual class. There also zero (0) ties ranks in the table which means there are no two users having the same score. The table concludes also the mean number of negative and positive ranks and their sum too. Below the table is footnoting that shows the comparison results represented arithmetically.

The Table 17 below determines the test statistics, Z score are calculated from the T score that was the lowest value of sum of negative and positive scores. The value of Z was respectively -9.9 and this value is significant at p= 0.0, therefore, because this value is based on the negative rank, it is safe to say that the time spent per user is increased in the direction of game than in the virtual class ($Z= -9.91$, $p<.05$). The value of Z in storytelling with game comparison was -7.93 and this value is significant at p=0.0. Therefore, because this value is based on the positive rank, the time used up was significantly lower in the storytelling than in the game ($Z= -7.93$, $p<.05$). With the same procedure in the case of storytelling with virtual class comparison, were based on negative ranks, the time consumed per users is significantly increased in storytelling than in the virtual class ($Z= -3.21$, $p<.05$).

The Table 18 below contains results of the test statistics of incorrect answers. The value of Z was -5.97 and this value is significant at p= 0.0, therefore, because this value is based on the positive rank, so the incorrectness decreased in the game than in the virtual class (Z= -5.97, p<.05). In the case of storytelling with virtual class comparison, Z was -.783 and this value is significant at p= .433, and because this score was based on negative ranks, the users made more incorrect answers in storytelling than in the virtual class (Z= -.783, p<.05).

The value of Z in storytelling with game comparison was -6.290 and this value is significant at p=0.0. Because this value is based on the positive rank, therefore, the incorrectness was significantly lower in the game than in the storytelling (Z= -6.290, p<.05).

4.7 Discussion

The focus of this chapter is to investigate user-involvement, while experiencing the edutainment features, in multimodal e-Learning systems. This applied to all three quantitative aspects, but, in particular, to the time, accuracy, and satisfaction scores, bearing in mind that the experimental circumstances were controlled, in order to guarantee validity, either by means of the rotation method used in the study, or by utilising the lesson-distribution mechanism provided. The experimental dependent- variable measurements were suitably managed, in order to acquire accurate results.

Ranks

		N	Mean Rank	Sum of Ranks
Game - V.Class	Negative Ranks	69[a]	98.22	6777.50
	Positive Ranks	219[b]	159.08	34838.50
	Ties	0[c]		
	Total	288		
Storytelling - Game	Negative Ranks	202[d]	158.60	32038.00
	Positive Ranks	86[e]	111.37	9578.00
	Ties	0[f]		
	Total	288		
Storytelling - V.Class	Negative Ranks	122[g]	133.30	16263.00
	Positive Ranks	166[h]	152.73	25353.00
	Ties	0[i]		
	Total	288		

a. Game < V.Class b. Game > V.Class c. Game = V.Class d. Storytelling < Game e. Storytelling > Game f. Storytelling = Game g. Storytelling < V.Class h. Storytelling > V.Class i. Storytelling = V.Class

Table 16 Wilcoxon Signed-Rank Test Results for Time.

Test Statistics[c]

	Game - V.Class	Storytelling - Game	Storytelling - V.Class
Z	-9.918[a]	-7.939[b]	-3.213[a]
Asymp. Sig. (2-tailed)	.000	.000	.001

a. Based on negative ranks. b. Based on positive ranks. c. Wilcoxon Signed Ranks Test

Table 17 Wilcoxon Signed-Rank Test Results Time.

Test Statistics[c]

	Game - V.class	Storytelling - V.class	Storytelling - Game
Z	-5.977[a]	-.783[b]	-6.290[b]
Asymp. Sig. (2-tailed)	.000	.433	.000

a. Based on positive ranks. b. Based on negative ranks. c. Wilcoxon Signed Ranks Test

Table 18 Wilcoxon Signed-Rank Test Results for Incorrect Answers.

These measurements were achieved by incorporating a fitted integral time-design into all systems; also, a webcam camera was used to facilitate the accurate recording of users' responses, by capturing their every expression and spontaneous reaction, in real time.

The outcome reported was positive. Furthermore, the overall test results highlighted several significant areas and implications for future studies, with the data analysis results affording further opportunities for in depth research.

The differences between the mean times for the three conditions were noticeable. In condition VC, the mean time was 14.51 seconds; in condition GBL, it was 24.67 seconds; and in condition ST, 16.99 seconds (refer to Figure 16). It is noteworthy that the time spent on condition GBL was longer than on the other conditions, with condition GBL tasks taking longer still, compared to the other two conditions; a result supporting the first hypothesis, H1. A possible explanation for the differences in mean times is that the game in question was designed to be more time-consuming, because of the incorporation of several multimedia elements that made the game interactive. Proof that the game was more successful than the other conditions is evidenced by the fact that the users made fewer mistakes, while using the game platform; they also appeared to enjoy playing the game; in other words, user-performance was positive, in the game condition, regardless of the time spent on the tasks.

As stated in H2, there are significant differences, in terms of accuracy, when comparing the proposed platforms. Where users performed much better, in condition GBL, the overall result was 78.82%, whereas in condition VC, it was 53.82%; scores were lower still, in condition ST, at 44.10% (refer to Figures 17, 18 and 19). Accordingly, the results advocated H2. These results indicate that users performed better, in condition GBL, followed by condition VC and, finally, by condition ST. In addition, it is clearly evident that the percentage of correct answers decreased, gradually, from condition GBL to VC and, finally, to ST. Although the majority of users had limited previous knowledge of Geology, the results were reasonably predictable, bearing in mind the effect of earcons on condition GBL, which may explain this success. However, the results gave additional evidence of the effect of multimodal metaphors, represented by non-speech sound (earcons), on the GBL interface, in further enhancing the usability and user-learning experience.

User percentage rates, in terms of task achievement and progress were elevated, with mean user completions for conditions GBL showing the highest percentage (97.9%), compared with conditions VC (79.86%), and condition ST (85.76%), respectively. The percentage rates for users completing their tasks, without making any mistakes, were as follows: condition GBL, 89.6%; VC, 77.08%; and condition ST, 45.80% (refer to Figures 20, 21 and 22). In general, an overall improvement was noticeable in the performance of students/users, in condition GBL; however, the results, in condition VC, although showing a degree of improvement, were not as significant as in GBL, whereas, in condition ST, the results were less valuable. This also emphasises the power of the game as an edutainment tool for conveying learning materials and enhancing the interaction between students and e-Learning systems; a finding borne out by previous research [217].

A comparison of SUS scores between all three interface systems found that subjects rated condition GBL higher than the other conditions, thus, adding strength to Hypotheses H3. The mean SUS score calculated for the condition VC was 58.67%, compared to 73.08% for GBL, and 52.23% for ST. However, as mentioned, previously, the additional statements provided were higher, at around 3.40 for condition VC, compared to 3.69 for GBL and 3.02 for ST, (refer to Figures 23 and 24). Overall, user satisfaction levels were a little higher for the GBL interface than for the VC condition; although, it would appear that storytelling did not prove as engaging, from a user perspective. Again, the games provided greater user satisfaction and also encouraged the participants to persevere with the game/task in hand; this, in turn, enabled the users to acquire the information, unconsciously, where they actually enjoyed playing the game, despite the time spent on it and complexity of the topic. Hypotheses H3, therefore, supports the results, above.

In addition to the evidence that GBL was the users' platform of preference, a number of serial tests (ANOVA) were also conducted using the data, in order to establish the differences between the experimental platforms, in terms of time taken and levels of accuracy achieved. Interestingly, these tests resulted in significant variance, as anticipated, and the null hypotheses were rejected. A Wilcoxon test result also differentiated between the platforms and, as stated above, error rates were significantly lower in the game experiment than they were under the storytelling and virtual class conditions.

Further analysis of the users' responses enabled the author to identify, specifically, those features which the users enjoyed most. In general, users smiled more, in condition VC, where the avatar was the mean modality used, with lower scores achieved, in the other conditions, particularly in condition ST, where the users exhibited a sense of boredom, demonstrated by the slightly increased number of times that the participants' hands touched their faces. The observations for condition GBL, on the other hand, were more natural, because the users' brains were pre-occupied with what they were doing and they were more oblivious to the outside world. Therefore, users in this situation rarely smiled or laughed, although their scores were not insignificant.

In terms of user preference, condition GBL was the main platform of preference, followed by condition VC, with condition ST being the least favoured. Also, a user order of preference for the various interfaces further supported the GBL interface, which achieved the highest mean user option, at 58.33%; 25% of users chose condition VC; and 16.67 % preferred condition ST.

The data analysis proved, unequivocally, that condition GBL (the game interface) was, ultimately, the superior platform, compared to the virtual class VC and storytelling ST interfaces. Nevertheless, the virtual class condition was the second most popular option, albeit that the users preferred a more "hands-on" approach, rather than listening, passively, to the lessons. This further endorses the power of the game in conveying learning materials, as established by previous research [161, 218].

4.8 Summary

This chapter documented the experimental work conducted to investigate user-involvement empirically, while experiencing the edutainment features in multimodal e-Learning systems, through three quantitative aspects, in particular: time spent by users; accuracy; and user satisfaction levels. The circumstances for the experiment were controlled, in order to guarantee validity, either by means of the rotation method used in the study, or by utilising the lesson-distribution mechanism provided. The experimental dependent-variable measurements were suitably managed, in order to acquire accurate results. These measurements were achieved by incorporating an integral fitted time-design into all systems; also, a webcam was employed to facilitate the accurate recording of users' responses, by capturing their every expression and spontaneous reaction, in real time.

The outcome reported was positive. Furthermore, the overall test results highlighted several significant areas and implications for future research. Moreover, the results established, conclusively, that the game-based learning interface outperformed all other interfaces examined in the experiment. In other words, the experiment provided empirical evidence that using multimodal features, as well as a game combined with the learning material, all integrated within the same interface constituent, proved more efficient, more effective and more satisfactory, as opposed to the two other e-Learning interfaces investigated. The use of a game as an educational channel proved a valuable tool for reducing error rates among the subjects sampled. Apart from teaching people raw facts, the game also offered a more pleasurable and enjoyable learning experience, overall; this, in turn, helped the users achieve their educational goals. Moreover, game-based learning can be tailored to realistically represent a complex environment, system, or process that is intrinsically relevant to the learner, simply because it is what they recognise as being relevant to their vocation or, indeed, their career aspirations. This might be achieved by allowing the users to explore a physical environment, or by allowing them to solve a problem from which they will, subsequently, derive satisfaction.

Chapter 5

Multimodal Game-Based Learning

5.1 Introduction

The experiment, detailed in the previous experimental phase (Chapter 4), resulted in a significant outcome, supporting the use of multimodal metaphors, when merged with a gaming medium. Interface (GBL) which integrated multimodal metaphors with an integral game outperformed the other platforms trialled in the experiment. Furthermore, the gaming environment proved a valuable e-Learning tool, resulting in reduced error rates, in the subject sample. However, the experiment did not determine the specific modality that was responsible for enhancing the platform, apart from defining the role of the game, itself. Although the Virtual Class interface (VC), which was the second preferred interface, represented the learning environment (teacher/student), the virtual avatars combined with the entertainment elements had a noticeable effect on the participants' performance. The majority of the users selected the gaming environment as the interface of preference, because the participants preferred a "hands-on" approach, rather than viewing the learning contents, passively. Therefore, in this chapter, in addition to entertaining the users through a gaming medium, a further target is to determine the multimodal attribute or set of attributes of preference that learners considered essential for creating the most conducive e-

Learning environment, e.g. visual-only metaphors (text and graphics), audio-visual metaphors (speaking avatar with full-body gestures), or auditory attributes (earcons and auditory icons).

This chapter introduces an empirical multi-platform study that compares the efficiency, effectiveness, user satisfaction, memorability and learn-ability, within a multimodal gaming medium. The experiments involved four interfaces designed to explore, in greater depth, the influence of multimodal metaphors, in addition to edutainment, in contributing to enhancing the learning process and the usability of e-Learning interfaces. The additional experiments were designed, specifically, to determine which multimodal attribute (or combination of attributes) was essential to the success of the chosen interface. The results are compared, contrasted and discussed, in order to reach conclusions and to produce empirically derived guidelines for the potential role of edutainment, in future multimodal e-Learning interfaces. The following sections introduce the aims and objectives of this experimental phase, the hypotheses and outcomes, as well as providing an outline plan for the experiments undertaken, and presenting an illustrative and descriptive analysis of the data collected; the results are discussed, in the context of the hypotheses.

5.2 Aims

This experiment was aimed:

1. at examining usability attributes in terms of efficiency, effectiveness, and user satisfaction of e-Learning interfaces that incorporate the use of edutainment elements along with combinations of multimodal metaphors in the presentation of the learning material.
2. to explore the effect of combination of set of multimodal features for each platform within the four gaming environments tested.
3. to judge the memorability of these set of multimodal combinations in terms of the user's remembrance of its meaning and use. The goal of gauging user satisfaction and enjoyment, which is part of the goals of this experiment, will be achieved by measuring the facial responses observed in relation to the e-Learning interfaces employed.
4. to estimate the quality of user's response and performance in relation to the required experimental learning tasks.
5. to inspect interface user's preference and selection studied in this experiment, in order to determine the most enjoyable and beneficial combinations of the modalities attached within each interface.

5.3 Objectives

In order to meet the aims of the experiment, a number of objectives should be fulfilled. The first objective is implementing four games as experimental e-Learning platforms that applied different combination sets of multimodal features, i.e. each game being implemented with a multimodal feature that is not used in the other games. These are as follows: a game with Text and Speech only (TS); a game with Text and Earcons only (TE); a game with Text, Speech and Earcons (TSE); and a game with Text, Speech, Earcons and Avatar (TSEA). The second objective is empirical evaluation of the four platforms dependently by means of one group of users. The third objective is measuring the effectiveness by calculating the percentage of correct answers, as well as the number of questions completed successfully by users, in order to measure the users' learning performance. The fourth objective is measuring the memorability of tested environments by the users' ability to remember its meaning and use. The fifth objective is measuring the satisfaction of users by their responses to questionnaires that have been individualised to assess the users' attitudes in relation to the applied e-Learning platform. And the final objective, evaluating the four different edutainment interfaces to find out which interface is more attractive throughout the student's response to each interface.

5.4 Hypotheses

In chapter 4 the only obvious attribute that proved to be valuable is the gaming environment, but the question is which multimodal attribute was responsible for enhancing the usability level and the users' learning achievements in the e-Learning platforms? That is what this experiment seeks to establish; therefore the following 13 hypotheses were derived:

Hypothesis 1: Efficiency of TS, TE, TSE and TSEA will be different in terms of time taken to complete the same tasks by users.

Hypothesis 2: Efficiency of TS, TE, TSE and TSEA will be different in terms of incorrect answers given by users.

Hypothesis 3: TSEA will be more efficient than TS, TE, and TSE in terms of shortening task accomplishment time.

Hypothesis 4: TSE will be more efficient than TS and TE in terms of shortening task accomplishment time.

Hypothesis 5: TE will be more efficient than TS in terms of shortening task accomplishment time.

Hypothesis 6: TSEA will be more efficient than TS, TE, and TSE in terms of reducing incorrect answers.

Hypothesis 7: TSE will be more efficient than TS and TE in terms of reducing incorrect answers.

Hypothesis 8: TE will be more efficient than TS in terms of reducing frequency of incorrect answers.

Hypothesis 9: Effectiveness of TS, TE, TSE and TSEA will be different in terms of number of tasks completed successfully.

Hypothesis 10: TSEA will be more effective than TS, TE, and TSE in terms of percentage of tasks completed successfully.

Hypothesis 11: TSE will be more effective than TS and TE, in terms of percentage of tasks completed successfully.

Hypothesis 12: TE will be more effective than TS in terms of percentage of tasks completed successfully.

Hypothesis 13: TS, TE, TSE and TSEA will be different in terms of user's satisfactions scored.

Hypothesis 14: TSEA will be more satisfied than TS, TE, and TSE.

Hypothesis 15: TSE will be more satisfied than TS, TE.

Hypothesis 16: TE will be more satisfied than TS.

5.5 Design of the Games

As stated earlier, this chapter aimed to investigate the role of game within a multimodal context in improving user's attention and interest as well as usability of e-Learning systems. Previous experimental studies showed the potential of multimodal metaphors in improving the usability of interfaces and users' performance [5, 6, 79, 80, 82, 125]. Practically integrated earcons has been proven by many researches to be useful in improving the usability of systems [219]. Also, auditory icons as environmental sounds were successfully used to communicate information in user interfaces [94]. In addition, using avatars in e-Learning with consideration to associated cognitive factors helped in making the learning process more fun to users; increased their interest, motivation, and retention of concepts; and at the same time improved higher order thinking and reasoning skills [2]. An avatar facial expression provides a more realistic interaction in human computer interfaces. An avatar can express emotions, feelings, and linguistic information that could be mimicking human face expressions. This study evaluated four multimodal interfaces constructed to be edutainment platforms; each of which is integrated with a combination of different multimodal features including text, earcons, speech, and avatar, to enrich the gaming environment with entertainment elements which are necessary to make users satisfied with the level of interaction. These four games based-learning interfaces were designed and built each with disparate multimodal attributes, the first game introduced with text and speech only (TS) second was with text and earcons only (TE), and third game integrated with text, speech and earcons (TSE) and finally fourth game was with text, speech, earcons and avatar (TSEA). The distribution of the four platforms multimodal features are illustrated in Table 19. The next section will describe in details the multimodal metaphors incorporated in each game.

5.5.1 Learning Topic

In this experiment as well as in previous experiment (refer to section 4.5.1) Geology remains the learning materials have been represented the e-Learning contents. Therefore, in order to guarantee that all experimental platforms had been regularly used for each lesson; four Geology lessons circulated on a systematic random rotation basis between the four platforms, please see Table 20 and 21. These lessons were, lesson one; *what is volcano*, lesson two; *earthquakes facts*, lessons three was *types of rocks,* and lesson 4; *how oil is formed* (refer to Table 20). Each lesson kept the same amount of information; this was done by counting the number of words per lesson to ensure that the four lessons are equal statistically and to minimise difficulty of tasks. Moreover the geology lessons used up here are completely different from the lessons that were tested in the second experiment. The complete lessons can be found in Appendix C-2.

5.5.2 First Game Interface: A Game with Text and Speech Only (TS)

In this experimental design the user has to read and listen to specific lesson and must go into tasks (questions) which are designed in a game form. The mechanism of this game starts when the users click specific button to start the game, the first question appears as both speech and text in the middle of the circle shape in the centre of the screen. As the user reads and listens to the question, without further ado the first answer is supplied as speech and text in another circle on the top of the screen for about 3-4 seconds. The first answer (circle) disappears, as soon as the second answer becomes is supplied as speech and text in another circle, and so on with the remaining six answers. The correct answers are distributed randomly within random circles in each task. By fast click on the chosen answer by the user, the system generates immediate feedback notifying if this was the right or incorrect answer.

Conditions	Features								
	Sound	Text	Graphics	Avatar	Earcons	Facial expression	Jokes	Normal Feedback	Amusing feedback
TS	√	√	√					√	
TE	√	√	√		√			√	
TSE	√	√	√					√	
TSEA				√		√	√	√	√

Table 19 The Distribution of Platforms Multimodal Features.

Learning materials	Interfaces (conditions)	Number of Words
L1 = Lesson 1 (What is a volcano)	Text + Speech. Text + Earcons. Text + Speech + Earcons. Text + Speech + Earcons+ Avatars.	494
L2 = Lesson 2 (Earthquake Facts)	Text + Speech. Text + Earcons. Text + Speech + Earcons. Text + Speech + Earcons+ Avatars.	500
L3 = Lesson 3 (Types of Rocks)	Text + Speech. Text + Earcons. Text + Speech + Earcons. Text + Speech + Earcons+ Avatars.	513
L4 = Lesson 4 (How Oil Is Formed)	Text + Speech. Text + Earcons. Text + Speech + Earcons. Text + Speech + Earcons+ Avatars.	498

Table 20 Lessons and Interfaces Rotation.

Platforms (Games)	Multimodal features	Lessons	Users
Platform 1	Text + Speech	L1,L2,L3,L4	10
Platform 2	Text + Earcons	L1,L2,L3,L4	10
Platform 3	Text + Speech + Earcons	L1,L2,L3,L4	10
Platform 4	Text + Speech + Earcons + Avatar	L1,L2,L3,L4	10

Table 21 Experimental Platforms.

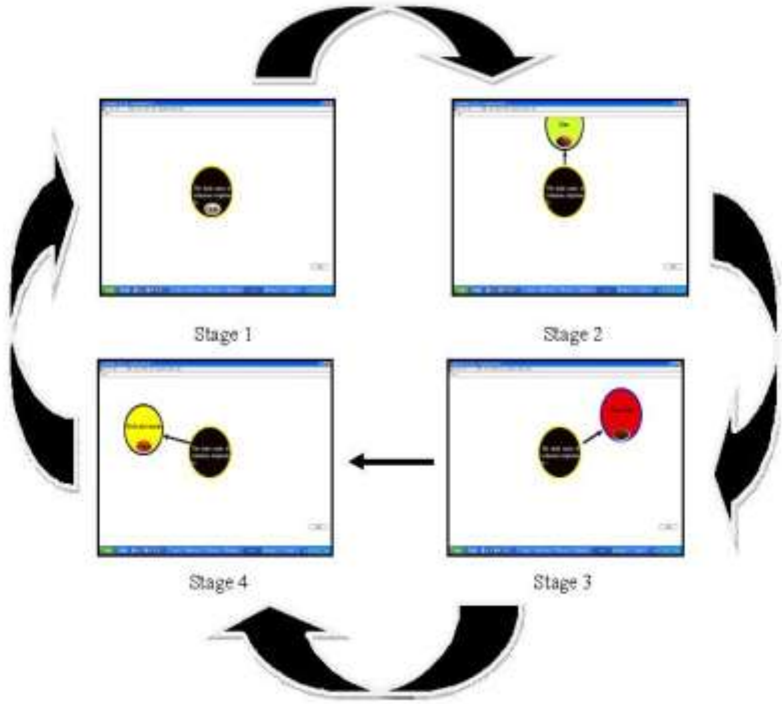


Figure 28 Example Snapshot of the Game with Text and Earcon Modalities.

The system automatically proceeds to the next question, if the user answer was right and all the circles disappears, and if the user answer was incorrect, the game continues until the maximum time elapses, prompting user to go to next question and the game starts over with the second task. This game can be seen as a wall clock, as the answers rotate in clockwise direction. Example snapshot of proposed game showed in Figure 28.

5.5.3 Second Game Interface: A Game with Text and Earcons Only (TE)

In this interface the same design described in the first interface is repeated, but here speech was replaced with earcons as seen in Figure 28, and also the way the game starts here differs from the previous game. In this game the user must click on the middle of the circle to see the questions and click on the tone button to hear the tone and start the game in the same time, bearing in mind that the question tone will be heard only once by user. The tone used in these earcons was generated by *visual music* [220], and separated to two halves, the first half allocated to question and the other half assigned to the answer. In this design the user has two ways to answer, by reading the text only, or by using or clicking on the tone button grouped with each circle or answer. The remaining procedures and time restrictions in this game are the same as those used in the first game.

5.5.4 Third Game Interface: A Game with Text, Speech and Earcons (TSE)

This game has a similar interface as that of the second game, but with speech included. In this game the user must click on the middle of the circle to see and listen to the question, and click on the tone button to hear the tone and start the game at the same time, bearing in mind again that the question tone will be heard only once by user.

Two ways are available to the user to accomplish the tasks provided, first by reading the text and listing or by using or clicking on the tone button grouped with each circle or answer. The other features were exactly the same as in the first game design detailed earlier; please refer to Figure 28.

5.5.5 Fourth Game Interface: A Game with Text, Speech, Earcons and Avatars (TSEA)

Fourth interface or game is a third interface enriched with an avatar. The avatar (with sound and human-like expressions), combined with the other modalities, such as text, speech, earcons which are used in this platform to introduce the edutainment aspects displayed simultaneously on the screen.

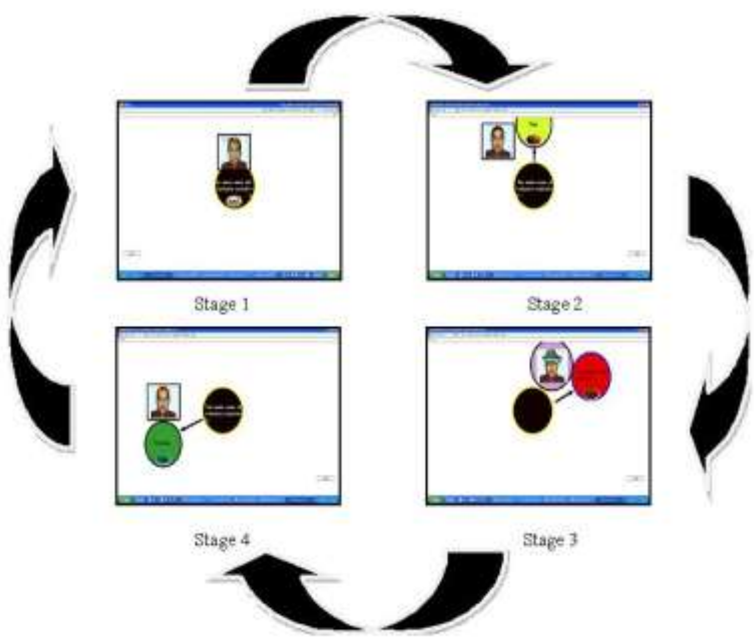


Figure 29 Example Snapshot of the Game with Text, Earcons and Avatars Modalities.

Besides, reading to the user the questions and answers, avatars are designed and targeted to entertain the learner with amusing messages, some amusing expressions and gesture. These avatars were integrated with Crazy Talk V5.1 software [212] with the author's speech, and other friend's photographs; this is shown in Figure 29.

5.6 Execution of Avatars and Earcons and Natural Speech

All the software used in previous chapters has again been utilised in this experiment. These were *Mimic* [195], *Poser* [196], *Camtasia Studio* [221], *Authorware* [197], musical software's such as *Audacity sound editor* and *Visual Music* [193, 220] and *CrazyTalk* [212] (see Section 4.8). These revolutionary technologies proved their strengths in affecting how people can teach and learn. It promoted the use of constructivist approaches in teaching and learning advocated by the current reform movement. These different types of software especially *Authorware* [209] which is designed to be pure educational software used to address different educational goals, in drill-and-practice and creating tutorial that can be effective in helping students develop specific skills. In summary interactive, exploratory, and software tool can support teachers as well as student as they implement reform oriented constructivist practices [3].

5.7 Experimental Design, Variables and Procedure

To verify proposed hypothesis, four games based-learning interfaces designed and were built, first game integrated with text and speech only, second game was with text and earcons only, and third game integrated with text, speech and earcons, fourth and last game, with text, speech, earcons and avatar. The users must use these four games (*dependent* *group* or *within-subject* procedure) and they have to decide which interface is superlative and enjoyable throughout, expressing their feedback in organised questionnaire.

The controlled, the dependent and the independent variables of this experimental study were identified and they were similar to those considered earlier in chapter 4 (refer to section 4.5.6). The Table 22 concludes these variables.

5.8 Experiment Tasks

A number of tasks were designed to test the components of the platforms. These were segmented according to the multimodal features and functions of each game. One group of users took part in the experiment; each user in the group had to answer 4 questions related to the presented learning content in order to measure the effectiveness of each interface as well as the learning gained by users from the presented material. These questions were the same for all four platforms in terms of number of questions, question-types, and difficulty level.

The question-type can be considered as a recognition structure, since the users has many choices to select from to answer a specific question. Nevertheless the system provides the user with 3 tries for each task, and also time is restricted to 60 seconds to complete each task. When he/she completes their attempts or time allocated for specific tasks elapses, the system automatically takes them to the next question. Tables 23 and 24 represented tasks instructors that the users had to follow to accomplish the required tasks.

5.9 Evaluation of the Experimental Platforms Prior the Real Experiment Study

In order to improve the later quality and efficiency of proposed platforms, a small experiment designed with 6 users to test, in order to gather information prior to main study. Bearing in mind training video files to explain how to use each of the proposed environments has been introduced to users before practicing in the experiment. It is expected that the pilot study might provide vital information on the severity of proposed treatments [222, 223].

Therefore this pilot study addressed a number of issues as part of the research strategy which can be resolved prior to the main study, these are:

- Define early design problems.
- Check that the multimodal attributes incorporated in each platform are compatible with each other.
- Check the reliability and validity of results.
- Verify that the platforms are sufficiently are usable.
- Check if any incorrect operations are present in the tested platform.
- Validate that the experimental tasks is easy to understand and can be performed in estimated time and if the lessons is too difficult or too easy.
- Identify external or internal effects caused by the procedure, and the effectiveness of actions taken to reduce them.

Controlled Variables	1	The tasks were the same for all users.
	2	The level of difficulty of the subject matter was the same.
	3	The time distribution is same between all tasks.
	4	None of the users were aware of the tasks that would be presented to them.
	5	All the users were with the same level of training and first time users of the tested interface. This was ensured by creating training video files to explain how to use each of the four environments
	6	The experimental platforms implemented were examined with the same users on individual basis with each user. Moreover the same procedure was followed throughout the process of the experiment as well as tools and computer used for measurements.
Dependent Variables	1.	Time spent
	2.	Number of correct answers
	3.	Users satisfactions
	4.	User reaction (smiles, laughs…)
	5.	User's platform preference.
	6.	User's platform preference order.
Independent Variables		Learning method proposed with four levels:
	1.	A game with text and speech only.
	2.	A game with text and earcons.
	3.	A game with text, speech, and earcons.
	4.	A game with text, speech, earcons and avatars.

Table 22 Experiment Variables.

Instructions	1. Read a lesson for maximum 5 minutes, where every page designed to give you one section of the as **text only.** 2. After you have finished reading you are asked to answer some questions using the **Game** provided.

Table 23 Lessons Instructions.

- Pilot Study and Users Feedback

As result of the study, improvements have been integrated into to the all platforms. Some users commented that some terms in the topic was difficult to understand or to remember, especially with those whom do not have any experience with subject. This issue was resolved by providing simple explanations to the majority of expressions as foot notes.

In addition, the majority of users stated that the tasks and instructions were easy to understand and clear. Whereas most users commented that the games was easy to use and enjoyable. About the compatibility of multimodals incorporated, mostly they noted that it was well structured and harmonious as regards each other.

5.10 Sampling

The test sample of this experiment consisted of 46 users who participated in the experiment on an individual basis. The majority of contributors used the experimental platforms for the first time and most of them were inexperienced in the field of geology; the learning topic presented by the experimental platforms.

Therefore, the users relied only on the communicated learning information to answer the required questions, thus avoiding the influence on the dependent variables and so ensure that the independent variables the only beyond the experimental results.

5.11 Data Collection

The same procedure which were used in the second experiment, were used all over again in this experiment to collect the data (refer to 3.9.2 and 4.5.4), i.e. via observations and questionnaires. The data structure of all the pre-experimental and post-experimental questionnaires required were used again with same manner, the difference was only in terms of the number of tasks required by each user and the questions-type (tasks) which were single multiple choice (One answer is correct) (see appendix C-1).

Tasks	Tasks Instructions
Task 1	1. Read the question in the top of the page by moving the mouse over the **black circle**. 2. Read or/and listen to the question in the middle of the page by moving the mouse over and click on the **black circle**. 3. After you have finished reading and listening, click on the **tone button** to listen to the tone (if this applicable) and to see the first answer which will appear inside a circle above the question exactly. 4. The first circle will disappear after approximately 2-3 seconds and automatically the second circle will appear with second answer in clockwise direction until all answers completed. 5. Click on the centre of the circle if you believe it is the correct answer and if you have chosen to answer the question by matching tones, still you have to click the circle to get the feedback. 6. Do the same operation if you have answered incorrect. 7. If you have answered correct, the program will automatically give you the next question until you have finished all of them.
Tasks 2-4	Repeat the same steps in task 1.

Table 24 Task Instructions Procedure.

Moreover the number and type of satisfaction statements were also different in the questionnaires. In summary the user had to read one page at maximum about geology topic prior to performing each of the required 4 Tasks. The user then would start performing the task and all taken actions (time, task completion, and incorrect answers) were observed and timed. Also, the user's responses were recorded using Camtasia studio [26] application in this experiment, as well to extract the percentage of smiles , laughs, brow rising and other facial expressions, later for each platform. This procedure was applied for all the platforms during and after, the required tasks are carried out.

5.12 Users Profile

The pre-experimental questionnaire data were analyzed in order to determine their personal and educational information as well as their previous knowledge and views in regards to the use of computer, Internet, avatars and e-Learning interfaces. Users whom took part in this exercise were mostly aged 25-44 and 100% (46 users) their gender were males. The mean age was 36 years with a standard deviation of 25.46%. In regards to the educational level, users were generally of a highly educated level, Doctoral degree was (21 users) 45.65%, and Masters was (27 users) 58.70% holders. In terms of area of study, the majority of them come from computing and informatics department with (18 users) 39.18%, engineering (in general) was (10 users) 21.74%, whereas communication and networking were (7 users) 15.22%. The remaining users were from different schools and department. Based on users' weekly use of computers and Internet, the participants were regarded as expert users, with 100% usage of computers for more than ten hours. 95.65% (44 users) usually use the Internet for more than 10 hours per week. Of all the users only (2 users) 4.35% had excellent knowledge about Geology, (11 users) 23.91% were good, (27 users) 58.70% limited, and (6 users) 13.04% had no knowledge at all. The frequency users whom had knowledge about e-Learning were found to be (13 users) 28.26%. Users were also inexperienced in regards to avatars, in this respect, (29 users) 63.04% had no knowledge, (13 users) 28.26% limited, (4 users) 8.70% were good, 0% were excellent. See Appendix C-3 for frequency of user profiles.

5.13 Pre- and Experimental Sessions

Before starting the main experiment, training video files explaining how to use each of the proposed environments is introduced to the users for at most 5 minutes. The time spent by users to perform the experiment was between 60 and 75 minutes with mean time of 67.5 minutes (standard deviation 10.60 minutes), including pre- and post-questionnaire. The time was distributed as follow: users started with pre-questionnaire, for mean of 3 minutes, and then read the tasks for an average of 4 minutes, and afterwards interacted with the platform 1 experiment for mean of 10 minutes, followed by first platform satisfaction questionnaire for mean of 6 minutes, and the equivalent distribution interacted with the second, third, and fourth platforms.

5.14 Results and Analysis

The following subsections provide descriptive and statistical analysis of the results obtained from the experiment. This was the results of the experimental group consisting of 46 volunteers who took part in the study that evaluated the four edutainment conditions (games), analysed and compared in terms of efficiency, effectiveness and satisfaction.

5.14.1 Efficiency

The timing observations gathered from the group of users are illustrated in Figure 30. This time was taken by computing the mean time users took in accomplishing each task as well as each condition (excluding reading, pre- and post-questionnaire). The mean values of the time taken by the users in all conditions were; TS was 21.04 seconds, TE was 25.26 seconds, TSE was 22.66; and TSEA was 22.47 seconds. In comparison, the time spent in condition TE was a bit higher than in the other conditions.

Moreover the time differences between tasks for the four conditions are depicted in Figure 31. The mean time percentage for Task 1 across all conditions was 22.34%, Task 2 was 23.46%, Task 3 was 23.67% and Task 4 was 21.94%.

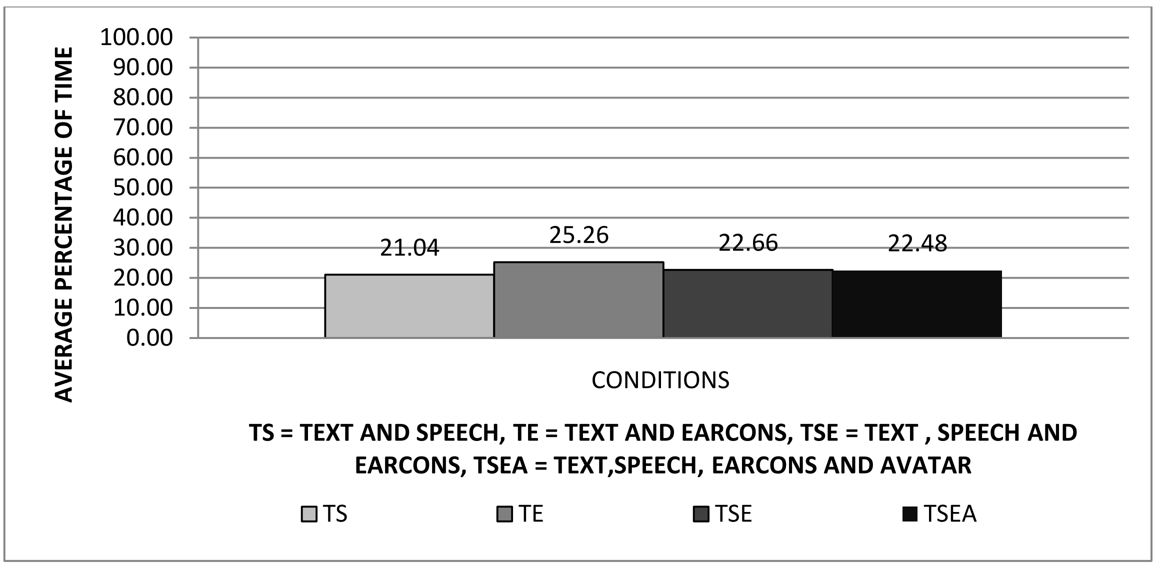


Figure 30 Mean Time for Conditions TS, TE, TSE and TSEA.

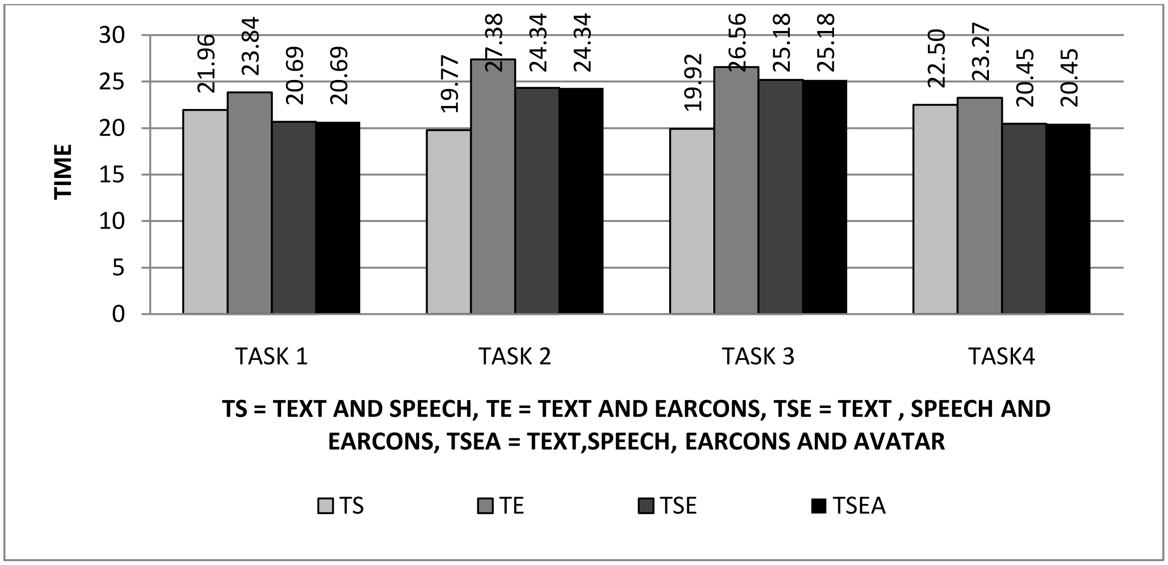


Figure 31 Mean Time for Each Task for Conditions TS, TE, TSE and TSEA.

It is clear that the time was approximately similar. The raw data for question answering time can be found in Appendix C-4, 5, 6 and 7.

5.14.2 Effectiveness

A mean correct answer percentage has been taken from each condition to show the general user performance, as illustrated in Figure 32. It is obvious that TSEA condition had a better performance level than the other conditions. For TSEA, the figure was about 85.33%, whereas that for TSE was 81.52%, that for TE was 69.02%, and finally TS was 68.23%.

Figure 33 states the number of correct answers compared to, incorrect and missing answers, whereas the highest mean for the correct answer was in TSEA condition than the other conditions. In condition TSEA the correct answer mean was 85.33%, TSE was 81.52%, TE was 69.02% and TS was 71.20%.

Figure 34 illustrate users whom responded all tasks successfully and unsuccessfully for all conditions and tasks, it clear that TSEA condition is gained more percentage than others in terms of correct answers , but from the graph the percentage of users whom answered incorrect was higher in condition TE followed by TS and finally TSE .

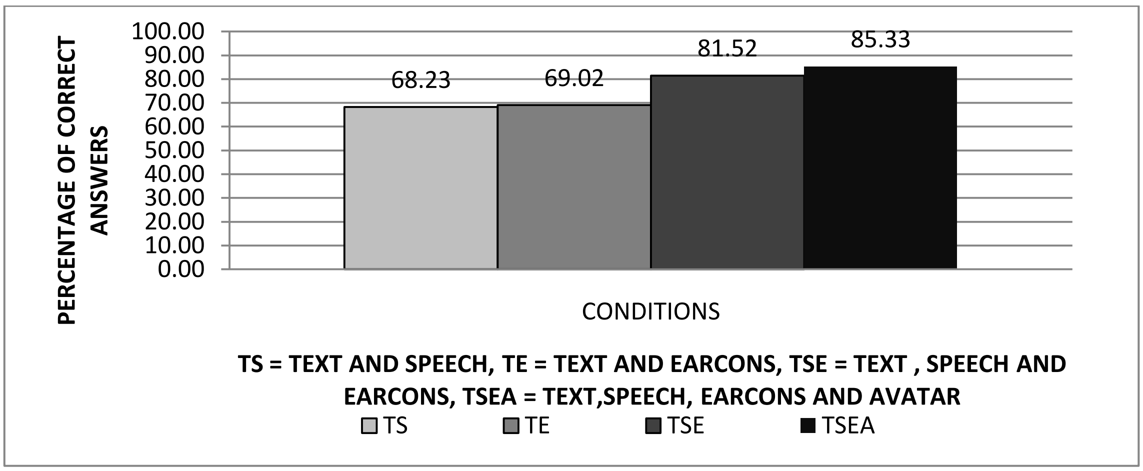


Figure 32 Mean Correct Answer for Conditions TS, TE, TSE and TSEA.

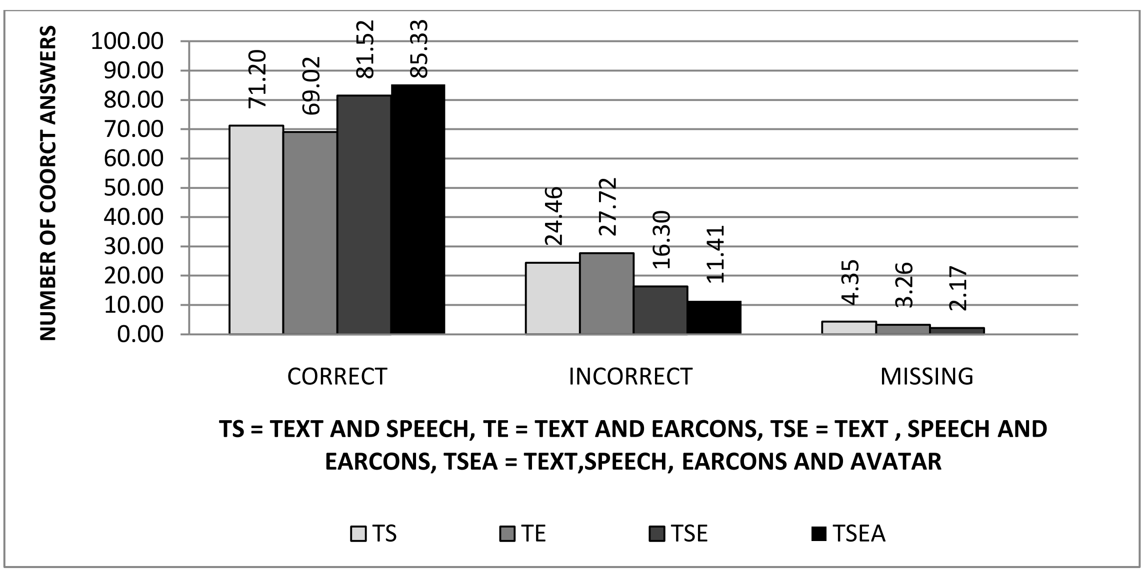


Figure 33 Correct, Incorrect and Missing Answer for Conditions TS, TE, TSE and TSEA.

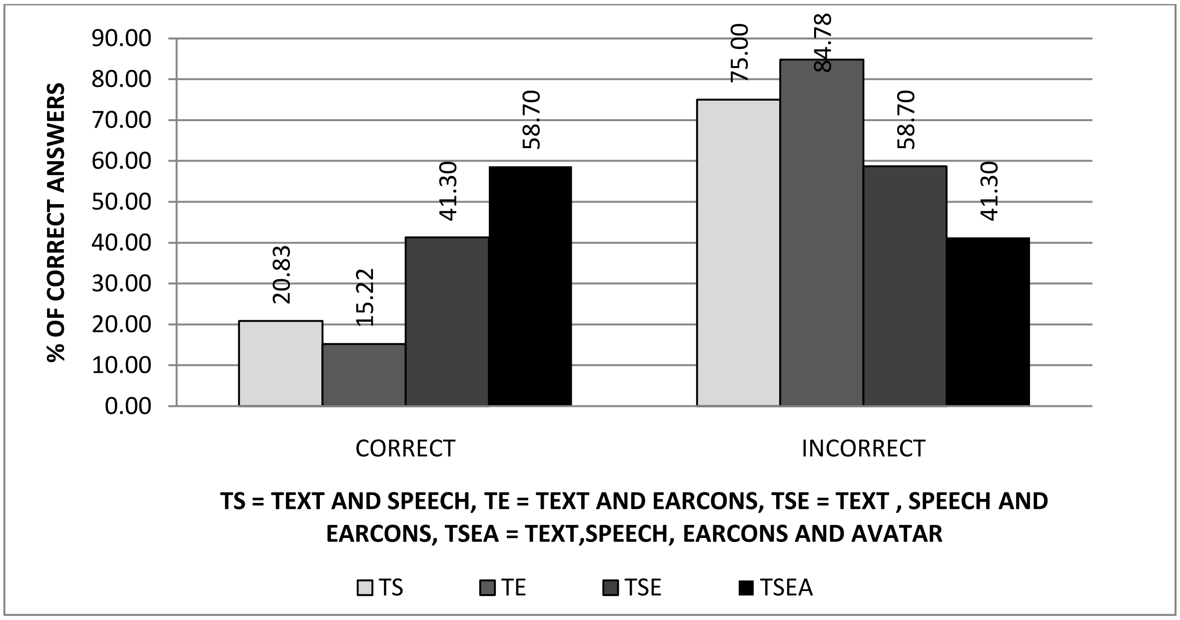


Figure 34 Correct and Incorrect Answer for Conditions TS, TE, TSE and TSEA.

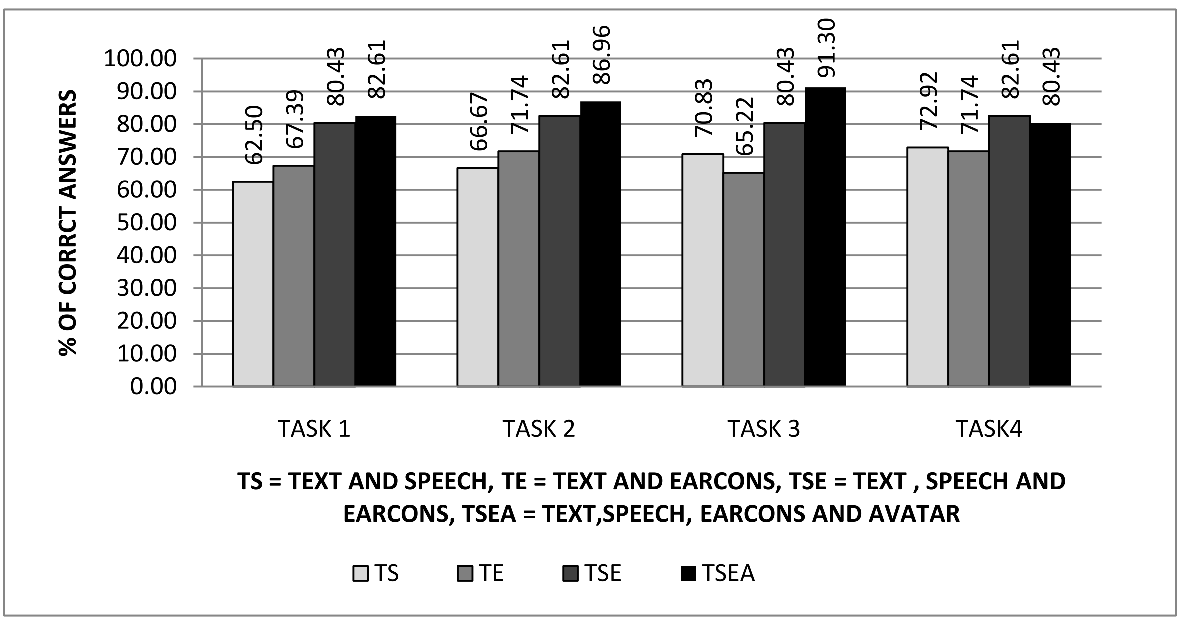


Figure 35 Correct Answers for Each Task for Conditions TS, TE, TSE and TSEA.

On the task level, as shown in Figure 35 below, Task 1 mean correct answer percentage was 73.23%, Task 2 was 76.99%, Task 3 was 76.94% and Task 4 was 76.92%. It is obvious that the higher correct answer percentage was in Task 3 and the lowest was in Task 1.

On the other hand, the successful of completion of the required tasks can also be used as a measure of effectiveness [224]. In this experiment, this parameter was measured in terms of platforms as well as tasks. Figure 36 shows the mean user completion for TE, TSE and TSEA conditions was a little higher in comparison to TS platforms. Respectively, the figures are (42 users) 91.67%, (43 users) 93.48%, (44 users) 95.65% and (45 users) 96.73. The proportion of users whom completed their tasks is illustrated in Figure 37 and was as follows: TS (36 users) 79.17%; TE (40 users) 86.96%; TSE (42 users) 91.30% and TSEA (42 users) 91.30%. Users whom did not completed their tasks were respectively (10 users) 16.67%, (6 users) 13.04%, (4 users) 8.70% and (4 users) 8.69%. Nevertheless the figure also showed missing data in the experimental platforms which was (2 users) 4.35%, (1 user) 3.26%, (1 user) 2.17% and (1 users) 3.26%, in that order.

In terms of each task on its own, as shown in Figure 38, the mean percentage of students who completed the four tasks were identical in all conditions. In general enhancement is noticeable for the performance of student in Task 2 in TE condition and also Task 3 in condition TSEA which was 100%, but in the other conditions the results are comparable. The raw data for correct answer can be found in Appendix C-4, 5, 6 and 7.

5.14.3 Satisfaction

As we know satisfaction is a measurement of user's attitude towards the computer system [225], to compare satisfaction with the interaction metaphors implemented in TS, TE, TSE and TSEA, ratings for satisfaction were taken for each interaction metaphor in each environment.

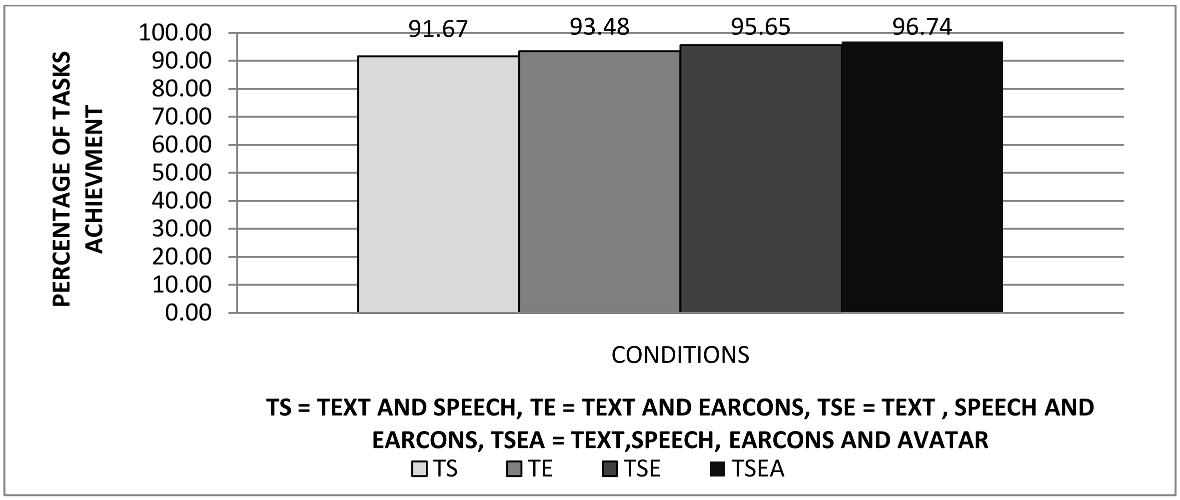


Figure 36 Tasks Completion for Conditions TS, TE, TSE and TSEA.

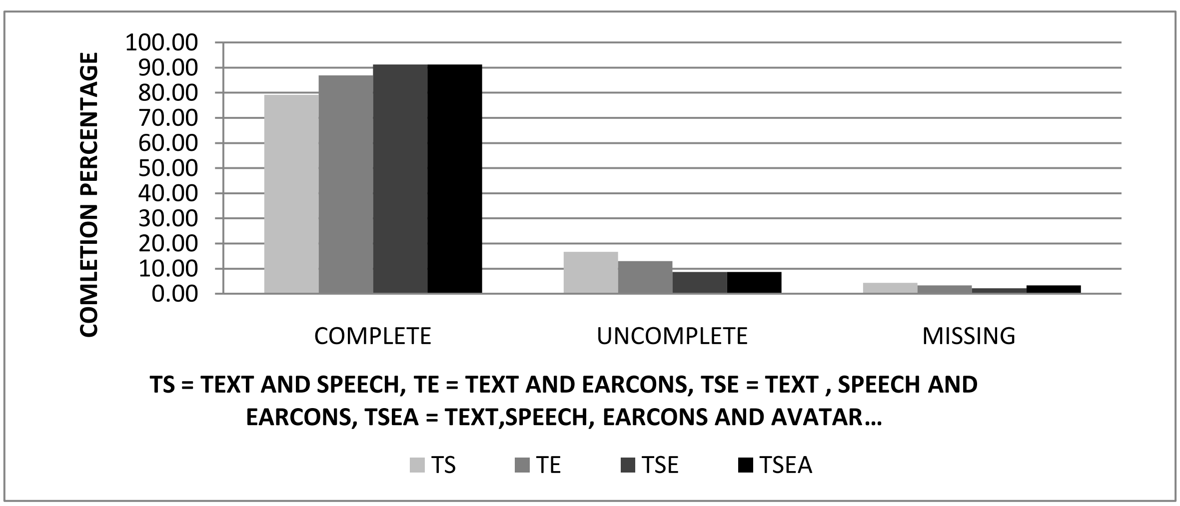


Figure 37 Completed, Uncompleted and Missing Tasks for all Conditions.

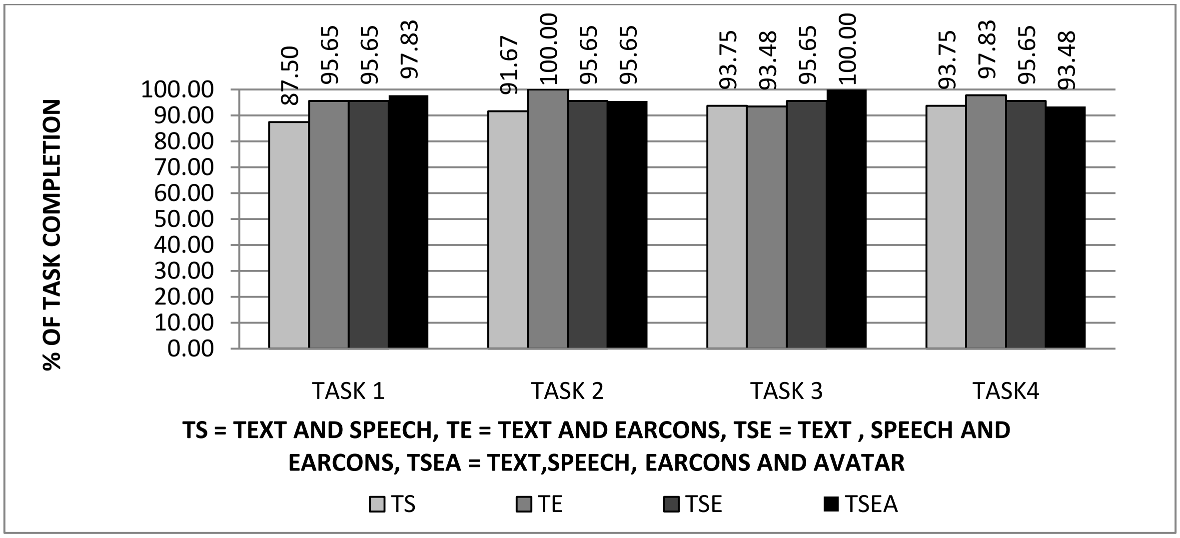


Figure 38 Tasks Completion for Each Task for all Conditions.

Ratings 1 to 2 were for ‘Disagree’ and ‘Very Disagree’, 3 for ‘Undecided’, 4 to 5 for ‘Agree and Very Agree’’. This Likert five-point scale with 10-items as general feedback presented asking users to express their agreement with standard statements [201]. The frequency of users’ different responses (i.e. agree, disagree, undecided) to each statement in the satisfaction questionnaire is illustrated in Figure 39. The mean score for condition TS was 72.13%, TE was 72.30%, TSE was 72.83% and TSEA was 79.29%. In addition to standard statement, the Likert five-point scale enriched by extra 6 and sometimes 8 statements that also expresses user opinion to obtain feedback regarding the tested e-Learning platforms. As these statements are varied in related multimodal feature combined to each platform, therefore each statement was treated alone as shown in Figure 40. On the whole, the interfaces and learning experience was satisfactory for users. Regarding the statement (11), *The learning material is easy*, mean of 94.8% of users agreed in all conditions that the learning materials were easy. Mean of 74.5% of users agreed that the

Questions and answers presented during the Game interface helped me to grasp the lesson more easily (12). Whereas in conditions TS, TE, TSE the percentage of users agreed that the *Game is excellent tool to learn from* (13) the mean was 81%, while in TSEA condition the statement included with the role of avatar and stated as follow: *I enjoyed the Game with Avatar (Human Like Expression) and it is excellent tool to learn from* (13), and the mean percentage was 93%. Concerning the statement shaped: *this system is boring and I felt sleepy* (14), only 3.1% of users agreed on it as mean about all games. The remaining statements (15, 16, 17, 18, and 19) are summarised in Table 25. As results the experiment showed that the multimodal metaphors especially avatar feature addressed in condition TSEA which gain the higher scores, offered the users the atmosphere they require to obtain the enjoyment level reflected in their higher satisfactory level.

Figure 13 on the other hand also illustrates each statement in individual base, the positive statements (S1, S3, S5, S7, and S9) in SUS questionnaire attained high levels of users' agreement (between 77% and 98%). More specifically, 77% of the users agreed that *they would like to use the TS frequently* (S1), whereas 98% was for TSEA condition and 77.39 were for the TE and TSE.

It can be noticed that these results are repeated or similar in statements articulating *I thought the system was easy to use* (S3), *I found the various functions in this Game were well integrated* (S5).

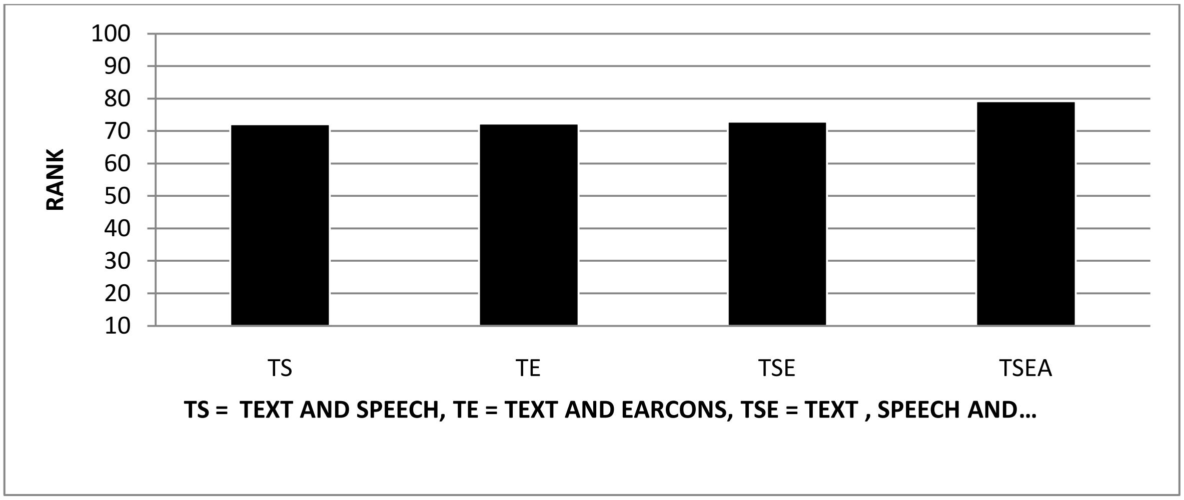


Figure 39 SUS Scale Results.

Statement no.	Statement description	Conditions	Agreement
S15	Speech + text made the game so easy	TS	86%
	Missing of speech made the game so difficult	TE	85%
	Speech model included helped me to understand the questions and answer these questions	TSE	77%
	The existence of Earcons (Tones) in the game helped me to answers provided questions.	TSEA	86%
S16	Overall, I am satisfied with this system	TS	73.9%
	The existence of Earcons (Tones) in the game confused me	TE	3.8%
	Overall, I am satisfied with this system	TSE	80%
	Speech made the game so difficult	TSEA	3.4%
S17	Overall, I am satisfied with this system	TE	80%
	The existence of Earcons (Tones) in the game helped me to answers provided questions	TSE	96.08%
	Adding Text+ Speech + Earcons+ avatars with the game confused experience.	TSEA	2.5%
S18	Speech made the game so difficult	TSE	2%
	Overall, I am satisfied with this system	TSEA	93.98%
S19	Overall, I am satisfied with this system	TSE	80%

Table 25 Additional Statements for All Conditions.

Decreasing percentage of users is observed in statement (S7) and (S9) which were respectively were *most people will learn how to use it very quickly* and *felt confident* during the interaction with TSE and were similar in conditions TS and TE, but the percentage was the highest in TSEA interface.

On the other hand, users' disagreement regarding the negative statements (S2, S4, S6, S8, and S10) was observed between 2% and 4%. Only (3% as average) of the users agreed that the TS, TE and TSE interfaces were *complex* (S2) *need support of a technical person to be able to use this Game* (S4), *too much inconsistency in this Game* (S6), *cumbersome to use* (S8) *and needed to learn a lot of things before getting going with this Game* (S10). However, a slightly lower percentage (approximately 2% of users) was observed in TSEA platform regarding these negative statements.

In summary, users were excited and interested about the multimodal attributes as well as learning materials and it was easy for them to identify the key features in this material in all condition without exemptions. More significant result was noticed in condition TSEA in comparison to the other conditions, this was because of the amusing facial expressions avatar besides the other amusing natural speech and amusing messages inserted in the TSEA interface. The raw data for satisfaction score can be found in Appendix C-8, 9, 10 and 11.

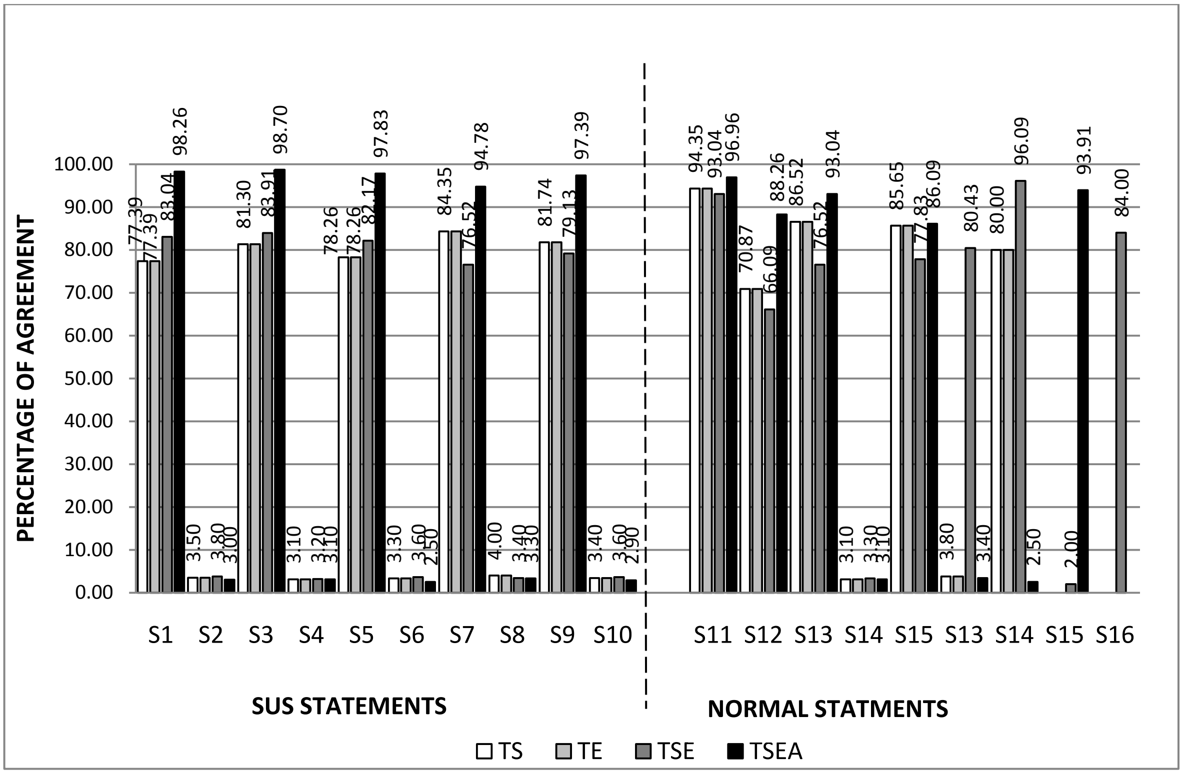


Figure 40 Frequency of User's Agreement for Each SUS and Normal Statement in All Experimental Conditions.

5.14.4 Users Responses

The experiment traced and recorded the user's reaction for each interface via a combination of a laptop built-in webcam and Camtasia software, where the users executed the experiment. Movies produced by the software were analyzed and converted in the form of numerical data. The criteria adopted from [226] to measure the users positive and negative reactions such as users smile, laugh, expressing vocally, and other features. Figure 41 shows the results of user's reactions, with the smile bar feature obtaining the highest total number in all conditions, with its highest value in condition TSEA which was 334, followed by TS condition 266, in TSE were 196 and TE was 151. Moreover laugh attribute is also gained the second highest with about 109 laughs in condition TSEA, TSE was 64, TE was 50 and TS was 39. Vocal expression featured mostly in condition TSEA, followed by TE. The other face features are very rare in condition TSEA, and appeared in condition TSE, TS and TE but in small numbers. Users Reactions Raw Data can be found in Appendix C-12, 13, 14 and 15.

5.14.5 Interfaces Preference

The users whom tested the multimodal environments were asked at the end of the experiments to choose the most preferred way of user interface interaction when designing. Figure 42 displays the user's preference to each condition, the results demonstrate that most of the users preferred to design interfaces using avatar, speech, earcons (Visual, Speech, Non-Speech metaphors) which was mainly employed in condition TSEA, it obtained the highest (52%)(24 users) preference rate among users, followed by condition TSE (23.9%) (11 users) were user preferred (Speech, Non-Speech metaphors), TE (13.04%) (6 users) was the third condition, were users choose to interact with interface with Non-Speech metaphors only, and condition TS was lowest in the graph (10.08%) (5 users), were (Speech metaphor) was the only feature used. The explanation could be referred to the absent of visual metaphor that most of users enjoyed than spoken messages in TSEA condition. See Appendix C-16 for users' preferred platform Raw Data.

5.14.6 Interfaces Preference Order

This section describes to varying designs of multimodal learning interfaces for eliciting user preferences order. Users required to order the interface according to their favorite, in other words the statements in the questionnaire were clarified to prompt the users to place number 1,2,3 or 4 in the box , were the number 1 represents the best interface the user experienced and 2, 3 and 4 are the second, third and fourth.

The results came keep going with interface 4 (TSEA condition) as shown in Figure 43 which was the highest mean 60.87% (28 users) of user's choice. 19.57% (9 users) of users have chosen the condition TSE, 8.70% (4 users) preferred condition TE and 10.87% (5 users) chosen TS condition. The Raw Data for users' preferred platform order can be found in Appendix C-17.

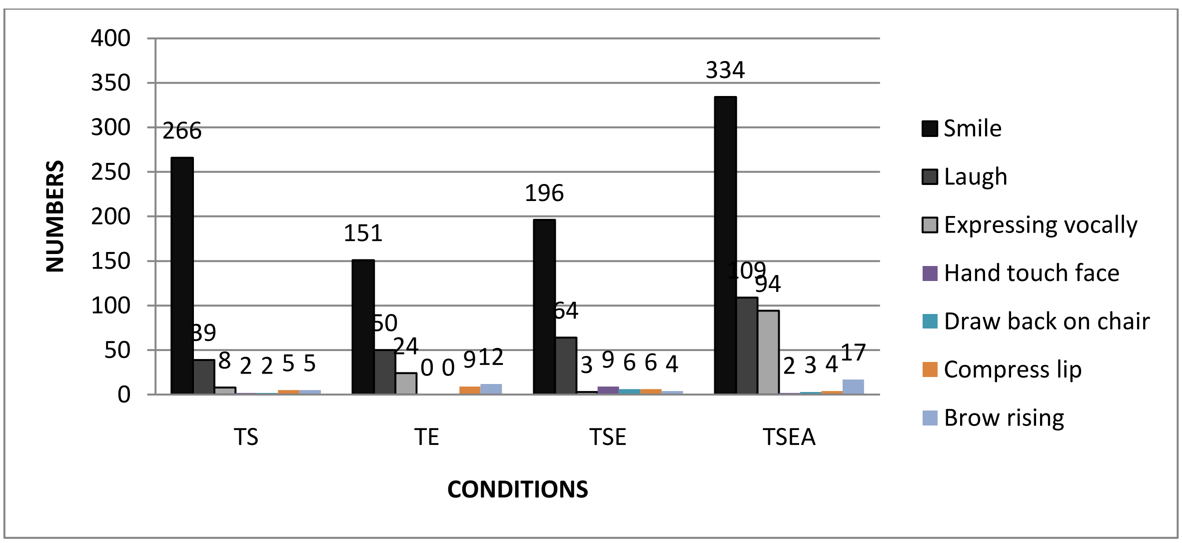


Figure 41 Number of Reactions for All Conditions.

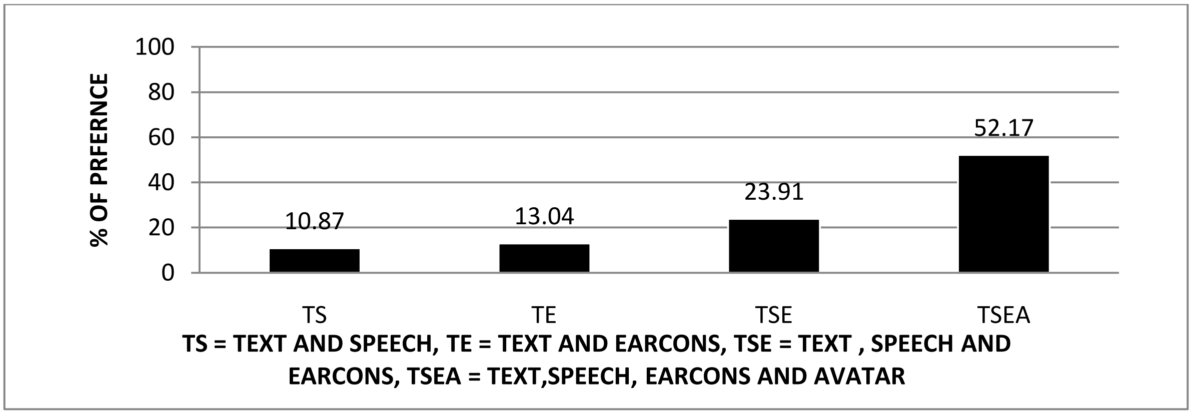


Figure 42 Users Interface Preference for All Conditions.

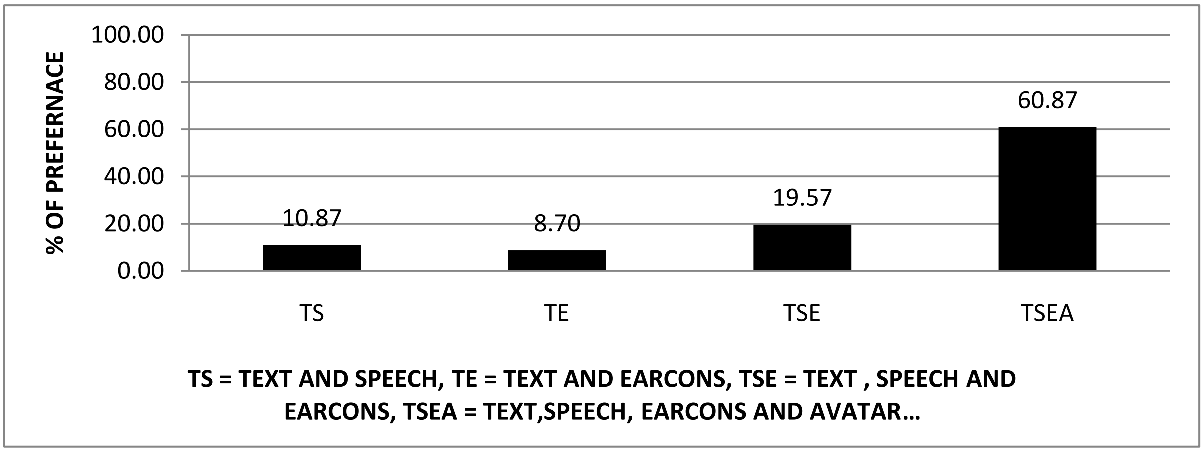


Figure 43 Users Interface Preference Order.

5.14.7 ANOVA Test

To verify the first and second efficiency hypothesis stated in Section 5.4, which predicted the existence of difference between the four environments in regard to time and incorrect answers occurrence, the One-way repeated measures ANOVA test was used. This was based on the type of data and independent and dependent variables applied in this experiments suggested by [215]. ANOVA test designed to compares how a *within-subjects* experimental group performs in three or more experimental conditions. The ANOVA compares whether the mean of any of the individual experimental conditions differ significantly from the total mean across the experimental conditions.

5.14.7.1 Normality Test

Before going with ANOVA test, normality test has been done using SPSS software to the time and correctness data in this experiment, and the Table 26 below concludes the test results. In Kolmogorov-Smirnova distribution the TS was, D (162) = 0.07, P< .05, and appears to be non-normal. In the TE, D (162) = >0.15, P<.05, it appeared non-normal distributed as well. In TSE D (162) = 0.08, P<.05, it came out non-normal, and in TSEA D (162) = 0.1, P<.05, it also came out non-normal. The other column in the table of results shows Shapiro-Wilk test, and showed that all conditions significantly were non-normal, D (162) = 0.0, p<.05. Based on the fact that the Shapiro-Wilk test yields more accurate statistics than the Kolmogorov-Smirnova test.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
TS	.073	162	.034	.969	162	.001
TE	.157	162	.000	.931	162	.000
TSE	.084	162	.007	.962	162	.000
TSEA	.103	162	.000	.954	162	.000

a. Lilliefors Significance Correction

Table 26 Normality Test for Time.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
TS	.436	162	.000	.610	162	.000
TE	.410	162	.000	.606	162	.000
TSE	.499	162	.000	.407	162	.000
TSEA	.502	162	.000	.377	162	.000

a. Lilliefors Significance Correction

Table 27 Normality Test for Correct-Incorrect Answer.

Therefore the final conclusion stated here is that all four variables is significantly non-normally distributed and non parametric test (Friedman test) should be conducted to compare and find out the differences between conditions.

In addition, normality test has been performed on the number of correct-incorrect answers data, as summarized in and the Table 27. The Kolmogorov-Smirnova distribution of the TS was, D (262) = 0.436, P< .05, and appeared to be non-normal. In the TE, D (162) = 0.41, P<.05, which also appeared non-normal distributed. In TSE D (162) = 0.49, P<.05, it came out non-normal, and in TSEA D (162) =0.502, P<.05, came out as non-normal as well. The other column in the table results Shapiro-Wilk test showed that all conditions significantly were non-normal, i.e. D (162) = 0.0, p<.05. Therefore all four variables are significantly non-normally distributed and non-parametric test (Friedman test) should be conducted to compare and find out the differences in the conditions as well.

5.14.7.2 Friedman's ANOVA Test

To find out the differences between experimental conditions in the *within-subjects* design when the assumption of normal distribution of the data is violated, Friedman's ANOVA test showed testing differences between these conditions, when there are more than two conditions. Therefore this test has operated on the time for the four conditions using the SPSS statistics software and the output of the result is shown in the Table 28.

Test Result:

The null hypotheses stated as follow:

H0 = there is no differences between the means of time of the four conditions.

$\mu 1= \mu 2=\mu 3= \mu 4$

H1 = there is differences between the means of time of the four conditions.

Since p-value = $0.18 \leq 0.05 = \alpha$, the null hypothesis is accepted, and we can say that at the $\alpha = 0.05$ level of significance, there exists enough evidence to conclude that there is no difference in the true mean time recorded in rats for the four experimental conditions.

Ranks

	Mean Rank
TS	2.36
TE	2.66
TSE	2.53
TSEA	2.45

Test Statistics[a,b]

N	162.000
Chi-Square	4.793
df	3.000
Asymp. Sig.	.188

Table 28 Friedman's ANOVA Test Result for Time.

In addition, Friedman's ANOVA test was conducted for the number of correct-incorrect answers for the four conditions using the SPSS statistics software again, and the output of the result is shown in the Table 29.

Test Result:

The null hypotheses stated as follow:

H0 = there is no differences between the means of the correct-incorrect answers in the four conditions.

$\mu1= \mu2=\mu3= \mu4$

H1 = there is differences between the means of the correct-incorrect answers in four conditions.

Since p-value = $0.00 \leq 0.01 = \alpha$, the null hypothesis is rejected, and we can say that at the $\alpha = 0.01$ level of significance, there exists enough evidence to conclude that there is a difference in the true mean correct-incorrect answers recorded in rats for the four experimental conditions and the treatment conditions used were effective.

Ranks

	Mean Rank
TS	2.64
TE	2.72
TSE	2.34
TSEA	2.31

Test Statistics[a,b]

N	162.000
Chi-Square	29.803
Df	3.000
Asymp. Sig.	.000

Table 29 Friedman's ANOVA Test Result for Correct-Incorrect Answers.

5.14.7.3 Post Hoc Tests for Friedman's ANOVA

5.14.7.3.1 Wilcoxon Signed-Rank Test

Friedman's ANOVA used to compare whether the mean of any of the individual experimental conditions differ significantly from the aggregate mean, across the experimental conditions, but this test does not give an indication of which condition is significantly the best; in other words the target of the study is to know the condition in which the user performs significantly better in comparison with others.

Wilcoxon signed-rank test is based on the differences between scores in the two conditions. Once these differences have been calculated, they are ranked, but the sign of the difference (positive or negative) is assigned to the rank. Therefore in this experiment, to see if there is significant difference in learning time using different training methods; each of the two conditions have been tested separately. And since four conditions are examined here, so the comparison distribution was as follow:

- Condition TS with condition TE
- Condition TS with condition TSE

- Condition TS with condition TSEA
- Condition TE with condition TSE
- Condition TE with condition TSEA
- Condition TSE with condition TSEA

The Table 30 (A) below determines the test statistics, Z score are calculated from the T score that was the lowest value of sum of negative and positive scores, the value of Z was -3.080 and this value is significant at p= 0.002, therefore, because this value is based on the negative rank, it is safe to say that the time spent per user increased in the direction of TE than in the TS ($Z= -3.080$, $p<.05$).

The value of Z in condition TS with condition TSE comparison was -1.567 and this value is significant at p=0.117, therefore, because this value is based on the negative rank. Therefore the time used up was increased significantly in the condition TSE than in the condition TS ($Z= -1.567$, $p<.05$). Table 30 (D) summarises the test.

A comparison was done between conditions TS and TSEA, based on negative ranks, the time consumed per users is significantly increased in TSEA than in the TS ($Z= -.903$, $p<.05$) as shown in Table 30 (B).

The value of Z in TE with TSE comparison was -1.972 and this value is significant at p=0.049. Therefore, because this value is based on the positive rank, the time used up was decreased significantly in the TE than in the TSE ($Z= -1.972$, $p<.05$). Table 30 (E) summarises the test.

The value of Z in TE with TSEA comparison was -1.936 and this value is significant at p=0.053. Therefore because this value is based on the positive rank, the time used up was decreased significantly in the TE than in the TSEA (Z= -1.936, p<.05). Table 30 (C) summarises the test.

The value of Z in TSE with TSEA comparison was -0.047 and this value is significant at p=0.962. Therefore, because this value is based on the positive rank, the time used up was decreased significantly in the TSE than in the TSEA (Z= -.049, p<.05). Table 30 (F) summarises the test.

Test Statistics[b]

	TE - TS
Z	-3.080[a]
Asymp. Sig. (2-tailed)	.002

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

A

Test Statistics[b]

	TESA - TS
Z	-.903[a]
Asymp. Sig. (2-tailed)	.366

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

B

Test Statistics[b]

	TESA - TE
Z	-1.936[a]
Asymp. Sig. (2-tailed)	.053

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

C

Test Statistics[b]

	TES - TS
Z	-1.567[a]
Asymp. Sig. (2-tailed)	.117

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

D

Test Statistics[b]

	TES - TE
Z	-1.972[a]
Asymp. Sig. (2-tailed)	.049

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

E

Test Statistics[b]

	TESA - TES
Z	-.047[a]
Asymp. Sig. (2-tailed)	.962

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

F

Test Statistics[b]

	TE - TS
Z	-2.301[a]
Asymp. Sig. (2-tailed)	.021

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

G

Test Statistics[b]

	TSE - TS
Z	-.804[a]
Asymp. Sig. (2-tailed)	.422

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

H

Test Statistics[b]

	TSEA - TS
Z	-3.120[a]
Asymp. Sig. (2-tailed)	.002

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

I

Test Statistics[b]

	TSE - TE
Z	-3.214[a]
Asymp. Sig. (2-tailed)	.001

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

J

Test Statistics[b]

	TSEA - TE
Z	-4.024[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

K

Test Statistics[b]

	TSEA - TSE
Z	-1.773[a]
Asymp. Sig. (2-tailed)	.076

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

L

Table 30 Wilcoxon Signed-Rank Test Results.

Table 30 also contains results of the test statistics of correct-incorrect answers for condition TS and condition TE. The value of Z was -2.301 and this value is significant at p= 0.021. Therefore, because this value is based on the positive rank, so the incorrectness decreased in the TS than in the TE (Z= -2.301, p<.05). See Table 30 (G).

In the case of TS with TSE comparison, Z was -.804 and this value is significant at p= .422, and because this score was based on negative ranks, the users made more incorrect answers in TS than in the TSE (Z= -.804, p<.05), see Table 30 (H).

The value of Z in TS with TSEA comparison was -3.120 as shown in Table 30 (I) and this value is significant at p=0.002. Therefore, because this value is based on the positive rank, the incorrectness was significantly lower in the TSEA than in the TS (Z= -3.120, p<.05).

In the case of TE with TSE comparison, Z was -3.214 and this value is significant at p= .001. And because this value is based on the positive rank, therefore, the incorrectness was significantly lower in the TSE than in the TE (Z= -3.214, p<.05). Table 30 (J) concludes the test.

Moreover the value of Z in TE with TSEA comparison was -4.024as shown in Table 30 (K) and this value is significant at p=0.000, therefore, because this value is based on the positive rank, therefore, the incorrectness was significantly lower in the TSEA than in the TE (Z= -4.024, p<.05).

Finally the value of Z in TSE with TSEA comparison was -1.773 as shown in Table 30 (L) and this value is significant at p=0.076. Therefore, because this value is based on the positive rank, the incorrectness was significantly lower in the TSEA than in the TSE ($Z= -1.773$, $p<.05$).

5.15 Discussion

This chapter evaluates four "edutainment" interfaces, through learning in a game-play environment. The environments are: (i) the TS interface (the game with text and speech, only); (ii) the TE interface (the game with text and earcons, only); (iii) the TSE interface (the game with text, speech and earcons); and finally, (iv) the TSEA interface (the game with text, speech, earcons and avatars). Efficiency, effectiveness and satisfaction levels were measured, in order to investigate the impact of integrating multimodal metaphors, within a game-play environment, on users' overall enjoyment (and, consequently, on their performance). The experimental conditions were controlled to guarantee validity, either by means of the platform rotation method used in the study, or by utilising the lesson-distribution mechanism followed. The experimental dependent-variable measurements were suitably managed, in order to acquire accurate results. These measurements were achieved by incorporating a fitted integral time-design into all systems; also, a webcam camera was used to facilitate the accurate recording of users' responses, by capturing their every expression and spontaneous reaction, in real time.

The outcome reported significant differences between the platforms, in general, and confirmed the vital role of avatars, in combination with the use of fun-features which helped focus the users' visual attention, more effectively, on the learning process and on the information being imparted. In addition, the statistical analysis supported this variance. Further explanation of these results is provided in the following section:

The first experimental hypothesis H1 assumed that the efficiency of TS, TE, TSE and TSEA would vary, in terms of time taken by users to complete the same tasks. Findings from this experiment demonstrated that variations existed between users, in terms of time taken to complete the tasks for the proposed interface; therefore, the hypothesis was accepted. The mean time taken by the users was less, in conditions TS, TSE and TSEA, and was greater, in condition TE. The users spent, approximately, the equivalent time on conditions TS, TSE and TSEA, as the mean was 22.05 seconds. Therefore, Hypothesis H3 was accepted, partially, despite the fact that the TSEA condition incorporated at least 5 multimodal attributes, which were expected to increase the length of time spent on the tasks. However, and contrary to expectations, it reduced, or actually maintained, the same user-completion time, compared to the other conditions; thus, it could be considered the most effective interface. With regards to Hypothesis H4, the assumption was that TSE would prove more efficient than TS and TE, in terms of reducing the time taken to complete the task. Therefore, Hypothesis H4 was accepted, partially, because the users, in this condition, spent less time on the task, than in condition TE. Hypothesis H5 was rejected, because the time taken was greater, in condition TE. The slightly longer time spent on condition TE could be attributed to the absence of visual, as well as aural metaphors, which the majority of users enjoyed more than the non-auditory version, alone, implemented in condition TE.

Hypothesis H2 was accepted, which addressed the users' performance, in terms of accuracy, because there was significant variance among platforms. On the other hand, users performed better, in condition TSEA (85.33%) and performed less well, in conditions TSE (81.52%), TS (69.02%) and TE (68.23%). These high results indicate the effect of multimodal metaphors, such as speech and earcons, in condition TSE, and the avatar with engaging factors, in condition TSEA, which explains this high success rate; thus, supporting Hypothesis 6. Condition TSE (81.52%) outperformed conditions TS (69.02%) and TE (68.23%), respectively. Consequently, Hypothesis 7 was, also, accepted. Hypothesis 8 suggested that condition TE would prove more efficient than condition TS, in terms of reducing the frequency of rejected incorrect answers, and this could be attributed to the absence of speech. From this, it can be concluded that speech, as a means of communication, is recommended for preventing the distraction of the users' attention away from the type of learning material where users have to look at graphical representations, while, at the same time, listening to auditory explanations. Consequently, this will reduce the working memory load, thus providing greater resources for the cognitive processing of the available learning material [227].

User progress, in terms of tasks completion, was computed; in general, slight variations were found in mean user completion rates, between all conditions; as a result, Hypothesis 9 was accepted. In contrast, condition TSEA was shown to be superior, achieving the highest mean, compared to conditions TS, TE and TSE, respectively. Condition TS attained 91.67% (42 users); condition TE, 93.48% (43 users); condition TSE, 95.65% (44 users); and condition TSEA, 96.73% (45 users); whereas, percentage rates for users who completed their tasks, without making any mistakes were as follows: condition TS 79.17% (36 users); TE, 86.96% (40 users); TSE, 91.30% (42 users). In this category, TSEA also achieved the highest score, 91.30% (42 users); thus, Hypothesis 10 was, also, accepted. Hypothesis 11 was accepted, as well, since condition TSE proved more effective than conditions TS and TE, in terms of the percentage tasks completed, successfully.

Based on the above findings, it can be seen, clearly, that condition TSEA out-performed the other conditions, for enhancing user-learning attainment. Moreover, it would appear that using more than one communication metaphor of a different nature, in condition TSEA, focussed the users' attention, more effectively, thus improving user-levels of concentration. It also helped the users to differentiate between the various types of information being presented by each of these metaphors, enabling them to retain this information, for a longer period of time, as reflected in the progress made by the users. This outcome concurs with the proposed multimedia guidelines, introduced by Fletcher [204], which confirmed that utilising other human senses, besides the visual channel, in the interaction process, increases the capability of working memory in capturing information and can, consequently, enhance the user's ability to perceive, assimilate and understand the information being presented.

Furthermore, a comparison of SUS scores, between all four interface systems, found that subjects rated the various conditions, differently, as anticipated, in Hypotheses H13. Here, again, condition TSEA attained a higher score than the other conditions, also as anticipated, in Hypotheses H14, with percentage scores, as follows: condition TS 72.13%, TE 72.30%, TSE 72.83%, and TSEA 79.29%. Moreover, the additional statements provided were also more positive for condition TSEA, than for condition TSE, condition TE and, lastly, condition TS. This result could be attributed to the addition of visual, speech, and non-speech metaphors, supported by the entertainment elements, which were mainly employed in condition TSEA. The latter obtained the highest (52%) preference rating among users, and was the interface selected by the majority of users. These results can be further explained by the auditory metaphor, provided by the engaging voice of the virtual avatar. User satisfaction rates were, approximately, equivalent for conditions TS, TE and TSE; this outcome could be attributed to the gradual effect of multimodal metaphors on users' learning performance, which can be improved by the incorporation of these metaphors, in e-Learning interfaces, in general. Accordingly, Hypotheses 15 and 16 were rejected, entirely.

In addition to the main experiments, a series of secondary system measurements was conducted, in order to corroborate the assumptions stated, in the experiment. This was achieved by implementing a number of serial tests (ANOVA), using the data, in order to establish the differences between the experimental platforms, in terms of time taken and levels of accuracy achieved. Crucially, these tests resulted in significant variance and supported the formulated hypotheses. A Wilcoxon test result also differentiated between the platforms and, as stated above, error rates were significantly lower, in condition TSEA, than they were in conditions TSE, TE and TS.

Furthermore, the users' responses analysed gave a strong indication of what features the users enjoyed most. In general, the users smiled and laughed more, in condition TSEA, where the avatar was the mean modal used. Scores, however, were lower, in the other conditions, particularly in condition TE, where the users appeared bored and, in this situation, rarely smiled or laughed. For conditions TSE and TS, on the other hand, these observations were of less valuable, as there were fewer enjoyment features involved.

Concerning user preference percentage scores, condition TSEA was the main platform selected (52%), followed by condition TSE; TSE came third, in terms of user preference, and condition TS was the least favoured option. Nevertheless, the order of preference for the different user-interfaces also supported the findings that interface condition TSEA had the highest mean, i.e. 60.87% preferred user option; 19.57% of the users chose condition TSE, and 8.70% preferred condition TE; finally, 10.87% selected condition TS.

The reason behind the users' preference for condition TSEA can be explained by the levels of enjoyment and satisfaction attained, as a result of the users' interaction with the avatars, in combination with the engaging messages and entertaining human-like gestures, which also added value to the e-Learning experience. However, the results also served to confirm that all conditions had been satisfied; thus, further emphasising the power of the game as an edutainment tool for conveying learning materials, re-enforced with multimodal metaphors, where, as mentioned, previously, the potential effect of the latter on enhancing the usability of the various interfaces had already been demonstrated.

5.16 Summary

This chapter presents the third set of experiments carried out to investigate, empirically, effectiveness, efficiency and user satisfaction, in order to determine the influence of edutainment, combined with multimodal metaphors, within e-learning environments. This was accomplished using four different interchangeable platforms, and four different Geology science lessons, with the intention of exploring, in greater depth, the effect of entertainment on cumulative user enjoyment, and, thus, on student performance. The four "edutainment" environments evaluated, in this chapter, are: interface TSEA (the game with text, speech, earcons and avatars); interface TSE (the game with text, speech, and earcons); interface TS (the game with text, and speech); and, finally, interface TE (the game with text, and earcons). These four interfaces and four lessons were rotated, randomly, depending on the group of users involved. Data on user ratings for effectiveness, efficiency and satisfaction were collected through questionnaires and observation methods, and then analysed. Moreover, a Likert five-point scale with 10 options was also analysed and reviewed. In addition, the ANOVA test was applied to the data and the user interface order of preference, and the findings compared, statistically.

The results demonstrated that the TSEA interface (the game with text, speech, earcons and avatars) clearly outperformed all the other interfaces, in terms of the time users took to complete the required tasks, the frequency of delivering incorrect answers, and user satisfaction levels. In addition, the TSEA interface (platform) received the highest number of user preference ratings. Nevertheless, the order of preference for user interfaces also endorsed the TSEA interface, which had the highest average score. Although the majority of users enjoyed participating in all the conditions, as game-play was seen to facilitate the learning process, the users preferred interface TSEA, because of the avatars which were incorporated to add elements of fun, thus improving the user's mood and reducing stress, during play, and increasing user satisfaction and enjoyment, which, in turn, assisted in achieving the users' goals.

Based on the results obtained, it can be extrapolated that most users in the target population are more likely to enjoy and derive satisfaction from the multimodal aided e-learning experience. This is linked to the ability of users to accomplish learning tasks, correctly, and in less time. Therefore, the overall results of this study recommend the significance of the multimodal communication metaphors examined, during the research, in enhancing user-learning performance, as well as the usability of e-learning interfaces, in terms of efficiency, effectiveness and user satisfaction levels.

Chapter 6

Conclusions and Empirically Derived Guidelines for Edutainment

6.1 Introduction

This Chapter discusses the final conclusions and empirically derived guidelines for the incorporation of multimodal metaphors and entertainment elements within interface structures for e-Learning applications. A brief summary of the main conclusions and empirically derived guidelines is followed by the author's recommendations for future research.

6.1.1 Outcomes of Experiments

This section introduces the outcomes resulting from the research experiments and concludes the key points regarding the usability aspects of e-Learning interfaces. The findings from the first experiment showed that users in condition (E), which was enriched with multimodal features, generally, obtained a higher percentage (63.63%) user-enhanced learning performance, compared to condition (NE), which was only 43.56%; (see Section 3.10.3, 3.10.4, 3.10.5, 3.10.6 and 3.10.7). The application of the analysis of variance between groups, so defined, further confirmed that the difference was statistically significant ($p<0.05$); (see Section 3.10.8). Therefore, it can be concluded that the tested multimodal metaphors, in this experiment, could significantly contribute to enhancing user learning performance and the usability of e-Learning interfaces, in terms of efficiency, effectiveness and user satisfaction. Consequently, these findings confirmed the assumptions made in H1- H6. In general, it was expected that users of the E platform would be more satisfied than the users of the NE, as assumed in Hypotheses 7. On this assumption, the multimodal presentation of the learning material in the E has been shown to offer significantly greater satisfaction than the text with graphics in the NE. It would appear that using the facially expressive avatar, in a human-like simulation, in addition to recorded speech and earcons, was interesting and attractive for users in the experimental group.

Concerning the platforms, overall, the supplementary results indicated that, generally, 31 users (70%) easily recognised the facial expression provided by the avatar, whereas 10 users (22%) answered incorrectly, and only 3 users (8%) refused to comment. Although 25 (56.81%) of users had no previous knowledge of avatar expressions, an important observation revealed that users easily distinguished between happy and sad expressions, when introduced immediately after correct and incorrect answers. Consequently, this significant outcome determined that the use of avatars was capable of conveying emotional expressions to the users, effectively.

With regards to preference, 36 (80%) of users preferred the condition (E), when asked about their opinion on the two conditions, regardless of subject matter and whether they responded, correctly, or not. Indeed, this positive view is attributable to the fact that the users enjoyed the edutainment platform more than the non-edutainment offering and, in turn, this improved their retention capabilities and memory recall.

The second experiment outcome reported was positive and the findings from the tests also resulted in other significant outcomes. The differences between the mean times for the three conditions were noticeable. In condition VC, the mean time was 14.51 seconds; in condition GBL, it was 24.67 seconds; and in condition ST 16.99, (refer to Figure 16). It is noticeable that the time spent in condition GBL was longer than in the other conditions. Even when comparing tasks, even more time was spent on condition GBL tasks, compared to the other two conditions; a result supporting the first hypotheses stated, H1. As stated in H2, there are significant differences regarding correctness of answers achieved, between the proposed platforms. Where users performed much better, in condition GBL, the results were 78.82%, whereas, in condition VC, percentage accuracy was 53.82%, and significantly lower, in condition ST, 44.10% (refer to Figures 17, 18 and 19). Accordingly, the results advocated H2. Users, in terms of task- achievement progress were elevated; the mean user completions for conditions GBL was the highest compared with conditions VC and ST, where percentage results were as follows: condition VC, 79.86%; condition GBL, 97.9% and condition ST, 85.76%. However, the percentage rate of users who completed their tasks, without any mistakes, in condition VC, was 77.08%. In condition GBL, the rate was 89.6%, and in condition ST, it was 45.80%, (refer to Figures 20, 21 and 22). A comparison of SUS scores between all three interface systems found that subjects rated condition GBL higher than the other conditions; therefore, it supported hypothesis H3. The mean SUS score calculated for condition VC was 58.67%, compared to 73.08% for GBL and 52.23% for ST. However, as mentioned, previously, the additional statements provided were higher, at around 3.40 for condition VC, compared to 3.69 for GBL and 3.02 for ST, (refer to Figures 23 and 24). A number of serial tests (ANOVA) were carried out using the data, in order to find out the differences between experimental platforms, in terms of time and accuracy. Crucially, these tests resulted in a significant variance, as anticipated, and the null hypotheses were rejected. A Wilcoxon test result also differentiates between platforms and, as stated above, the level of inaccuracy was significantly lower in the game, than in the storytelling and virtual class conditions. The order of preference for user interfaces further supports the GBL interface, which was the highest mean user option, at 58.33%; 25% of users chose condition VC and 16.67 % preferred condition ST.

The results of the experiments established that the game-based learning interface outperformed all other interfaces. In other words, the experiment provided empirical evidence that using multimodal features, in addition to a game structure, combined with the learning material, within the same interface constituent, is more efficient, more effective and offers greater satisfaction, from a user perspective, as opposed to the other two types of e-Learning interfaces investigated, (see Sections 4.6.1, 4.6.2 and 4.6.3, respectively).

The results of the third experiment demonstrated that the TSEA, (the interface with the game test, speech, earcons and avatars), outperformed all the other interfaces, in terms of the time users took to complete the required tasks, the frequency of inaccuracy and levels of user satisfaction, (see Sections 5.15.1, 5.15.2 and 5.15.3, respectively, and Figures 30 to

40). The first experimental hypothesis (H1) assumed that the efficiency of TS, TE, TSE and TSEA would be different, in terms of the time taken to complete the same tasks by the users. Findings from this experiment demonstrated that differences existed between users, in terms of the time taken to complete the tasks, in the proposed interface; therefore, the hypothesis was accepted. The mean time taken by the users was shorter in conditions TS, TSE and TSEA, and was longer in condition TE. Approximately the equivalent time was spent by users in conditions TS, TSE and TSEA, as the mean was 22.05 seconds. Therefore, hypothesis (H3) was partially accepted, although the TSEA condition included at least 5 multimodal attributes which, it was anticipated, would increase the time taken on the tasks. However, contrary to expectations, it reduced, or maintained the same completion time for the users, compared to the other conditions; thus, it could be considered the most effective of the interfaces involved. With regards to hypothesis H4, the assumption was that TSE would be more efficient than TS and TE, in terms of shortening the time taken to accomplish the task; therefore, this hypothesis was partially accepted, because the users in this condition spent less time than in condition TE. Hypothesis H5 was rejected, because the time taken was greater in condition TE. The slightly longer time spent in condition TE could be attributed to the absence of visual, as well as aural metaphors, which the majority of the users enjoyed more than the non-auditory interface, alone, implemented in condition TE.

Hypothesis 2 was accepted, which addressed the users' performance, in terms of accuracy, because there was a significant variance among platforms. On the other hand, users performed better in condition TSEA (85.33%) and worse in conditions TSE (81.52%), TS

(69.02%) and TE (68.23%). These high results indicate the effect of multimodal metaphors, such as speech and earcons in condition TSE, and the avatar with amusement factors in condition TSEA, which explains this successful outcome; therefore, hypothesis 6 is acceptable. Condition TSE (81.52%) outperformed conditions TS (69.02%) and TE (68.23%); consequently, hypothesis 7 was, also, accepted. Hypothesis 8 proved that condition TE was more efficient than condition TS, in terms of reducing the frequency of incorrect answers rejected, and this could be attributed to the absence of speech**.**

User task completion progress was computed; in general, there were slight differences in mean users' completion rates, across all conditions; as a result, hypothesis 9 was accepted. In comparison, condition TSEA was superior and gained the highest mean compared with conditions TS, TE and TSE. Percentage results were as follows: condition TS, 91.67% (42 users); condition TE, 93.48% (43 users); condition TSE, 95.65% (44 users); and condition TSEA, 96.73% (45 users); whereas, the number of users who completed their tasks without making any mistakes in condition TS was 79.17% (36 users); TE was 86.96% (40 users); TSE was 91.30% (42 users); with TSEA, similarly, accounting for the highest figure of 91.30% (42 users); thus, hypothesis 10 was, also, accepted. Hypothesis 11 was accepted, as well, since the TSE condition proved more effective than the TS and TE conditions, in terms of the percentage of tasks completed, successfully.

Moreover, a comparison of SUS scores, across all four interface systems, found that subjects rated conditions, differently, as anticipated in hypotheses H13, with the TSEA condition attaining higher scores than the other conditions, a result which was also anticipated in hypotheses H14. In condition TS, the score was 72.13%; TE was 72.30%; TSE was 72.83%; and TSEA was 79.29%. Furthermore, the additional statements provided were also more positive for condition TSEA, than for conditions TSE, TE and, lastly, condition TS. This result could be attributed to the addition of visual, speech and non-speech metaphors, supported by the entertainment elements, which were mainly employed in condition TSEA, where it obtained the highest (52%) preference rate, among users and, significantly, was the interface that most users selected. At the same time, the auditory element provided by the amusing voice of the virtual avatar, offered greater insight and a further explanation of these results. The similar satisfaction ratings scored by users in the TS, TE and TSE conditions could, potentially, be explained by the gradual effect of multimodal metaphors and the possibility that users' learning performance can be improved by the incorporation of these metaphors, in e-Learning interfaces, in general. Accordingly, all of hypotheses 15 and 16 were rejected.

The application of a Wilcoxon test resulted in significant variance and supported the hypotheses developed, hitherto. A Wilcoxon test result also differentiates between platforms and, as reflected in the results, above, the level of inaccuracy was significantly lower in condition TSEA, than it was in the TSE, TE and TS conditions.

Concerning users' preference, condition TSEA was the main platform selected (52%), followed by condition TSE; TSE came third, and condition TS was the least popular option. Nevertheless, the order of preference for user interfaces also supports the fact that interface TSEA (condition) achieved the highest mean user option, at 60.87%, with 19.57% of users choosing condition TSE, and 8.70% pre erring condition TE; and, finally, 10.87% selecting condition TS.

Based on the results obtained, it can be deduced that most users in the target population are more likely to enjoy (and gain satisfaction from) the multimodal aided e-Learning experience. This is linked to the ability of users to accomplish learning tasks, correctly, and in less time. Therefore, the overall results of this experimental study emphasise the significance and the role of the multimodal communication metaphors examined, in enhancing user learning performance, as well as the usability of e-Learning interfaces, in terms of efficiency, effectiveness and user satisfaction.

6.2 Empirically Derived Design Guidelines

The results obtained from the three experimental phases are interpreted, in this section, in order to extract the key factors that can be considered as guidelines for enhancing e-Learning interfaces enriched with entertainment features. These guiding principles, along with the previous research findings, in the literature, (see Chapter 2), could prove beneficial to multimodal e-Learning interfaces, with a view to increasing usability and user satisfaction.

6.2.1 Recorded Speech Guidelines

6.2.1.1 Educational and Entertaining User-Relevance

Choosing appropriate words or amusing sentences that contain both educational and entertaining user-relevance is another key point that should be considered, during the process of creating the learning dialogue or scenario. For example, the following two sentences have the same meaning, but the first one is more amusing and engaging when communicating the scientific facts about gravity:

“The law of gravity says no fair jumping up without coming back down”.

“Gravity is a force that keeps us on the ground”.

6.2.1.2 Time Frame

Selecting a suitable time-frame in which to deliver the entertainment patterns and deciding on the way that this should be delivered was another challenge posed by this study. For example, injecting strategically amusing speech ‘prompts’, from time to time, directed at users, where boredom is beginning to creep in, is an effective tool for directing users’ attention to the remaining learning contents.

6.2.1.3 Silent Interval

A short, carefully positioned silent interval or strategic pause is also recommended between the speech segments of the virtual lecture, to provide the user with a chance to look at the accompanying text information. Sometimes, users feel surprised by the amusing messages or amusing expressions used to convey specific pieces of information; however, this novel approach actually helps them re-focus on the lesson, when their minds may wander, and assists not only in the immediate assimilation of information, but also in improving memory recall, at a later date.

6.2.1.4 Instructor Motivation

Another important factor is to stimulate the instructor in the system to direct the users' attentions to the text or graphics provided, from time to time, by selecting some amusing or engaging words and phrases that encourage the users' to concentrate harder on this part of the information.

6.2.1.5 Play Forward/Back Functions

Providing stopping, play forward/back anytime functions in the system is suggested, because it presents a more realistic environment for facilitating the learning process, for example, when users feel ready to progress, or when they miss certain pieces of information.

6.2.1.6 Engaging Avatars with Entertaining Facial Expressions

Based on the findings of this study, several key rules were established which the developer needs to take into account, throughout the design process.

6.2.1.7 Influence of Positive/Negative Facial Expressions

The study showed that the users enjoyed and engaged, not only with the positive facial expressions of happiness and surprise, but also with the negative expressions, such as anger, frustration, disapproval, sadness and upset. Therefore, whatever the expression, the focus should be on exactly how and when to present and express these wide-ranging facial expressions, in an e-Learning situation. For example, the appropriate time to prompt the user to revise what has been learnt or understood is immediately after delivering some new information; it could be presented by using an avatar with pondering facial expressions, perhaps, closing one eye, which encourages the user to interact with the avatar and therefore remember that particular piece of information.

6.2.1.8 Balance between Speech and Facial Expressions

Another suggested rule is that the facial expressions selected to present the entertainment should be attached with reinforcing speech (words, phrases or sentences) that give the same meaning by using varying intonation and pitch. Playing with these sound properties, integrated with a suitable facial image is important, as this mimics the real human-to-human interaction that makes the user more receptive.

6.2.1.9 Accurate Combination

The accurate combination of voices and engaging faces can also be used to emphasise the importance of specific key words or statements presented through the medium of text, or other types of learning content. This is based on the fact that human interaction comprises numerous facial expressions and moods, all of which are required to make the learning process more interesting.

6.2.1.10 Transition between Moods

Transition between moods, is an issue which should be dealt with, carefully. For example, shifting from a serious to an amusing mood, abruptly, and vice versa, confuses the users' feelings; therefore, the moods used should be switched, smoothly, to make the avatar's expressive face, as well as the learning environment more realistic.

6.2.1.11 Consistency

The final, important rule that should be focused upon is achieving consistency between all facial features including eyes, eyebrows, mouth, forehead and general facial movements, each of which must correspond to the mood that the avatar represents, and should reflect the same impression that the accompanying spoken words are trying to communicate.

6.2.2 Expressive Avatars with Engaging Body Gestures

6.2.2.1 Honesty & Realism

All the ranges of human gestures or types of body-language examined, in this research, are, in reality, recommended, as they were favoured by the users when they trialled them with a combination of other different facial expressions and recorded speech; all, in combination, provided the required edutainment communication, when used, effectively, honestly and in a realistic manner.

6.2.2.2 Culture Issues

A crucial factor that the designers should bear in mind is that of cultural issues, since some non-verbal gestures have different meanings for different people, in different countries, and this may confuse the user.

6.2.2.3 Distraction

Gestures should be used, briefly, when required to forward a meaningful message and to avoid distraction that may lead to divert the users' attention, thus failing to meet the main cognitive goals that avatars need to convey. This, in turn, could negatively influence their feelings and involvement, as well as their performance in the e-Learning process.

6.2.3 Guidelines for Non-Speech Type Sounds

6.2.3.1 Earcons should be an Option

Although the study recommends the use of earcons with the game design, they should not be the users' first choice for answering the questions set out in the task. This is because users are sometimes looking for the quickest route possible to completing the required tasks, and, in this respect, the earcon provides a short-cut to finding the answers, quickly. However, earcons should be presented as an optional solution that can only be used in situations when the users fail to answer by means of a text or spoken words; Otherwise the users might entertain themselves, instead of learning or benefiting from the associated educational attributes that the game is supposed to provide.

6.2.4 Use of the Game with Avatars

6.2.4.1 More Multimodals Mean More Interactivity

Besides the challenging environment provided by the game, itself, introducing more than one option (earcon, speech and avatar) for users to interact with, when playing a game, enriched the users' overall experience.

6.2.4.2 Simplicity of the Game

Another interesting finding to result from this experimental study concerned the simplicity of the game design. Moreover, as the participants were mostly students of a high educational level (Masters and PhD), they tended to dislike complex games that take time to understand; rather, they preferred simple, easy games that contain valuable information.

6.2.4.3 Avatar Styles and Appearance

Changing the avatar styles and appearance, during the presentation of the game, was preferred by the users, who took part in the study, i.e. each change in avatar style or appearance should, therefore, involve a different expression, be it positive or negative.

6.2.4.4 Sufficient Training and Timing

The last rule that needs to be taken into account is the time-frame, which should be managed and distributed, efficiently, when presenting all of the text, avatars, recorded speech, and earcons, within the game, and supported by sufficient training, thus ensuring that users can progress, easily, with the game.

6.3 Future Work

This section outlines suggestions and recommendations for future research into furthering the use of edutainment in the on-going enhancement e-Learning interfaces.

6.3.1 Other Possible Approaches to Evaluating Fun and Entertainment

The technique selected in this study is well-known and an extensively used method, especially in the HCI research domain. Furthermore, a large number of alternative approaches are available, currently, that could be used to evaluate the usability of e-Learning interfaces. For example, Cognitive Walkthrough, Focus Group Evaluation, Feature inspection and other numerous approaches exist that could also serve as alternative methods for the evaluation of Usability Engineering.

6.3.2 Balanced Sample & Future Research

Due to the practical circumstances of the author of this thesis, the majority of the participants in the study were also students in the same faculty and university, although they were from different backgrounds. However, it is very important to select a suitable sampling technique, to avoid any errors that might occur, when estimating the corresponding parameters in the population. Therefore, a range of alternative sampling techniques is also recommended, in order to represent the population, in a more balanced manner, with techniques such as probability sampling or stratified sampling, rather than the one used in this research programme.

6.3.3 Larger Scale Experimentation

As this study has a limited budget and that, in turn, determines the sample size, the majority of the subjects who took part in the study were students and this, inevitably, reduces external validity. As a result, the study must be of sufficient size, to be compatible with the goals of the research, to ensure that the results of the experiment are valid; therefore, the subjects should be drawn from an appropriate population. A large scale representative sample is suggested, to guarantee the statistical significance of the study.

6.3.4 Linked with Intelligent Systems

Intelligent systems are computational systems that have intelligent capabilities, in which all input modes, (e.g. speech, gesture, and facial expression) are also available for output, and vice versa. Such systems could be considered as one of many research fields for human-computer interaction, or affective computing. Speech recognition technology and emotion recognition by speech are examples of those agents. Moreover, these technologies can be involved to respond to individual users, differently, according to his/her queries, learning needs and emotional states. Therefore, by applying the avatar as an agent or a robot, it could generate complex automatic verbal, non-verbal, facial expressions and gesture responses, according to the users' demands.

6.3.5 Personalised Characters

This current thesis did not cover avatar personalised characteristics such as age, gender, culture and languages. For example, using an avatar that represents an older teacher may affect the users' performance, compared with using a young teacher/avatar. Therefore, many other avenues could be pursued, in order to test the influence of each of these individual parameters on users' advancement in e-Learning interfaces.

6.3.6 Different Game Design

The role of game-based learning, merged with multimodal attributes, in increasing motivation and stimulating curiosity, has been proved by this experimental study. However, further experimental studies that examine a different set of multimodal metaphors with a different game design and structure are recommended, to enable e-Learning users to acquire enhanced motor skills, improve memory recall, visualisation skills and problem solving, for the future.

6.4 Summary

The overall aim of this thesis was to investigate the usability aspects of multimodal interaction metaphors, (e.g. speech, earcon, avatar, etc.), with edutainment fundamentals, (e.g. amusing/engaging speech and facial expressions), in enhancing the presentation of the learning content, in e-Learning interfaces. The lack of face-to-face contact and text-based interfaces, in the e-Learning segment, are major issues that this thesis attempted to address. These types of problems make learners dissatisfied, due to the absence of personal interaction and useful feedback messages, as well as real-time information on their learning performance. The empirical research methodology proposed, in this research programme, to overcome these issues comprises three experimental stages: the first experiment involved 44 users and evaluated the usability features of two interfaces; one, an edutainment interface, using avatars (human-like representations) to convey some form of entertainment to engage the users; the other, a non-edutainment (typical e-Learning interface). The second experiment investigated three new interfaces, (Virtual Class using Avatar, Game using Speech, and Earcon and Storytelling using Speech, only), and involved 48 participants, with a view to identifying which edutainment activity was best preferred by the users. The third experiment involved four gaming platforms, namely, TSEA (a game with text, speech, earcons and avatar); TSE (a game with text, speech and earcons); TS (a game with text and speech) and, finally, TE (a game with text and earcons), with 46 users, in order to determine the best preferred multimodal attribute. In this context, the multimodal features, such as earcons, speech and particularly avatars investigated, in this research project, were shown to help improve usability, as well as the users' learning performance, when utilised to communicate the incorporated learning material. These various features, therefore, can be considered as suitable attributes, in terms of providing an effective substitution for lack of face-to-face contact with the teacher, in an e-Learning interface environment. Furthermore, the research established that, overall, the presence of an avatar, or 'talking to' a virtual human, in e-Learning situations, with associated cognitive factors, with edutainment, increases the users' interest, motivation, and retention, while, at the same time, improving levels of cognitive behaviour and reasoning skills.

The experimental findings, stated above, form the basis for establishing a set of empirical guidelines for the design of usable multimodal e-Learning and edutainment interfaces, while also contributing towards enriching the research literature on multimodal interaction and e-Learning , as well as the field of edutainment. In addition, recommendations have been made for future studies and experimental work, which can be developed to emphasise the potential of multimodal metaphors with edutainment features in enhancing Human-Computer Interaction and usability, in the e-Learning domain.

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APPENDICES

Appendix A :- Experimental Design Phase I: The Role of Edutainment in E-Learning Interface

Appendix A-1 : Questionnaire

Dear user
I am pleased to present myself to you as one of the postgraduate research students in the School of Informatics in the University of Bradford. I am currently investigating the use of fun in e-Learning human computer interaction, and I would like to obtain your views regarding the use of such multimodal metaphors such as: avatar with funny body and facial expressions, speech, and non-speech.
Please follow the following procedure:
Answer the pre-session questions.
Read instructions of each task carefully.
Start the task.
On completion of the task or when are requested to stop, answer the post-task questions.
After completion of all tasks, answer the general feedback questions.
Answer the post-experiment questions.

Note that if you are asked to fill in a questionnaire, there is a standardised six-point scale. This scale consists of six agreement and disagreement levels as shown below:

	Scale levels	
Type	**Level**	**Level name**
Agreement	6	Agree Strongly
	5	Agree Moderately
	4	Agree Slightly
Disagreement	3	Disagree Slightly
	2	Disagree Moderately
	1	Disagree Strongly

Please answer all the questions as truthfully as possible. It would be grateful if you could fill in the following questionnaire sincerely and provide your views. Your privacy is guaranteed as your name will not be mentioned in any part of the study.
Thank you very much, and I highly appreciate your participation.

Khaled Ayad

Your name: ……………………………………………………….

Part 1	Pre-Session Questions

Age, Gender and Education

1 **What is your age?**
☐ 18 - 24. ☐ 25 - 34. ☐ 35 - 44. ☐ 45 - 54. ☐ 55 +.

2 **What is you gender?**
☐ Male. ☐ Female.

3 **What is your education level?**
☐ High School. ☐ College. ☐ Under-graduate.
☐ Master Degree. ☐ Doctorate Degree. ☐ Other.

Area of study: ……………………………………………………..

Experience

1 **How often do you use the computer (average) per week?**
☐ Never. ☐ Less than 1 hour. ☐ 1-5 hours.
☐ 6-10 hours. ☐ More than 10 hours.

2 **How many hours do you use the internet (average) per week?**
☐ Never. ☐ Less than 1 hour. ☐ 1-5 hours.
☐ 6-10 hours. ☐ More than 10 hours.

3 **Do you have knowledge about Human Computer Interaction ?**
☐ Limited. ☐ Good ☐ Excellent. ☐ No

4 **Did you practice the use of any e-Learning web sites or software?**
☐ Yes. ☐ No.

5 **Do you have knowledge about avatar and facial expressions?**
☐ Limited. ☐ Good ☐ Excellent. ☐ No

Platform 1 A Edutainment (E)

1. You will have to read chapter **one** which is **Introduction**, where every page designed to give you one section of the chapter as text, and you have choice to listen to the avatar at any time to explain to you the text by pressing on the specific button shown.
2. After you have finished reading and listening, you are asked to answer some questions by pressing on the Quiz button:

Note: To accomplish the following tasks you have only <u>30 seconds</u> for every task.

Task 1:

1 Move the mouse cursor over the button labeled **"Q1"** and click to read and listen to the question.

2 After you have finished reading and listen the question, move the mouse cursor over the remaining buttons in the page to read and listen to the answers.

3 Whatever you find correct click on it to check the response whether it is correct or not.

4 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 2:

1 Move the mouse cursor over the button labeled "Q2" and click to read and listen to the question.

2 After you have finished reading and listen the question, move the mouse cursor over the remaining buttons in the page to read and listen to the answers.

3 Whatever you find correct click on it to check the response whether it is correct or not.

4 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 3:

1 Move the mouse cursor over the button labeled "Q3" and click to read and listen to the question.

2 After you have finished reading and listen the question, move the mouse cursor over the remaining buttons in the page to read and listen to the answers.

3 Whatever you find correct click on it to check the response whether it is correct or not.

4 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Note: To accomplish the following tasks you have only <u>60 seconds</u> for every task.

Task 4:

Here you will find **short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Task 5:

After you have finished the first question , click on the next button to go to the second **short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Task 6:

After you have finished the second question , click on the next button to go to the third **short answer question short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Part 3	Tasks

Platform 2 B Non-Edutainment (NE)

1. You will have to read some section from chapter two which is titled **Understanding Users,** where every page designed to give you one section of the chapter as **<u>text only.</u>**
2. After you have finished reading you are asked to answer some questions by pressing on the Quiz button where you will find Target Area questions with 4 answers for every page.

Note: To accomplish the following tasks you have only <u>30 seconds</u> for every task.

Task 1:

1 Drag the colored word (Term) in the middle of the page to the right position (Depiction) you believe it is correct or matches it.
2 Do the same operation if you have answered incorrect.
3 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 2:

1 Drag the colored word (Term) in the middle of the page to the right position (Depiction) you believe it is correct or matches it.
2 Do the same operation if you have answered incorrect.
3 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 3:

1 Drag the colored word (Term) in the middle of the page to the right position (Depiction) you believe it is correct or matches it.
2 Do the same operation if you have answered incorrect.
3 If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Note: To accomplish the following tasks you have only <u>60 seconds</u> for every task.

Task 4:

Here you will find **short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Task 5:

After you have finished the first question , click on the next button to go to the second **short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Task 6:

After you have finished the second question , click on the next button to go to the third **short answer question short answer question**, and all you have to do is **to write down the proper word (s) in the space shown and click on the Record Answer Button.**

Part 4	Satisfaction for Edutainment

For each statement below, please express your view by placing a tick in the appropriate column.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think the interface was easy to use.	1	2	3	4	5
2	The interface of this system is pleasant.	1	2	3	4	5
3	It was easy to answer the exercises.	1	2	3	4	5
4	There have been times while interacting with the system where I felt challenging.	1	2	3	4	5
5	I enjoyed the exercises because of Avatar	1	2	3	4	5
6	The challenge forces me to continue.	1	2	3	4	5
7	People will learn the use of this tool quickly.	1	2	3	4	5
8	This system is boring.	1	2	3	4	5
9	I would recommend this system to my colleagues	1	2	3	4	5
10	Overall, I am satisfied with this system.	1	2	3	4	5

Part 5	Satisfaction for Non- Edutainment

For each statement below, please express your view by placing a tick in the appropriate column.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think the interface was easy to use.	1	2	3	4	5
2	The interface of this system is pleasant.	1	2	3	4	5
3	It was easy to answer the exercises.	1	2	3	4	5
4	There have been times while interacting with the system where I felt challenging.	1	2	3	4	5
5	I enjoyed the exercises.	1	2	3	4	5
6	The challenge forces me to continue.	1	2	3	4	5
7	People will learn the use of this tool quickly.	1	2	3	4	5
8	This system is boring.	1	2	3	4	5
9	I would recommend this system to my colleagues	1	2	3	4	5
10	Overall, I am satisfied with this system.	1	2	3	4	5

Part 6	Memorability

What the following picture represents?

- **Incorrect answers try again.**
- **Right answer, that is of course true.**

- **Incorrect answer (Try again)**
- **Right answer (Bravooooooooooo)**

Part 7	General feedback

Which interface did you like most?

1. **Edutainment Interface.**
2. **No Edutainment interface.**

What were the problems that you experienced, if any?

……………………………………………...
....
....

Do you have any other comments, suggestion?
……………………………………………...
....

Thank you for taking part in this study.

Appendix A-2 : Learning Content Examined in First Experiment both Platforms

Chapter 1: Introduction to HCI

- Definition of HCI

The study of the relationships between humans and the computer systems they use in performance of tasks.

- Human Computer Interface

HCI those parts of the computer system with which the user comes into contact i.e. What the user thinks the

- The goals of HCI

To develop or improve the safety, efficiency and usability of systems that includes computers.

- The importance of HCI
  - Safety
    - Health and safety
    - Safety-critical systems
  - Profitability
    - Competitive edge
    - Improved productivity
    - Reduced costs of training
  - Jobs
- This module
  - Concerned with the “human” side of computing.
  - What the user can and can’t be expected to do in relation to computer systems.
  - The importance of designing for the target users to carry out their particular tasks.
- If the user can’t use it, it doesn’t work.

Chapter 2: Interactive systems: Understanding users: Human information processing -Perception - Visual perception

- Interactive systems:

For successful interaction, i.e. ‘fitness for purpose’ the designers of the system must take account of the user, the task and the environment in which it is carried out i.e. designers must:

  - Know the user.
  - know the task
  - Know the environment.

- Knowing the user - in general terms.

Cognitive psychology attempts to explain:

- How humans perceive the world.
- How they store and process information.
- How they solve problems.
- How they learn and acquire skills.

To provide insight into the way human users interact with computer systems (in general) and guidance for designers.

- Interpreting what we see: our brains automatically
  - Look for order, patterns, meaning in visual images.
  - Use context and existing knowledge to recognise and understand.
  - Attempt to construct meaning from incomplete visual information.
  - Make assumptions based on cultural and personal associations.

Appendix A-3 : Frequency Table for Users' Profiles

Data Description		No. of Users	%
Age	18-24	5	11.36
	25-34	22	50.00
	35-44	14	31.82
	45-54	3	6.82
	Total	44	100.00
Gender	Male	43	97.73
	Female	1	2.27
	Total	44	100.00
Educational Level	PhD	14	31.82
	Master	26	59.09
	Undergraduate	4	9.09
	Total	44	100.00
Area of study	Computer	22	50.00
	Engineering	6	13.64
	Biology	3	6.82
	Chemistry	3	6.82
	Management	1	2.27
	Social S.	1	2.27

	Environment	3	6.82
	Communication	4	9.09
	Mathematics	1	2.27
	Total	44	100.00
Use of computer/week	6 -10 hours	3	6.82
	1 - 5 hours	1	2.27
	10 +hours	40	90.91
	Total	44	100.00
Use of Internet/week	6 -10 hours	5	11.36
	1 - 5 hours	1	2.27
	10 +hours	38	86.36
	Total	44	100.00
Knowledge about HCI	Excellent Good Limited No	8 15 9 12	18.18 34.09 20.45 27.27
	Total	44	100.00
Prior experience in E-Learning applications?	yes	19	43.18
	No	25	56.82
	Total	44.00	100.00
Experience on avatars and facial expressions	Excellent Good Limited No	2 7 10 25	4.55 15.91 22.73 56.82
	Total	44.00	100.00

Appendix A-4 : Time and Incorrectness Row Data for Edutainment (E) Interface from Experimental Phase I

T = Time & W= No. of wrong answer & / = Missing or No answer

	Recognition Qestions						Recall Questions					
	Easy task		Modrate task		Difficult task		Easy task		Modrate task		Difficult task	
	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
USERS	T	W	T	W	T	W	T	W	T	W	T	W
U1	16.16	0	14.21	0	6.34	0	28.64	0	9.76	0	7.66	0
U2	19.79	0	14.76	1	30	2	60	3	60	3	60	/
U3	21.8	1	14.67	1	30	3	55.66	2	60	3	56.81	3
U4	26.31	0	20.62	/	19.28	0	60	2	60	/	47.54	1
U5	30	/	27.49	1	30	/	58.89	0	18.96	0	20.21	1
U6	29.2	0	21.51	0	19.29	1	27.11	0	45	2	51	2
U7	28.18	1	23.86	0	14.16	1	24.06	0	58.6	1	44.95	0
U8	15.06	0	15.01		8.03	0	21.07	0	60	2	24.92	0
U9	15.2	0	16.11	0	15.58	0	37.06	0	7.55	0	57.25	/
U10	16.59	0	21.64	0	10.59	0	43.1	0	60	2	11.57	0
U11	30	1	18.22	0	12.96	0	22.28	0	60	1	45.9	1
U12	4.83	0	18.01	0	5.14	0	21.23	0	24.47	1	10.01	0
U13	6.13	0	3.1	0	2.1	0	33	0	21.01	0	12.05	0
U14	21.72	1	17.51	0	10.46	0	60	2	30	0	7.02	0
U15	19.41	0	25.91	0	9.86	0	58.41	0	30	0	20.32	1
U16	15.93	0	14.59	0	13.91	0	25.15	0	37.78	/	8.36	0
U17	30	1	17.2	0	21.7	0	55.02	0	42	1	50.94	1
U18	27.48	0	13.9	0	11.59	0	21.46	0	35.02	0	8.4	0
U19	10.2	0	12.14	0	5.13	0	35.1	0	60	/	43.1	/
U20	17.17	0	12.68	0	5.54	0	9.08	0	15.31	0	5.86	0
U21	29	0	21.9	0	19.86	0	22.1	0	23.7	0	8.2	0
U22	13	0	11.76	0	14.15	0	56.1	1	30.98	0	40	2
U23	21.63	1	3.8	0	22	1	60	2	60	3	13.13	0
U24	4.84	0	2.74	0	13.9	1	60	2	60	/	42.31	2
U25	16.49	0	7.58	0	30	2	60	1	59.4	1	60	1
U26	20	0	30	1	8.77	0	60	1	60	2	60	/
U27	23.58	0	3.89	0	30	1	60	1	60	1	59.1	1
U28	21.25	1	22.7	1	9.03	0	14.42	0	42.17	0	60	/
U29	7.43	0	17.49	0	30	2	60	1	60	/	60	/
U30	30	/	17.2	0	24.75	1	38.86	0	60	/	60	2
U31	30	/	29	2	30	1	60	1	60	/	40	2
U32	15.3	0	5.34	0	4.93	0	7.91	0	7.72	0	8.5	0
U33	4.86	0	27.1	1	7.12	0	26.1	0	30	1	15.1	0
U34	19.22	0	17.03	0	30	/	45.02	0	58.62	1	47.5	0
U35	15.16	0	14.12	0	7.91	0	3.41	0	48.5	0	51.26	1
U36	9.59	0	23	1	30	/	60	2	39.15	1	60	2
U37	6.86	0	5.88	0	6.52	0	39.45	0	28.85	0	14.13	0
U38	15.32	0	23.1	0	5.4	0	4.71	0	4.94	0	4.1	0
U39	6.4	0	2.86	0	10.9	0	15.42	0	8.3	0	60	1
U40	3.66	0	30	/	12.43	0	56	0	44.02	1	23.11	0
U41	12.02	0	7.61	0	3.13	0	16.4	0	23.1	0	5.69	0
U42	3.66	0	3	0	12.43	0	56	0	44.2	/	23.11	0
U43	12.02	0	7.61	0	3.15	0	16.4	0	23.1	0	5.69	0
U44	11.1	0	30	/	9.22	0	44.3	1	15.16	0	21.9	0
SUM	**17.1261**	**7**	**16.09**	**9**	**14.94**	**16**	**38.61**	**22**	**39.71**	**27**	**32.65**	**24**
Std dev	**8.43**		**8.24**		**9.32**		**19.28**		**19.10**		**21.39**	
Min	**3.66**		**2.74**		**2.10**		**3.41**		**4.94**		**4.10**	
Median	**16.33**		**16.57**		**12.43**		**39.16**		**42.09**		**32.46**	
Max	**30.00**		**30.00**		**30.00**		**60.00**		**60.00**		**60.00**	

Appendix A-5 : Time and Incorrectness Row Data for Non-Edutainment (NE) Interface from Experimental Phase I

T = Time & W= No. of wrong answer & / = Missing or No answer

	Recognition Qestions						Recall Questions					
	Easy task		Modrate task		Difficult task		Easy task		Modrate task		Difficult task	
	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
USERS	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**
U1	29.38	1	16.66	0	17.56	0	60	2	10.43	0	18.92	0
U2	23.75	2	7.11	0	12.28	0	39.12	1	10.43	0	27.8	3
U3	13.84	0	13.42	1	5.49	0	60	2	60	2	25.16	0
U4	27.22	1	28.01	0	23.99	1	46.2	0	60	1	60	2
U5	18.83	0	15.19	0	30	/	47.43	0	60	2	60	1
U6	20.1	0	22.7	1	11.16	0	33.09	0	30	0	20.07	0
U7	17.65	0	13.42	0	17.53	0	54.37	0	32.29	0	52	1
U8	20.02	2	30	/	22.1	0	60	1	60	2	56	1
U9	30	/	23.75	1	30	/	48	2	36.61	0	44.23	1
U10	12.79	1	12.09	0	6.29	0	19.89	0	13.12	0	10.08	0
U11	18.13	0	23.47	1	18.87	1	28.82	2	60	/	60	2
U12	12.98	0	14.42	0	6.35	0	15.87	0	23.03	1	10.82	0
U13	13.22	1	26.5	2	3.99	0	50.69	2	36.11	1	10.78	2
U14	30	/	23.41	0	21.5	0	33.02	0	47.9	2	24.32	1
U15	20.16	1	9.22	0	12.41	0	14.7	0	26.75	0	55.37	3
U16	11.46	0	17.7	0	7.9	0	60	/	37.6	1	60	/
U17	6.88	0	5.46	0	7.11	0	36.71	0	47.5	2	60	3
U18	16.72	0	12.3	0	14.84	0	30.91	0	29.3	0	9.3	0
U19	7.15	0	13.8	0	8.31	0	60	2	42.91	1	8.98	0
U20	16.72	0	30	/	14.84	0	30.19	0	29.3	0	9.3	0
U21	7.15	0	13.8	0	8.31	0	60	/	42.19	2	8.95	0
U22	8.4	0	26.6	2	4.9	0	38.3	1	6.4	0	50.2	1
U23	2.55	0	5.77	0	4.99	0	53.92	3	15.57	1	60	3
U24	6.46	0	4.85	0	4.79	0	16.04	0	10.82	1	8.77	0
U25	30	/	20.32	1	20.22	2	56.82	3	46.74	3	44.98	3
U26	30	/	3.6	0	15.51	1	60	3	60	/	20.21	0
U27	14.75	1	19.49	0	23.39	1	60	/	60	/	60	/
U28	15.3	2	30	3	18.89	1	60	/	40	2	60	/
U29	11.7	0	12.6	0	17.35	0	60	/	60	/	60	/
U30	20.81	1	10	0	12.22	1	12.1	0	29.76	1	60	/
U31	8.14	0	6.62	0	6.61	0	32.76	3	19.19	0	7.7	0
U32	8.07	0	7.39	0	2.41	0	49	2	10.93	0	12.81	0
U33	15.41	1	16.86	1	16.39	1	58.27	3	54.1	2	60	2
U34	29	2	21.18	1	15.18	2	50	2	40	2	60	3
U35	14.04	1	18.68	1	16.44	1	28.3	2	30	/	13.1	0
U36	9.35	0	15.01	0	11.86	1	21	0	60	/	60	/
U37	5.2	0	7.14	0	6.19	1	60	1	60	/	60	/
U38	29.95	2	3.35	1	8.15	0	60	1	30	1	60	/
U39	10.43	0	3.42	0	19.25	1	35.1	1	41.13	2	34.05	1
U40	7.52	0	19.17	0	2.28	0	60	/	60	/	60	1
U41	2.42	0	2.48	0	2.2	0	60	/	5.59	0	12	0
U42	30	/	30	/	30	/	60	/	54.19	0	60	/
U43	13.95	0	18.46	0	23.27	2	14.09	0	60	/	13.12	0
U44	5.46	0	4.15	0	5.19	0	26.04	0	11.82	0	18.77	0
SUM	**15.98**	**19**	**15.44**	**16**	**13.38**	**17**	**43.65**	**39**	**37.77**	**32**	**37.45**	**34**
Std dev	**8.54**		**8.41**		**7.87**		**16.51**		**18.46**		**22.12**	
Min	**2.42**		**2.48**		**2.20**		**12.10**		**5.59**		**7.70**	
Median	**14.40**		**14.72**		**12.35**		**48.50**		**38.80**		**44.61**	
Max	**30.00**		**30.00**		**30.00**		**60.00**		**60.00**		**60.00**	

Appendix A-6 : Users' Satisfaction Raw Data for Edutainment (E) Platform

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

Edutainment Interface											
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Score
U1	5	5	5	4	5	4	4	5	5	5	4.7
U2	5	4	4	4	5	5	4	5	4	5	4.5
U3	4	4	4	1	4	4	4	5	4	5	3.9
U4	5	5	5	5	5	5	4	5	5	5	4.9
U5	4	3	4	4	4	3	4	5	4	4	3.9
U6	4	4	2	4	3	3	4	4	3	5	3.6
U7	4	4	2	3	4	4	4	4	4	5	3.8
U8	4	4	3	4	4	4	4	4	4	4	3.9
U9	4	4	4	3	4	4	4	4	4	4	3.9
U10	4	3	2	2	3	3	4	3	3	3	3
U11	5	5	5	4	4	5	5	5	5	5	4.8
U12	4	4	3	4	4	4	4	5	4	4	4
U13	3	2	2	3	3	2	2	2	2	3	2.4
U14	5	4	3	4	4	4	4	4	4	4	4
U15	2	3	4	3	3	4	4	4	3	4	3.4
U16	4	4	3	3	4	4	4	4	4	5	3.9
U17	4	3	3	3	4	3	3	4	4	4	3.5
U18	5	5	5	1	5	1	5	5	5	5	4.2
U19	5	4	4	1	4	3	5	5	4	4	3.9
U20	5	5	5	4	5	5	5	5	5	5	4.9
U21	4	5	3	4	5	5	4	5	5	4	4.4
U22	4	4	2	3	4	3	4	4	4	5	3.7
U23	5	4	2	3	4	4	4	5	5	5	4.1
U24	5	5	5	4	5	5	5	5	5	5	4.9
U25	5	5	5	3	4	4	5	5	4	4	4.4
U26	4	4	5	4	5	4	4	4	4	5	4.3
U27	4	4	5	4	4	5	4	5	4	5	4.4
U28	5	4	5	4	4	3	4	4	4	5	4.2
U29	4	4	4	2	3	3	4	4	4	4	3.6
U30	5	5	5	4	4	5	4	5	4	5	4.6
U31	2	5	2	5	5	5	4	5	4	5	4.2
U32	5	5	3	2	3	2	3	4	4	2	3.3
U33	5	3	4	4	3	5	5	4	3	4	4
U34	5	5	5	2	4	3	4	5	4	4	4.1
U35	5	4	4	4	4	3	4	5	4	5	4.2
U36	5	5	4	4	5	5	5	5	5	5	4.8
U37	4	2	2	4	3	4	4	4	3	3	3.3
U38	4	4	4	4	4	3	4	4	4	4	3.9
U39	3	4	3	4	5	5	4	4	4	5	4.1
U40	5	5	5	5	5	5	4	5	5	5	4.9
U41	5	4	3	4	4	5	4	5	4	5	4.3
U42	5	4	5	4	5	4	5	5	5	5	4.7
U43	5	5	5	5	5	5	4	5	4	5	4.8
U44	5	5	3	4	4	3	4	5	4	4	4.1
Average	4.386	4.159	3.75	3.5	4.136	3.909	4.114	4.5	4.091	4.455	4.1

Appendix A-7 : Users' Satisfaction Raw Data for Non-Edutainment (NE) Platform

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

	Non-Edutainment Interface										
USERS	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**Score**
U1	2	2	2	3	3	4	3	3	2	2	2.6
U2	3	2	3	4	3	2	3	2	2	3	2.7
U3	5	5	5	1	5	5	5	5	5	5	4.6
U4	5	5	5	5	5	5	5	5	5	5	5
U5	4	4	4	3	4	4	4	5	5	4	4.1
U6	4	3	3	4	4	2	4	2	2	4	3.2
U7	2	2	3	2	2	3	2	4	2	3	2.5
U8	4	4	3	4	4	4	4	4	4	4	3.9
U9	4	4	2	4	2	3	4	4	4	4	3.5
U10	4	4	3	3	3	2	3	3	3	4	3.2
U11	4	5	3	4	5	5	4	5	5	5	4.5
U12	4	4	3	4	4	4	5	5	4	5	4.2
U13	3	3	4	3	4	4	3	3	3	3	3.3
U14	4	4	3	4	4	4	4	4	4	4	3.9
U15	4	3	4	3	4	3	4	5	4	4	3.8
U16	5	4	3	3	4	4	3	5	4	4	3.9
U17	4	3	3	4	4	3	3	4	4	4	3.6
U18	4	2	2	2	4	1	4	4	2	2	2.7
U19	4	3	4	2	3	3	4	3	4	4	3.4
U20	5	5	5	4	5	5	5	5	5	5	4.9
U21	4	4	2	4	3	4	3	2	3	3	3.2
U22	5	3	2	2	4	2	3	4	4	4	3.3
U23	2	3	1	3	1	2	2	4	1	1	2
U24	5	5	4	2	5	5	5	5	4	4	4.4
U25	1	1	3	4	4	3	3	2	2	2	2.5
U26	4	3	4	2	2	2	4	1	2	3	2.7
U27	4	4	4	4	5	5	4	4	4	4	4.2
U28	5	4	5	3	4	3	5	3	4	5	4.1
U29	4	4	4	2	3	3	4	3	3	3	3.3
U30	5	5	5	4	5	5	5	4	4	4	4.6
U31	5	4	5	5	5	5	5	5	4	5	4.8
U32	4	2	2	2	1	3	4	2	3	3	2.6
U33	4	3	3	4	2	3	3	4	4	4	3.4
U34	5	1	2	4	4	4	4	4	3	3	3.4
U35	4	5	4	4	5	5	4	3	4	5	4.3
U36	5	5	4	4	5	5	5	5	5	5	4.8
U37	4	4	4	3	4	4	4	4	4	4	3.9
U38	3	3	3	3	3	2	2	4	2	3	2.8
U39	4	4	4	4	4	5	4	4	4	4	4.1
U40	4	2	3	3	3	4	4	3	3	4	3.3
U41	4	2	3	2	2	2	3	2	3	3	2.6
U42	4	2	1	2	2	4	4	2	4	4	2.9
U43	3	3	2	3	2	2	4	4	3	4	3
U44	4	2	2	3	1	2	4	2	4	3	2.7
Average	**3.955**	**3.386**	**3.25**	**3.227**	**3.523**	**3.5**	**3.818**	**3.636**	**3.5**	**3.75**	3.55

Appendix A-8 : Users' Memorability Raw Data and Final Result for Edutainment (E) Platform

1 = TRUE , 0 = INCORRECT , / = Missing

USERS	EXPRESSION 1	EXPRESSION 2
U1	/	1
U2	0	1
U3	0	/
U4	1	1
U5	0	0
U6	0	0
U7	1	1
U8	1	1
U9	0	1
U10	1	1
U11	0	0
U12	1	1
U13	1	1
U14	1	1
U15	1	1
U16	0	0
U17	1	/
U18	0	1
U19	0	0
U20	1	1
U21	1	1
U22	1	1
U23	1	1
U24	0	1
U25	1	1
U26	1	1
U27	/	/
U28	1	1
U29	1	1
U30	0	0
U31	1	1
U32	1	1
U33	/	/
U34	1	1
U35	1	1
U36	0	1
U37	1	1

U38	1	1
U39	1	1
U40	1	1
U41	1	1
U42	1	1
U43	0	1
U44	1	1
TRUE	28	34
INCORRECT	13	6
MISSING	3	4
%	63.64	77.27

The final result

	No. of Users	%
TRUE	**62**	**70.45**
INCORRECT	**19**	**21.59**
MISSING	**7**	**7.95**

Appendix A-9 : Users' Preferred Platform Experienced Raw Data with Final Result.

USER PREFER = 1 , NOT PREFER = 0

USERS	EDUTAINMENT	Non-EDUTAINMENT
U1	1	0
U2	1	0
U3	1	0
U4	1	1
U5	1	0
U6	1	0
U7	1	0
U8	1	1
U9	1	1
U10	0	1
U11	1	0
U12	0	1
U13	1	0
U14	1	1
U15	1	0
U16	1	0
U17	1	0
U18	1	0
U19	1	0
U20	1	0

U21	1	0
U22	1	0
U23	1	0
U24	1	0
U25	1	0
U26	1	0
U27	1	0
U28	1	0
U29	1	0
U30	1	1
U31	0	1
U32	1	0
U33	1	0
U34	1	0
U35	1	1
U36	1	0
U37	0	1
U38	1	0
U39	1	0
U40	1	0
U41	1	0
U42	1	0
U43	1	0
U44	1	0
Total	**34**	**4**
%	**77.27**	**9.09**

Users who preferred both interfaces

	No. of Users	**%**
Both	6	**13.64**

Appendix B :- Experimental Design Phase II: Comparing Virtual Classroom, Game-Based Learning and Storytelling Teachings in E-Learning.

Appendix B-1 : Questionnaire

Part 2	Tasks

Condition 1 Virtual Class with Avatar & Lesson 1

1. You will have to read and listen to lesson **one** which is **Geology , What is it?**, for maximum **5 minutes**, where every page designed to give you one section as text, and in the same time you will listen to the avatar all the time to read and explain the lesson .
2. After you have finished reading and listening, you are asked to answer some questions by pressing on the Quiz button:

Task 1: Multiple choice questions: chose at least 2 answers that you believe is correct and click on the check answer button to find out the result.

Task 2: Repeat the same steps in task 1.

Task 3: Single choice questions**:** chose just one answer that you believe is correct and click on the check answer button to find out the result.

Task 4: Repeat the same steps in task 3.

Task 5: True and falls questions**:** click on the answer (true or falls words) that you believe is correct and click on the check answer button to find out the result.

Task 6: Repeat the same steps in tasks 5.

Part 3	Satisfaction for Condition 1

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this system frequently	1	2	3	4	5
2	I found the system unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5	I found the various functions in this system were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this system	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the system	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this system	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the virtual class interface helped me to grasp the lesson more easily	1	2	3	4	5
13	The virtual lecture and discussion made it easier to me follow and understand the lesson	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Overall, I am satisfied with this system	1	2	3	4	5

Condition 2 Squares Game & Lesson 2

1. You will have to read lesson two which is titled **Earth Cycles,** for maximum 5 minutes, where every page designed to give you one section of the as **text only.**
2. After you have finished reading you are asked to answer some questions by pressing on the Quiz button where you will find **Squares Game**.

Task 1:

1. Read the question in the top of the page by moving the mouse over the **black rectangular or press** is colored button labeled **Tone** to hear to the sound or tone.
2. After you have finished reading the question move the mouse over 6 any of colored squares or colored button labeled **Tone**, to see the answer or to hear and mach the tone in the question given.
3. Click on the square if you believed it is the correct answer and if you have chosen to answer the question by hearing the tone, still you have to click the square to get the feedback.
4. Do the same operation if you have answered incorrect.
5. If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 2 - 6:

Repeat the same steps in task 6.

Part 5	Satisfaction for condition 2

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this Game frequently	1	2	3	4	5
2	I found the Game unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this Game	1	2	3	4	5
5	I found the various functions in this Game were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this Game	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the Game	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this Game	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the Square Game interface helped me to grasp the lesson more easily	1	2	3	4	5
13	In my opinion the Game is excellent tool to learn from	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Overall, I am satisfied with this system	1	2	3	4	5

Part 6	Tasks

Condition 3 Storytelling & Lesson 3

1. In this interface simply you required to listen to lesson **one** which is **Geology , What is it?**, for maximum **5 minutes**, where every page designed to give you one section as text, and in the same time you will listen to the teacher all the time to read for you and explain the lesson as story .
2. After you have finished reading and listening, you are asked to answer some questions by pressing on the Quiz button:

Task 1: Multiple choice questions: chose at least 2 answers that you believe is correct and click on the check answer button to find out the result.

Task 2: Repeat the same steps in task 1.

Task 3: Single choice questions**:** chose just one answer that you believe is correct and click on the check answer button to find out the result.

Task 4: Repeat the same steps in task 3.

Task 5: True and falls questions**:** click on the answer (true or falls words) that you believe is correct and click on the check answer button to find out the result.

Task 6: Repeat the same steps in tasks 8

Part 7	Satisfaction for condition 3

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this system frequently	1	2	3	4	5
2	I found the system unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5	I found the various functions in this system were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this system	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the system	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this system	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	The storytelling made it easier to me follow and understand the lesson	1	2	3	4	5
13	Storytelling interface helped me answering the quiz more easily	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Overall, I am satisfied with this system	1	2	3	4	5

Part 8	General feedback for all conditions

Please select the most preferred interface?

1 **Virtual classroom with avatar**

2 **Square game**

3 **Storytelling**

Please order the interfaces according your experience?
Preferred one = 1, Second = 2, Third= 3

1	**Virtual classroom with avatar**	
2	**Square game**	
3	**Storytelling**	

What were the problems that you experienced, if any?
………
………
……………………………………………………………………………………………
………
………
……………………………………………………………………………………………

Do you have any other comments, suggestion?
………
………
……………………………………………………………………………………………
………
………
……………………………………………………………………………………………

Thank you for taking part in this study.

Appendix B-2 : Lessons Examined in Second Experiment Rotated between All Platforms

Lesson 1: Introduction to Geology,

Geology, what is it?

Geology is the study of the Earth. It includes not only the surface process which have shaped the earth's surface, but the study of the ocean floors, and the interior of the Earth. It is not only the study of the Earth as we see it today, but the history of the Earth as it has changed to its present condition.

Important point (facts) to be considered:

- The Earth has evolved (changed) throughout its history and will continue to evolve.
- The Earth is about 4.6 billion years old; human beings have been around for only the past 2 million years.
- Thus, mankind has been witness to only 0.043% of Earth history.
- The first multi-celled organisms appeared about 700 million years ago. Thus, organisms have only been witness to about 15% of Earth's history.

Thus, for us to have an understanding of the earth upon which we live, we must look at processes and structures that occur today, and interpret what must have happened in the past. One of the major difficulties we have is with the time scale. Try to imagine 1 million years-- That's 50,000 times longer than most of you have lived. It seems like a long time doesn't it?

Yet, to geologists, 1 million years is a relatively short period of time. But one thing we have to remember when studying the earth is that things that seem like they take a long time to us, may take only a short time to earth.

Let's give some examples:

- A river deposits about 1mm of sediment (mud) each year. How thick is the mud after 100 years? -- 10 cm hardly noticeable over your lifetime.
- What if the river keeps depositing that same 1 mm/yr for 10 million years? Answer 10,000 meters Things can change drastically!

Why Study the Earth?

Actually as I said we're part of it. Dust to Dust. Humans have the capability to make rapid changes. All construction from houses to roads to dams is effected by the Earth, and thus requires some geologic knowledge. All life depends on the Earth for food and nourishment. The Earth is there everyday of our lives.

- Energy and Mineral resources that we depend on for our lifestyle come from the Earth. At present no other source is available.
- Geologic Hazards -- Earthquakes, volcanic eruptions, hurricanes / cyclones, landslides, could affect us at any time. A better understanding of the Earth is necessary to prepare for these eventualities.
- Curiosity-- We have a better understanding of things happening around us.
- Science in general. I'll try to relate geology (and science in general) to our everyday lives.

Earth Materials and Processes

- The materials that make up the Earth are mainly rocks (including soil, sand, silt, dust). Rocks in turn are composed of minerals. Minerals are composed of atoms…………………and so on.
- Processes range from those that occur rapidly to those that occur slowly

Examples of slow processes are:

- Formation of rocks
- Chemical breakdown of rock to form soil (weathering)
- Chemical cementation of sand grains together to form rock (diagenesis)
- Recrystallization to rock to form a different rock (metamorphism)
- Construction of mountain ranges (tectonism)
- Erosion of mountain ranges

Examples of faster processes are:

- Beach erosion during a storm.
- Construction of a volcanic cone
- Landslides (avalanches)
- Dust Storms
- Mudflows

Processes such as these are constantly acting upon and within the Earth to change it. Many of these processes are cyclical in nature.

Lesson 2: Hydrologic Cycle

Rain comes from clouds - falls on surface, picks up sand, silt and clay, carries particles and sometimes people to river and into ocean. Water then evaporates to become clouds, which move over continents to rain again.

Rock Cycle

Most surface rocks started out as igneous rocks- rocks produced by crystallization from a liquid. When are exposed at the surface they are subject to weathering (chemical and mechanical processes that reduce rocks to particles). Erosion moves particles into rivers and oceans where they are deposited to become Sediment. Sedimentary rocks can be buried or pushed to deeper levels in the Earth, where changes in pressure and temperature cause them to become metamorphic rocks. At high temperatures may melt to become magmas. Magmas rise to the surface, crystallize to become igneous rocks and the processes starts over.

Acutely there are two types of processes help to create this circulation

External Processes

- Erosion- rocks are broken down (weathered) into which are then carried by wind, water, ice and gravity. External because erosion operates at the Earth's surface. The energy source for this process is solar and gravitational.

Internal Processes

- Processes that produce magmas, volcanoes, earthquakes and build mountain ranges. Energy comes from the interior of the Earth, Most from - nuclear energy.

Energy

All processes that occur on or within the Earth require energy. Energy can exist in many different forms:

Gravitational energy –this type of Energy released when an object falls from higher elevations to lower elevations.

Heat energy – Energy exhibited by moving atoms, the more heat energy an object has, the higher its temperature.

Chemical Energy -- Energy released by breaking or forming chemical bonds.

Radiant Energy -- Energy carried by electromagnetic waves (light). Most of the Sun's energy reaches the Earth in this

Atomic Energy -- Energy stored or released in binding of atoms together. Most of the energy generated within the Earth comes from this source.

Lesson 3: The Earth -- What is it?

The Earth has a radius of about 6371 km, although it is about 22 km larger at equator than at poles.

- Compositional Layering
- Crust - variable thickness and composition
- Continental 10 - 50 km thick
- Oceanic 8 - 10 km thick
- Mantle - 3488 km thick, made up of a rock called peridotite
- Core - 2883 km radius, made up of Iron (Fe) and small amount of Nickel (Ni)
- Layers of Differing Physical Properties
- Lithosphere - about 100 km thick (deeper beneath continents)
- Asthenosphere - about 250 km thick to depth of 350 km - solid rock, but soft and flows easily.
- Mesosphere - about 2500 km thick, solid rock, but still capable of flowing.
- Outer Core - 2250 km thick, Fe and Ni, liquid
- Inner core - 1230 km radius, Fe and Ni, solid

All of the above is known from the way seismic (earthquake waves) pass through the Earth as we will discuss later in the course.

Surface Features of the Earth

Oceans cover 71% of Earth's surface -- average depth 3.7 km. Land covers remaining surface with average of 0.8 km above sea level.

Plate Tectonics

Tectonics = movement and deformation of the crust, incorporates older theory of continental drift.

Plates: are lithospheric plates - about 100 km thick, which move around on top of the asthenosphere.

Plate tectonics explains why earthquakes occur where they do, why volcanoes occur where they do, how mountain ranges form, as well as many other aspects of the Earth. It is such an important theory in understanding how the Earth works that we cover it briefly here, but will return for a better understanding of later in the course.

Appendix B-3 : Frequency Table for Users' Profiles

Data Description		No. of	%
Age	18-24	8	16.67
	25-34	22	45.83
	35-44	15	31.25
	45-54	3	6.25
	Total	48	100.00
Gender	Male	46	95.83
	Female	2	4.17
	Total	48	100.00
Educational Level	PhD	21	43.75
	Master	26	54.17
	Undergraduate	1	2.08
	Total	48	100.00
Area of study	Computer	25	52.08
	Engineering	7	14.58
	Biology	3	6.25
	Chemistry	1	2.08
	Management	1	2.08
	Social S.	1	2.08
	Geography	4	8.33
	Communication	4	8.33
	Mathematics	2	4.17
	Total	48	100.00
Use of computer/week	6 -10 hours	3	6.25
	1 - 5 hours	1	2.08
	10 +hours	44	91.67
	Total	48	100.00
Use of Internet/week	6 -10 hours	3	6.25
	1 - 5 hours	1	2.08
	10 +hours	44	91.67
	Total	48	100.00
Knowledge about Geology	Excellent	1	2.08
	Good	11	22.92
	Limited	27	56.25
	No	9	18.75
	Total	48	100.00
Prior experience in E-Learning applications?	yes	16	33.33
	No	32	66.67
	Total	48.00	100.00
	Excellent	2	4.17

Experience on avatars and facial expressions	Good	5	10.42
	Limited	20	41.67
	No	21	43.75
	Total	48.00	100.00

Appendix B-4 : Time and Incorrectness Row Data for Virtual Class (VC) Interface

T = Time & W= No. of wrong answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
USERS	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**
U1	24.1	1	35.23	1	13.43	2	3.77	0	13.7	0	7.9	0
U2	14.1	1	17.01	0	15.1	2	4.3	0	30.1	0	22.7	0
U3	25.2	2	12	2	9.8	1	5.1	0	17.42	0	9.1	0
U4	32.21	1	26.1	/	13.01	0	22.8	0	24	/	28.05	1
U5	18.3	/	8.5	0	5.52	/	7.2	1	6.1	0	3.9	0
U6	19.1	2	8.9	0	4.52	0	8.2	1	5.1	0	4.9	0
U7	30	1	25	1	25.07	1	7.2	0	6.1	1	3.9	1
U8	20.9	1	15.9	2	22.9	1	3.7	0	6.54	0	8	0
U9	31.9	1	16.82	1	21.5	2	3.9	0	8.6	0	9.2	0
U10	13.18	0	10.07	0	13.1	0	16.71	0	8.51	0	7.4	0
U11	32	2	32.1	2	22.9	0	4.61	0	20.13	0	8.75	1
U12	20.1	0	16.1	2	9.27	0	4.63	0	13.51	0	19.21	1
U13	28.33	2	24.7	1	36.19	1	27.23	1	27.23	0	16.12	1
U14	30.11	0	29.5	0	6.8	0	13.22	1	10.77	0	15	1
U15	29.26	0	18.45	0	15.81	2	12.34	0	13.95	0	7.04	0
U16	6.2	0	7.6	0	12.1	0	4.9	0	6.15	/	2.26	0
U17	20	1	28	2	21.63	2	28.16	2	3.8	1	4.18	0
U18	18	0	18.1	1	17.16	2	21.25	2	6.3	0	10.9	0
U19	18.33	0	8.78	0	15.46	2	7.8	1	5.95	/	8.65	/
U20	11.1	0	29	1	7.64	1	20.55	1	17	0	3.88	0
U21	5.5	0	26.14	0	10.15	0	8.7	0	15.9	0	14.27	1
U22	16.45	1	8.07	0	27.88	0	12.61	0	0.18	1	10.71	0
U23	19.5	2	6.66	0	17.31	1	26.42	0	15.82	0	7.41	0
U24	25.2	1	16.31	0	10.57	0	15.6	0	17.73	/	7.17	0
U25	18.56	1	11.15	0	6.16	0	17.1	1	20.61	0	9.55	1
U26	13.6	1	8.29	2	20.7	0	10.44	0	17.01	0	19	/
U27	15.1	2	10.76	2	7.17	1	9.13	0	15.98	0	2.7	0
U28	25.63	0	20.61	1	13.18	1	6.4	1	5.34	0	10.36	0
U29	8.19	2	15.59	0	10.91	2	17.53	1	6.16	0	8.56	0
U30	23.15	/	18.3	0	13.72	1	6.62	0	7.81	0	4.2	0
U31	16.7	/	7.86	0	8.8	0	5.9	0	18.19	0	4.3	1
U32	18.35	0	7.25	0	22.48	0	19.3	0	9.12	0	10.12	0
U33	11.2	2	15.5	1	5.44	1	16.33	1	9.4	1	9.18	0
U34	12.3	2	10.32	0	17.27	0	18.45	0	25.77	0	20.5	0
U35	5.99	0	9.91	0	10.8	1	17.12	1	11.15	1	4.16	1
U36	8	0	8.98	1	10.71	0	4.11	0	6.13	0	2.7	1
U37	21.15	1	17.8	0	8.7	0	2.97	0	14.7	0	6.6	0
U38	32.82	1	18.37	0	22.86	1	3.86	0	23.61	1	7.15	0
U39	16.71	0	18.91	0	27.15	2	4.1	0	16.64	0	5.44	0
U40	15.13	0	19.7	/	28.2	2	22.2	1	8.14	0	4.7	0
U41	12.91	0	16.82	0	9.71	0	13.5	0	9.52	0	3.6	0
U42	22.35	1	20.01	2	17.45	0	11.39	0	11.4	/	5.11	0
U43	30	2	24.3	2	5.97	0	23.32	1	14.9	1	4.7	0
U44	31.36	1	26.8	1	12.14	0	25.16	1	22.13	1	11	1
U45	20.42	0	10.6	0	15.9	0	5.2	0	7.1	0	16.91	1
U46	21.86	0	16.4	0	30.11	2	9.21	0	19.14	0	2.9	0
U47	13.9	0	21.15	1	28.13	1	12.8	0	20.9	1	21.77	1
U48	24.44	1	22.24	/	25.33	1	10.2	0	9.66	0	3.4	0
SUM	**19.77**	**18.8**	**17.14**	**15.1**	**15.7**	**18.75**	**12.15**	**9.38**	**13.15**	**4.688**	**9.15**	**7.292**
Std dev	**7.62**	**81.25**	**7.43**	**84.896**	**7.76**	**81.25**	**7.46**	**90.63**	**6.93**	**95.313**	**6.08**	**92.708**
Min	**5.50**		**6.66**		**4.52**		**2.97**		**0.18**		**2.26**	
Median	**19.30**		**16.82**		**13.58**		**10.32**		**12.46**		**7.66**	
Max	**32.82**		**35.23**		**36.19**		**28.16**		**30.10**		**28.05**	

Appendix B-5 : Time and Incorrectness Row Data for Game- Based Learning (GBL) Interface

T = Time & W= No. of wrong answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
USERS	T	W	T	W	T	W	T	W	T	W	T	W
U1	11.2	0	19.1	1	40.1	0	35.2	0	17.23	1	25.1	0
U2	22.32	0	53	0	44.6	0	29	0	27.9	0	40	0
U3	13.4	1	43.5	0	18.6	0	16.7	0	43	1	41	1
U4	27.3	0	41.9	0	28.3	0	47	1	35.09	0	26.7	0
U5	16.3	0	13.02	0	8.9	0	21.1	0	26.08	0	23.3	0
U6	16.4	0	12.7	0	32.3	0	9.9	0	14.53	0	5.7	0
U7	30.1	0	30	0	40	0	45	0	50	1	55	0
U8	40.62	0	21.5	0	13.1	0	50	1	22.18	0	25.37	0
U9	4.9	0	27.95	0	23.31	0	14.89	0	33.21	0	24.96	0
U10	6.17	0	18.5	0	25.9	0	13.17	0	30	1	14.1	0
U11	31.21	0	38.98	0	40	0	16	0	25.8	0	24.6	0
U12	25.81	0	61.09	0	60	0	50	2	45	1	56	2
U13	16.42	0	30.94	0	20.29	0	44	0	26.08	1	25.66	0
U14	3.9	/	23.22	0	29.51	0	24.54	0	42.03	0	2.8	0
U15	6.7	0	27.9	1	23	1	40.51	1	10.43	0	28.1	1
U16	36.66	0	6.04	0	23.15	0	16.09	0	13.53	0	10.35	0
U17	7.5	0	9.1	0	45	3	15.41	0	15.3	0	16	0
U18	33.5	0	13.03	0	17.12	0	8.01	0	6.6	0	2.4	0
U19	28.7	0	18.99	0	32	0	9.28	0	10	0	12.2	0
U20	15.16	0	10.61	0	20.42	0	16.45	1	7.3	1	25.39	1
U21	38.09	0	30.3	0	18.3	0	26	0	14.16	0	5.3	1
U22	23.15	0	36.7	0	22.1	0	0.25	0	33	1	19.21	1
U23	9.1	1	28	0	25.16	0	40.11	0	19.9	0	22.6	0
U24	16.27	0	12	0	20.36	0	21.35	1	44	0	17.15	0
U25	29.15	0	27.55	0	29.54	0	10.17	0	16	0	23.43	0
U26	16.33	0	13.56	0	30.61	0	18.5	0	27.2	0	9.25	0
U27	27.22	0	23.91	0	16.4	0	35	1	25.96	0	30.45	0
U28	31.12	1	13.7	0	34.3	0	16	0	30.24	1	15.26	0
U29	28.2	1	19.8	1	20	0	24.61	0	17.5	0	13.65	1
U30	25.11	0	10.4	0	20.37	0	30.27	0	28.12	0	18.72	0
U31	7.3	0	16.33	0	21.93	0	14.18	0	16.1	1	8.4	0
U32	13.11	0	26.88	0	13.61	0	22.32	1	33.1	2	29.63	1
U33	26	0	25.19	0	40.2	1	23.3	1	37.8	1	25	0
U34	40	0	20.9	0	29.7	0	13.5	2	25.33	0	5.35	0
U35	40.61	0	21.29	1	36.1	1	19.1	0	17.52	/	19.2	1
U36	19.2	0	30.56	1	41.17	0	28	0	10.7	1	23.52	0
U37	30.11	0	17.7	0	37.2	1	35.6	0	16.7	0	27.2	0
U38	27.15	0	20.5	0	39.16	0	34.21	0	41.9	0	33.4	0
U39	16.23	0	22.3	0	9.87	0	8.31	0	29.1	0	44	0
U40	19.42	0	33.6	0	11.6	0	20.62	0	23.19	/	33.31	0
U41	40.12	1	35.2	0	19.5	0	7.83	0	19.24	0	27.42	1
U42	33.3	0	8.9	0	27.3	0	15.8	0	24.19	0	38.6	/
U43	30.6	0	14.4	0	22.76	0	24.08	0	22.91	0	17.1	0
U44	29.2	0	13.61	0	33.41	0	41.81	1	25.43	0	9.54	0
U45	19.96	0	19.8	0	39.82	0	29.01	1	42.37	0	12.53	0
U46	18.8	1	20.1	0	40.1	2	30.4	0	36.1	1	14.15	0
U47	25.3	0	26.22	0	42.47	0	63.67	0	35.07	0	31.46	0
U48	6.1	0	30.71	1	14.9	0	21.01	0	28	0	42.2	1
SUM	**22.51**	**3.125**	**23.77**	**3.125**	**27.99**	**4.688**	**24.94**	**7.292**	**25.88**	**7.813**	**22.95**	**6.25**
Std dev	**10.57**		**11.43**		**11.09**		**13.54**		**10.88**		**12.61**	
Min	**3.90**		**6.04**		**8.90**		**0.25**		**6.60**		**2.40**	
Median	**24.13**		**21.40**		**26.60**		**21.84**		**25.88**		**23.48**	
Max	**40.62**		**61.09**		**60.00**		**63.67**		**50.00**		**56.00**	

Appendix B-6 : Time and Incorrectness Row Data for Storytelling (ST) Interface

T = Time & W= No. of wrong answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
USERS	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**
U1	16.4	1	16.23	1	20.06	1	9.52	0	6.72	0	10.03	0
U2	37	2	25.5	0	7.3	1	9.25	0	7.6	0	12.5	0
U3	20.11	0	34.21	1	9.89	2	3.6	0	9.3	1	11.7	0
U4	49.1	2	44.1	0	20.12	0	22.06	0	12.1	0	17.86	1
U5	18.9	0	24.9	1	15.1	/	21.12	1	4.1	0	5.8	0
U6	22.1	2	17.03	0	29.2	0	12.08	0	8.19	1	8.5	0
U7	28.1	1	30.63	1	25.01	2	3.12	0	10.97	0	10.06	0
U8	18.01	0	21.54	/	11.38	0	8.09	0	9.9	1	14	0
U9	32.1	/	25.19	2	7.35	/	9.25	0	7.66	0	12.54	1
U10	8.5	0	10.11	0	8.21	0	3.5	0	7.14	0	6.72	0
U11	7.4	1	31.1	1	8.1	1	13.32	0	7.65		14.1	0
U12	34.73	2	35.05	3	22.81	2	42.04	1	31.91	0	13	0
U13	21.21	0	42	1	50	3	3.16	0	17.33	0	17.28	0
U14	20	/	37.71	3	10.4	2	2.721	0	10.8	0	11.2	0
U15	23.2	2	24	1	26.18	1	27.91	2	7.66	0	6.88	1
U16	1.9	1	3.6	0	7.6	0	1.3	/	7	0	3.3	/
U17	10.22	1	20.1	1	8.4	1	5.73	0	10.25	0	11	0
U18	17.3	1	24.85	2	14.13	3	7.78	0	5.33	0	8.1	0
U19	12.21	0	15	2	3.9	0	10.6	2	11.5	0	9.13	1
U20	20.33	2	15.9	/	25.23	2	11.6	0	16.46	1	10.18	0
U21	34.15	2	36.7	1	21.2	1	40.2		15.19	1	12.36	0
U22	31.35	1	30.16	1	21.71	0	38.17	0	17.8	0	13.24	0
U23	35.22	1	40.66	0	30.17	0	20.5	1	31.97	0	17.3	0
U24	18.36	0	22.01	0	18.5	0	23.4	0	4.76	0	10.31	0
U25	27.32	/	30.76	0	21.89	0	5.12	0	10.28	1	6.26	1
U26	16.41	/	18.24	1	25.19	1	9.22	0	7.18	/	17.12	1
U27	7.13	0	30.24	1	9	2	13.26	/	25.6	/	21.21	/
U28	24.2	0	21.88	3	16.4	3	30.15	/	10.31	0	4.81	/
U29	3.99	2	5.97	2	7.77	2	12.27	/	9.14	/	7.25	/
U30	31.55	0	40	1	25.38	1	27.37	0	17.29	1	24.16	/
U31	20	1	27.4	1	20.41	0	13.72	1	4.82	1	12.18	0
U32	29.13	2	31.31	0	22.61	0	17.7	0	10.91	1	3.81	0
U33	7.51	0	21.75	3	10.1	0	12.72	0	9.2	1	14.15	1
U34	22.1	2	17.26	0	29.3	1	13	2	9.2	0	9.33	1
U35	8.29	2	14.19	0	18.26	2	3.75	0	21.34	/	11.6	1
U36	23.23	1	20.98	1	17.11	1	26.15	0	7.88	/	6.39	/
U37	15.4	0	17.5	1	7.88	0	3.5	0	25.24	/	21.11	/
U38	17.37	1	5.82	0	18.6	1	6.2	0	16.8	1	31.31	/
U39	33.1	1	20.21	0	8.3	0	17.2	1	6.81	0	5.85	0
U40	28.22	1	23.87	0	21.9	0	7.9	/	4.36	/	17.15	1
U41	23.12	2	10.1	0	15.21	0	2.1	/	4.8	0	6.51	0
U42	7.31	/	9.3	/	16.42	/	3.6	/	20	1	19.1	/
U43	9.59	0	28.5	2	16.3	1	3.15	0	17.3	/	14.92	0
U44	18.23	0	31.7	1	22.11	1	16.3	1	13.61	/	14.12	0
U45	31.1	1	33.6	2	20.01	0	10.8	0	30.1	/	32.72	1
U46	24.4	0	15.13	0	21.73	2	4.84	1	27.1	/	12.3	0
U47	27.2	1	41.7	2	17.5	2	5.6	0	20.6	/	6.9	0
U48	16.7	0	30.66	0	9.02	1	6.55	0	22.7	2	25.8	1
SUM	**21.05**	**20.31**	**24.51**	**22.40**	**17.51**	**22.40**	**12.96**	**6.77**	**13.16**	**7.29**	**12.77**	**6.25**
Std dev	**9.98**		**10.24**		**8.49**		**10.36**		**7.67**		**6.57**	
Min	**1.90**		**3.60**		**3.90**		**1.30**		**4.10**		**3.30**	
Median	**20.22**		**24.43**		**17.88**		**10.06**		**10.30**		**11.94**	
Max	**49.10**		**44.10**		**50.00**		**42.04**		**31.97**		**32.72**	

Appendix B-7 : Users' Satisfaction Raw Data for Virtual Class (VC) Interface

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

	System Usability Scale (SUS) Statements											Additional Statements						
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	SCORE
U1	3	4	4	4	3	3	4	3	4	1	82.5		4	5	5	1	5	4
U2	3	3	3	3	3	3	2	3	3	1	67.5		2	2	2	2	2	2
U3	3	3	3	3	3	3	3	3	4	3	77.5		4	4	4	2	4	3.6
U4	1	3	3	3	3	3	3	3	3	3	70		3	4	3	2	4	3.2
U5	3	2	3	3	3	3	4	3	3	2	72.5		5	5	4	1	4	3.8
U6	3	4	4	4	3	3	4	3	4	4	90		5	5	5	1	5	4.2
U7	2	0	3	3	3	2	3	3	3	3	62.5		4	4	4	3	4	3.8
U8	3	4	4	4	3	3	4	3	4	4	90		4	5	4	1	5	3.8
U9	3	4	4	4	3	3	4	3	4	3	87.5		5	5	5	1	5	4.2
U10	3	3	3	3	1	2	3	3	1	4	65		4	4	5	1	5	3.8
U11	3	4	3	4	3	3	3	3	4	1	77.5		5	3	3	1	4	3.2
U12	4	4	4	3	4	4	3	4	4	4	95		4	2	4	3	2	3
U13	1	0	2	3	2	1	3	2	1	1	40		5	4	5	1	5	4
U14	3	3	3	2	3	2	3	3	3	1	65		2	3	4	2	4	3
U15	4	4	4	3	4	4	3	4	4	1	87.5		5	4	4	2	5	4
U16	4	3	3	3	3	3	3	3	3	3	77.5		4	3	3	2	4	3.2
U17	1	3	0	1	1	2	0	2	0	1	27.5		1	2	2	4	3	2.4
U18	3	3	4	4	3	4	4	4	3	4	90		3	5	5	3	5	4.2
U19	3	4	4	4	3	3	4	3	4	4	90		2	2	4	1	4	2.6
U20	3	3	3	3	3	3	2	3	3	1	67.5		5	5	5	1	5	4.2
U21	3	3	3	3	3	3	3	3	4	3	77.5		1	2	2	3	2	2
U22	1	3	3	3	3	3	3	3	3	3	70		4	4	4	2	4	3.6
U23	3	2	3	3	3	3	4	3	3	2	72.5		2	4	3	2	3	2.8
U24	3	4	4	4	3	3	4	3	4	4	90		5	5	4	1	4	3.8
U25	2	0	3	3	3	2	3	3	3	3	62.5		5	5	5	1	5	4.2
U26	3	4	3	4	3	3	4	3	4	4	87.5		4	4	3	3	4	3.6
U27	3	4	3	4	3	3	4	3	4	3	85		3	5	3	1	5	3.4
U28	3	3	3	3	1	2	3	3	1	4	65		5	5	5	1	3	3.8
U29	3	4	3	4	3	3	3	3	4	1	77.5		4	4	5	2	5	4
U30	4	4	4	4	4	4	4	4	4	4	100		3	3	3	1	4	2.8
U31	1	0	2	3	2	1	3	2	1	1	40		4	2	4	3	2	3
U32	3	3	3	2	3	2	3	3	3	1	65		5	4	5	1	5	4
U33	4	3	4	4	3	4	4	4	4	4	95		2	3	4	2	4	3
U34	4	3	3	3	3	3	3	3	3	3	77.5		1	4	4	2	5	3.2
U35	1	3	0	1	1	2	0	2	0	1	27.5		4	3	3	2	4	3.2
U36	3	3	4	4	3	4	4	4	4	4	92.5		1	2	2	4	3	2.4
U37	3	4	4	4	3	3	4	3	4	4	90		3	5	5	1	4	3.6
U38	3	3	3	3	3	3	2	3	3	1	67.5		2	2	4	3	5	3.2
U39	3	3	3	3	3	3	3	3	4	3	77.5		1	5	5	1	5	3.4
U40	1	3	3	3	3	3	3	3	3	3	70		2	2	2	2	2	2
U41	3	2	3	3	3	3	4	3	3	2	72.5		4	3	4	2	4	3.4
U42	3	4	4	4	3	3	4	3	4	4	90		1	4	3	3	4	3
U43	2	0	3	3	3	2	3	3	3	3	62.5		5	3	4	1	3	3.2
U44	3	4	4	4	3	3	4	3	4	4	90		3	5	5	1	5	3.8
U45	3	4	4	4	3	3	4	3	4	3	87.5		2	3	3	2	3	2.6
U46	3	3	3	3	1	2	3	3	1	4	65		3	5	5	1	4	3.6
U47	3	4	3	4	3	3	3	3	4	1	77.5		4	5	5	1	3	3.6
U48	4	3	4	4	3	4	4	4	4	4	95		4	2	5	3	3	3.4
AVERAGE	2.79	3.00	3.19	3.29	2.81	2.85	3.23	3.06	3.17	2.71	75.26	AVERAGE	3.40	3.73	3.94	1.81	3.98	3.3708
MEDIAN	3	3	3	3	3	3	3	3	3.5	3		MEDIAN	4	4	4	2	4	
MODE	3	3	3	3	3	3	3	3	4	4		MODE	4	5	5	1	4	
Min	1	0	0	1	1	1	0	2	0	1		Min	1	2	2	1	2	
Max	4	4	4	4	4	4	4	4	4	4		Max	5	5	5	4	5	

Appendix B-8 : Users' Satisfaction Raw Data for Game-Based Learning (GBL) Interface

1 = STRONGLY DISAGREE **2 = DISAGREE** **3 = UNDECIDED** **4 = AGREE** **5 = STRONGLY AGREE**
S1 – S10: Statements of the satisfaction

System Usability Scale (SUS) Statements											Additional Statements						
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	SCORE
U1	2	1	1	2	1	1	2	1	1	2	35		2	5	5	2	4	3.6
U2	1	3	3	3	3	3	3	3	3	1	65		4	5	4	2	4	3.8
U3	3	3	3	2	3	3	3	3	2	1	65		2	3	5	2	5	3.4
U4	3	3	3	3	1	3	3	1	3	3	65		4	4	4	2	4	3.6
U5	4	3	4	3	4	4	4	4	4	0	85		5	5	5	1	5	4.2
U6	4	3	3	0	4	4	3	3	3	3	75		4	4	5	1	4	3.6
U7	2	1	3	3	1	3	3	3	3	3	62.5		4	4	4	2	5	3.8
U8	3	3	1	3	1	3	3	3	3	3	65		4	5	5	2	4	4
U9	4	4	3	4	4	4	4	4	3	3	92.5		4	4	4	1	5	3.6
U10	3	2	4	4	3	3	4	4	4	1	80		4	5	5	1	5	4
U11	4	4	4	3	3	4	3	3	3	0	77.5		5	4	4	1	4	3.6
U12	3	3	3	2	3	3	3	3	4	1	70		5	4	5	1	5	4
U13	3	4	3	4	2	3	4	4	4	4	87.5		4	5	5	1	5	4
U14	3	2	3	3	2	3	3	3	3	3	70		3	4	4	2	4	3.4
U15	4	3	4	3	3	3	4	2	4	3	82.5		4	5	4	2	5	4
U16	3	4	4	4	3	3	4	4	4	4	92.5		4	4	5	1	4	3.6
U17	4	2	3	3	2	3	4	4	3	2	75		4	5	3	1	4	3.4
U18	3	4	4	4	4	4	4	4	4	4	97.5		5	5	5	1	5	4.2
U19	2	1	1	2	1	1	2	1	1	2	35		2	5	5	1	5	3.6
U20	1	3	3	3	3	3	3	3	3	1	65		2	5	5	2	2	3.2
U21	3	3	3	2	3	3	3	3	2	1	65		4	4	4	2	4	3.6
U22	3	3	3	3	1	3	3	1	3	3	65		5	3	4	2	4	3.6
U23	4	3	4	3	4	4	4	4	4	0	85		4	4	4	2	4	3.6
U24	4	3	3	0	4	4	3	3	3	3	75		5	5	5	1	5	4.2
U25	2	1	3	3	1	3	3	3	3	3	62.5		4	4	5	1	4	3.6
U26	3	3	1	3	1	3	3	3	3	3	65		4	4	4	2	5	3.8
U27	4	4	3	4	4	4	4	4	3	3	92.5		4	5	5	2	4	4
U28	3	2	4	4	3	3	4	4	4	1	80		4	4	4	1	5	3.6
U29	4	4	4	3	3	4	3	3	3	0	77.5		4	5	5	1	5	4
U30	3	3	3	2	3	3	3	3	4	1	70		5	4	4	1	4	3.6
U31	3	4	3	4	2	3	4	4	4	4	87.5		5	4	4	1	5	3.8
U32	3	2	3	3	2	3	3	3	3	3	70		4	5	5	1	5	4
U33	4	3	4	3	3	3	4	2	4	3	82.5		3	4	4	2	4	3.4
U34	3	4	4	4	3	3	4	4	4	4	92.5		4	5	5	2	5	4.2
U35	4	2	3	3	2	3	4	4	3	2	75		4	5	4	1	4	3.6
U36	3	4	4	4	4	4	4	4	4	4	97.5		4	5	4	1	4	3.6
U37	2	1	1	2	1	1	2	1	1	2	35		5	5	5	1	5	4.2
U38	1	3	3	3	3	3	3	3	3	1	65		2	5	5	1	5	3.6
U39	3	3	3	2	3	3	3	3	2	1	65		3	2	5	2	4	3.2
U40	3	3	3	3	1	3	3	1	3	3	65		4	4	4	2	4	3.6
U41	4	3	4	3	4	4	4	4	4	0	85		2	3	5	2	4	3.2
U42	4	3	3	0	4	4	3	3	3	3	75		4	4	4	2	5	3.8
U43	2	1	3	3	1	3	3	3	3	3	62.5		5	5	5	1	5	4.2
U44	3	3	1	3	1	3	3	3	3	3	65		4	5	5	1	4	3.8
U45	4	4	3	4	4	4	4	4	3	3	92.5		4	5	4	2	5	4
U46	3	2	4	4	3	3	4	4	4	1	80		5	4	5	2	4	4
U47	4	4	4	3	3	4	3	3	3	0	77.5		3	4	5	1	5	3.6
U48	3	3	3	2	3	3	3	3	4	1	70		4	5	5	1	5	4
AVERAGE	3.08	2.85	3.06	2.88	2.60	3.17	3.33	3.06	3.17	2.15	73.385417	AVERAGE	3.90	4.40	4.54	1.46	4.46	3.75
MEDIAN	3	3	3	3	3	3	3	3	3	3		MEDIAN	4	4.5	5	1	4.5	
MODE	3	3	3	3	3	3	3	3	3	3		MODE	4	5	5	1	5	
Min	1	1	1	0	1	1	2	1	1	0		Min	2	2	3	1	2	
Max	4	4	4	4	4	4	4	4	4	4		Max	5	5	5	2	5	

Appendix B-9 : Users' Satisfaction Raw Data for Storytelling (ST) Interface

1 = STRONGLY DISAGREE   2 = DISAGREE   3 = UNDECIDED   4 = AGREE   5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

	System Usability Scale (SUS) Statements												Additional Statements					
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	SCORE
U1	4	1	5	1	4	2	5	2	5	1	75		2	2	2	1	2	1.8
U2	3	3	3	1	3	1	1	1	3	1	50		2	3	3	2	3	2.6
U3	3	3	3	1	3	1	1	1	3	1	50		2	2	2	4	3	2.6
U4	3	3	3	3	3	3	3	3	3	3	75		4	4	4	2	4	3.6
U5	3	1	3	2	3	3	4	4	4	2	72.5		5	4	4	1	4	3.6
U6	3	3	4	3	3	2	4	3	3	4	80		5	3	4	1	5	3.6
U7	3	1	3	3	1	3	3	3	3	3	65		4	4	4	2	4	3.6
U8	3	3	0	4	0	4	3	4	0	3	60		4	4	4	2	4	3.6
U9	3	0	1	0	3	3	1	2	4	0	42.5		4	3	5	2	5	3.8
U10	3	4	4	3	4	3	3	4	4	2	85		4	4	5	1	5	3.8
U11	3	0	3	3	3	3	3	3	4	1	65		3	3	4	2	3	3
U12	3	4	4	3	2	4	4	3	4	3	85		4	4	5	2	5	4
U13	3	2	3	3	3	2	3	3	3	2	67.5		5	5	5	1	4	4
U14	1	1	1	1	1	1	1	1	1	1	25		1	4	4	2	4	3
U15	1	1	1	2	2	1	1	3	3	3	45		3	2	3	3	3	2.8
U16	3	3	3	3	3	3	3	3	3	3	75		4	3	4	2	4	3.4
U17	2	2	3	3	3	3	2	2	3	1	60		4	3	3	3	4	3.4
U18	2	2	2	4	2	3	3	2	3	4	67.5		1	3	2	4	3	2.6
U19	4	1	5	1	4	2	5	2	5	1	75		2	2	2	4	2	2.4
U20	3	3	3	1	3	1	1	1	3	1	50		2	1	2	1	2	1.6
U21	3	3	3	1	3	1	1	1	3	1	50		2	3	3	2	3	2.6
U22	3	3	3	3	3	3	3	3	3	3	75		1	2	1	4	3	2.2
U23	3	1	3	2	3	3	4	4	4	2	72.5		4	4	4	2	4	3.6
U24	3	3	4	3	3	2	4	3	3	4	80		4	5	5	1	4	3.8
U25	3	1	3	3	1	3	3	3	3	3	65		5	4	4	1	5	3.8
U26	3	3	0	4	0	4	3	4	0	3	60		4	4	3	2	4	3.4
U27	3	0	1	0	3	3	1	2	4	0	42.5		4	4	4	2	4	3.6
U28	3	4	4	3	4	3	3	4	4	2	85		4	4	5	2	5	4
U29	3	0	3	3	3	3	3	3	4	1	65		4	4	3	1	5	3.4
U30	3	4	4	3	2	4	4	3	4	3	85		3	3	4	2	3	3
U31	3	2	3	3	3	2	3	3	3	2	67.5		4	4	5	2	5	4
U32	1	1	1	1	1	1	1	1	1	1	25		4	5	4	1	4	3.6
U33	1	1	1	2	2	1	1	3	3	3	45		1	4	4	2	4	3
U34	3	3	3	3	3	3	3	3	3	3	75		3	3	3	3	3	3
U35	2	2	3	3	3	3	2	2	3	1	60		4	2	4	2	4	3.2
U36	2	2	2	4	2	3	3	2	3	4	67.5		4	3	3	3	4	3.4
U37	4	1	5	1	4	2	5	2	5	1	75		1	3	3	4	3	2.8
U38	3	3	3	1	3	1	1	1	3	1	50		2	2	2	4	2	2.4
U39	3	3	3	1	3	1	1	1	3	1	50		2	2	2	1	2	1.8
U40	3	3	3	3	3	3	3	3	3	3	75		2	3	3	2	3	2.6
U41	3	1	3	2	3	3	4	4	4	2	72.5		2	2	1	4	3	2.4
U42	3	3	4	3	3	2	4	3	3	4	80		4	4	4	2	4	3.6
U43	3	1	3	3	1	3	3	3	3	3	65		3	2	5	1	4	3
U44	3	3	0	4	0	4	3	4	0	3	60		4	3	4	1	5	3.4
U45	3	0	1	0	3	3	1	2	4	0	42.5		4	4	3	2	4	3.4
U46	3	4	4	3	4	3	3	4	4	2	85		4	3	4	2	2	3
U47	3	0	3	3	3	3	3	3	4	1	65		4	4	5	2	5	4
U48	3	4	4	3	2	4	4	3	4	3	85		4	4	5	1	3	3.4
AVERAGE	2.81	2.08	2.79	2.35	2.58	2.54	2.73	2.65	3.17	2.08	64.48	AVERAGE	3.25	3.27	3.56	2.08	3.69	3.17
MEDIAN	3	2	3	3	3	3	3	3	3	2		MEDIAN	4	3	4	2	4	
MODE	3	3	3	3	3	3	3	3	3	1		MODE	4	4	4	2	4	
Min	1	0	0	0	0	1	1	1	0	0		Min	1	1	1	1	2	
Max	4	4	5	4	4	4	5	4	5	4		Max	5	5	5	4	5	

Appendix B-10 : Users responses Raw Data for Virtual Class (VC) Interface

USERS	Brow rising	Compress	Draw	Hand	Expressing	Laugh	Smile
U1	0	0	0	0	0	1	4
U2	0	0	0	0	0	0	3
U3	0	0	0	0	0	2	5
U4	0	0	0	0	0	0	7
U5	0	0	0	0	1	0	10
U6	0	1	0	0	0	0	12
U7	0	0	0	1	0	3	7
U8	0	0	0	0	0	0	6
U9	0	0	0	0	2	0	11
U10	0	0	0	0	0	3	15
U11	0	0	0	0	0	5	10
U12	0	0	0	1	0	0	12
U13	0	0	0	0	0	0	10
U14	0	0	0	0	3	0	7
U15	0	0	0	0	0	1	5
U16	0	0	0	0	0	0	3
U17	0	0	0	0	0	0	3
U18	1	0	0	0	0	2	3
U19	0	0	0	0	0	1	5
U20	0	0	0	0	0	1	10
U21	0	0	0	0	1	2	11
U22	0	0	0	0	0	1	7
U23	0	0	0	0	0	3	9
U24	1	0	1	0	0	0	12
U25	0	0	0	0	0	2	15
U26	0	0	0	0	0	0	2
U27	0	0	0	0	0	4	6
U28	0	0	0	0	1	0	8
U29	0	0	0	0	0	5	13
U30	1	0	0	0	0	0	4
U31	0	0	0	0	0	0	8
U32	0	0	0	0	0	3	7
U33	0	0	1	0	0	2	15
U34	0	0	0	0	0	4	14
U35	0	0	0	0	0	1	4
U36	0	0	0	0	0	0	3
U37	0	0	0	0	0	1	11
U38	0	0	0	0	0	1	2
U39	0	0	0	0	0	2	6
U40	0	1	0	0	0	0	11
U41	0	0	0	0	0	0	2
U42	0	0	0	0	0	1	15
U43	0	0	0	0	0	0	3
U44	0	0	0	0	0	0	8
U45	0	0	0	0	0	0	12
U46	0	0	0	0	0	1	6
U47	0	1	0	0	0	0	5
U48	0	0	0	0	0	1	7
Total	**3**	**3**	**2**	**2**	**8**	**53**	**374**

Appendix B-11 : Users responses Raw Data for Game-Based Learning (GBL) Interface

USERS	Brow rising	Compress lip	Draw back on chair	Hand touch face	Expressing vocally	Laugh	Smile
U1	0	0	0	0	0	0	2
U2	0	0	0	0	0	0	1
U3	0	0	0	0	0	1	3
U4	1	0	0	0	0	0	4
U5	0	0	0	0	0	0	7
U6	0	0	0	0	0	0	3
U7	0	0	0	0	0	0	2
U8	0	0	0	0	0	2	1
U9	0	0	0	0	0	0	0
U10	0	0	0	0	0	0	0
U11	0	0	0	0	0	0	2
U12	0	0	0	0	0	0	1
U13	0	0	0	0	0	1	3
U14	0	0	0	0	0	0	4
U15	0	0	0	0	0	0	5
U16	0	0	0	0	0	2	1
U17	1	0	0	0	0	1	3
U18	0	0	0	0	1	0	6
U19	0	0	0	0	0	0	2
U20	0	0	0	0	0	0	1
U21	0	0	0	0	0	2	2
U22	0	0	0	0	0	3	3
U23	0	0	0	0	0	0	5
U24	0	0	0	0	0	1	4
U25	0	0	0	0	0	2	6
U26	0	0	0	0	0	0	14
U27	0	0	0	0	0	2	8
U28	0	0	0	0	0	0	12
U29	0	0	0	0	2	1	2
U30	1	0	0	0	0	1	1
U31	0	0	0	0	0	1	9
U32	1	0	0	0	0	1	10
U33	0	0	0	0	0	0	2
U34	0	0	0	0	0	1	13
U35	1	0	0	0	3	2	11
U36	0	0	0	0	0	1	6
U37	0	0	0	0	0	1	1
U38	0	0	0	0	0	1	0
U39	0	0	0	0	0	2	2
U40	1	0	0	0	0	1	2
U41	0	0	0	0	0	2	1
U42	0	0	0	0	0	2	4
U43	0	0	0	0	0	3	3
U44	0	0	0	0	0	2	7
U45	1	0	0	0	0	4	5
U46	0	0	0	0	0	2	4
U47	0	0	0	0	0	3	3
U48	0	0	0	0	0	2	3
Total	**7**	**0**	**0**	**0**	**6**	**50**	**194**

Appendix B-12 : Users Responses Raw Data for Storytelling (ST) Interface

USERS	Brow	Compress	Draw	Hand	Expressing	Laugh	Smile
U1	1	0	1	1	0	0	0
U2	0	0	0	0	0	0	1
U3	0	0	0	1	0	0	0
U4	1	0	1	0	0	0	0
U5	0	0	0	0	0	0	0
U6	0	0	0	2	0	0	0
U7	0	0	1	0	0	0	0
U8	0	0	0	0	0	0	0
U9	0	0	0	0	0	0	1
U10	0	0	0	2	0	0	0
U11	0	0	0	1	0	0	0
U12	0	0	1	0	0	0	0
U13	1	0	0	3	0	0	0
U14	0	0	0	0	0	0	0
U15	0	0	0	1	0	0	0
U16	0	0	1	0	0	0	0
U17	1	0	0	0	0	0	0
U18	0	0	0	1	0	0	0
U19	0	0	1	0	0	0	0
U20	0	0	0	0	0	0	1
U21	0	0	0	0	0	0	0
U22	1	2	0	2	0	0	1
U23	1	0	0	0	0	0	0
U24	0	0	0	0	0	0	0
U25	2	0	0	0	0	0	0
U26	0	0	0	1	0	0	0
U27	0	0	0	0	0	0	0
U28	0	0	0	1	0	0	1
U29	0	1	0	0	0	0	0
U30	0	0	0	0	0	0	0
U31	0	0	0	0	0	0	0
U32	1	0	0	2	0	0	0
U33	0	0	0	0	0	0	0
U34	0	0	0	0	0	0	0
U35	1	0	0	0	0	0	0
U36	0	0	0	5	0	0	0
U37	0	0	0	0	1	0	0
U38	0	0	0	0	0	0	2
U39	0	0	0	0	0	0	0
U40	0	2	0	0	0	0	0
U41	0	0	0	0	0	0	1
U42	0	0	0	2	0	0	0
U43	0	0	0	0	0	0	0
U44	0	1	0	0	0	0	0
U45	0	0	0	2	0	0	0
U46	0	0	0	0	2	0	0
U47	0	0	0	0	0	0	0
U48	0	0	0	0	0	0	0
Total	10	6	6	27	3	0	8

Appendix B-13 : Users' Preferred Platform Experienced Raw Data between All Interfaces

VC = Virtual Class
GBL = Game-Based Learing
ST= Storytelling Interface

USERS	VC	GBL	ST
U1	1		
U2		1	
U3		1	
U4	1		1
U5		1	
U6	1		
U7			1
U8	1		
U9		1	
U10		1	
U11		1	
U12		1	
U13		1	1
U14	1		
U15	1		
U16		1	
U17		1	
U18	1		
U19	1		
U20		1	
U21		1	
U22	1		1
U23		1	
U24	1		
U25			1
U26	1		
U27		1	
U28		1	
U29		1	
U30		1	
U31		1	1
U32	1		
U33	1		
U34		1	
U35		1	
U36	1		
U37	1		
U38		1	
U39		1	
U40	1		1
U41		1	
U42	1		
U43			1
U44	1		
U45		1	
U46		1	

U47		1	
U48		1	
Total	18	27	8
%	37.50	56.25	16.67

Appendix B-14 : Users' Interfaces Preference Order Final Result for All Interfaces

VC = Virtual Class

GBL = Game-Based Learning

ST= Storytelling Interface

	VC	GBL	ST
Total	12	28	8
%	25.00	58.33	16.67

Appendix C :- Experimental Design Phase III: Multi-Modal Game-Based Learning in E-Learning Approach

Appendix C-1 : Questionnaire

Part 2	Tasks

<u>General Instructions for all Platforms</u>

1. Read a lesson for maximum 5 minutes, where every page designed to give you one section of the as **<u>text only.</u>**
2. After you have finished reading you are asked to answer some questions using the **Game** provided.
3. **Task 1:**
4. Read or/and listen to the question in the middle of the page by moving the mouse over and click on the **black circle**.
5. After you have finished reading and listening, click on the **tone button** to listen to the tone (if this applicable) and to see the first answer which will appear inside a circle above the question exactly.
6. The first circle will disappear after approximately 2-3 seconds and automatically the second circle will appear with second answer in clockwise direction until all answers completed.
7. Click on the center of the circle if you believe it is the correct answer and if you have chosen to answer the question by matching tones, still you have to click the circle to get the feedback.
8. Do the same operation if you have answered incorrect.
9. If you have answered correct, the program will automatically give you the next question until you have finished all of them.

Task 2-4:

Repeat the same steps in task 1.

Part 3	General feedback for Text +Speech

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this Game frequently	1	2	3	4	5
2	I found the Game unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this Game	1	2	3	4	5
5	I found the various functions in this Game were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this Game	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the Game	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this Game	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the Game interface helped me to grasp the lesson more easily	1	2	3	4	5
13	In my opinion the Game is excellent tool to learn from	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Speech + text made the game so easy	1	2	3	4	5
16	Overall, I am satisfied with this system	1	2	3	4	5

Part 4	General feedback for Text +Earcons

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this Game frequently	1	2	3	4	5
2	I found the Game unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this Game	1	2	3	4	5
5	I found the various functions in this Game were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this Game	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the Game	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this Game	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the Game interface helped me to grasp the lesson more easily	1	2	3	4	5
13	In my opinion the Game is excellent tool to learn from	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Missing of speech made the game so difficult	1	2	3	4	5
16	The existence of Earcons (Tones) in the game confused me	1	2	3	4	5
17	Overall, I am satisfied with this system	1	2	3	4	5

Part 5	General feedback for Text +Speech + Earcons

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this Game frequently	1	2	3	4	5
2	I found the Game unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this Game	1	2	3	4	5
5	I found the various functions in this Game were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this Game	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the Game	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this Game	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the Game interface helped me to grasp the lesson more easily	1	2	3	4	5
13	In my opinion the Game is excellent tool to learn from	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	Speech model included helped me to understand the questions and answer these questions	1	2	3	4	5
16	Overall, I am satisfied with this system	1	2	3	4	5
17	The existence of Earcons (Tones) in the game helped me to answers provided questions	1	2	3	4	5
18	Speech made the game so difficult	1	2	3	4	5
19	Overall, I am satisfied with this system	1	2	3	4	5

Part 6	General feedback for Text +Speech + Earcons + Avatar

For each statement below, please express your view by placing a circle in the appropriate column and number.

	Statement	Strongly Disagree	disagree	Undecided	Agree	Strongly Agree
1	I think that I would like to use this Game frequently	1	2	3	4	5
2	I found the Game unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this Game	1	2	3	4	5
5	I found the various functions in this Game were well integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this Game	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the Game	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this Game	1	2	3	4	5
11	The learning material is easy.	1	2	3	4	5
12	Questions and answers presented during the Game interface helped me to grasp the lesson more easily	1	2	3	4	5
13	I enjoyed the Game with Avatar (Human Like Expression) and it is excellent tool to learn from	1	2	3	4	5
14	This system is boring and I felt sleepy	1	2	3	4	5
15	The existence of Earcons (Tones) in the game helped me to answers provided questions	1	2	3	4	5
16	Speech made the game so difficult	1	2	3	4	5
17	Adding Text+ Speech + Earcons+ avatars with the game confused experience.	1	2	3	4	5
18	Overall, I am satisfied with this system	1	2	3	4	5

Part 7	General feedback for all conditions

Please circle the most preferred platform?

Platform (1) text only game.
Platform (2) text + speech game.
Platform (3) text + earcones game.
Platform (4) text + speech + earcones game.
Platform (5) text + speech + earcones + avatar game.

Please order the most preferred platform (Preferred one = 1, Second = 2, Third= 3) **according to your experience?**

Platform (1) text + speech game. →
Platform (2) text + earcones game. →
Platform (3) text + speech + earcones game. →
Platform (4) text + speech + earcones + avatar game. →

Part 8	General feedback for all conditions

What were the problems that you experienced, if any?

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……………………………………………………………………………………………………
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Do you have any other comments, suggestion?

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Thank you for taking part in this study.

Appendix C-2 : Lessons Examined in Second Experiment Rotated between All Platforms

Lesson 1: What is a volcano?

A volcano is a mountain that opens downward to a pool of molten rock below the surface of the earth. When pressure builds up, eruptions occur. Gases and rock shoot up through the opening and spill over or fill the air with lava fragments. Eruptions can cause lateral blasts, lava flows, hot ash flows, mudslides, avalanches, falling ash and floods. Volcano eruptions have been known to knock down entire forests. An erupting volcano can trigger tsunamis, flash floods, earthquakes, mudflows and rock falls.

Why do volcanoes erupt?

The Earth's crust is made up of huge slabs called plates, which fit together like a jigsaw puzzle. These plates sometimes move. The friction causes earthquakes and volcanic eruptions near the edges of the plates. The theory that explains this process is called plate tectonics.

What are plate tectonics?

The theory of plate tectonics is a interesting story of continents drifting from place to place breaking apart, colliding, and grinding against each other. The plate tectonic theory is supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates that move relative to one another. The plates are all moving in different directions and at different speeds. Sometimes the plates crash together pull apart or sideswipe each other. When this happens, it commonly results in earthquakes.

How many volcanoes are there?

There are more than 1500 active volcanoes on the Earth. We currently know of 80 or more which are under the oceans. Active volcanoes in the U.S. are found mainly in Hawaii, Alaska, California, Oregon and Washington.

Why does lava take a long time to cool down?

Lava cools slowly because lava is a poor conductor of heat. Lava flows slow down and thicken as they harden.

What is the largest active volcano?

The world's largest, active volcano is Mauna Loa in Hawaii, where famous coffee is grown in the rich volcanic soils. Mauna Loa is 13,677 feet above sea level. From its base below sea level to its summit, Mauna Loa is taller than Mount Everest.

What is the Ring of Fire?

The Pacific Ring of Fire is an area of frequent earthquakes and volcanic eruptions encircling the basin of the Pacific Ocean. The Ring of Fire has 452 volcanoes and is home to over 50% of the world's active and dormant volcanoes. Ninety percent of the world's earthquakes and 81% of the world's largest earthquakes occur along the Ring of Fire.

What is a tsunami?

A tsunami is a large ocean wave usually caused by an underwater earthquake or a volcanic explosion. Tsunamis are NOT tidal waves. Tidal waves are caused by the forces of the moon, sun, and planets upon the tides, as well as the wind as it moves over the water. With typical waves, water flows in circles, but with a tsunami, water flows straight. This is why tsunamis cause so much damage!

Lesson 2: Earthquake Facts

Earthquakes are one of the most dangerous of natural disaster which isn't dependent on the weather. Therefore, earthquakes can occur whether it's the cold, hot or rainy season.

An earthquake occurs due to the strain put on the ground by the tectonic plates when they get stuck. When this strain increases, the rocks give way and these results in an occurrence of fault lines. The earthquake results in the sudden release of the stored energy in the Earth's crust. This creates seismic waves and results in the shaking or a displacement of the ground. Earthquakes can cause shaking and ground rupture, fires, soil liquefaction, landslides and avalanches and tsunamis.

Further, earthquakes can also cause loss of life, disease, loss of basic amenities, property damage, as well as road and bridge damage, building collapses or the destabilization of the base of the building. Therefore, earthquakes result in personal as well as economic losses.

The recent earthquake related tsunami took place in 2004 in the Indian Ocean. The earthquake occurred within the sea, which in turn triggered a large number of tsunamis along the borders of the Indian Ocean. The tsunamis struck Sri Lanka, Indonesia, India and Thailand.

Seismologists depend on the seismogram, numeric modeling and other geodetic measurements to measure the capacity of magnitude of the earthquakes. Therefore, 'magnitude' is the quantitative expression of the earthquake, while the shaking capacity of the earthquake is called 'intensity'. The location below the Earth's surface, where the rupture of the fault begins is known as the hypocenter. The point directly above the hypocenter on the surface of the Earth is known as the epicenter.

There are about five hundred thousand detectable earthquakes globally every year. While a ten thousand of these can be felt, a hundred can cause serious damage. Most of the earthquakes occur at a distance of fifty miles from the Earth's surface. The earliest earthquake was recorded in the Shandong province of China back in 1831 BC.

The most earthquake prone zone in the world is Alaska. It is one of the most seismically active zones in the world. In the year 1960, during the Chilean earthquake, the seismic waves traveled around the globe for many days. This is known as free oscillation of the earth. The interiors of Antarctica have a phenomenon similar to earthquakes, known as the icequakes. The icequakes occur within the ice sheet, instead of the land under the ice sheet.

The first earthquake in America was experienced in 1663 by the European settlers. The largest recorded earthquakes in the United States of America, Alaska on March 28, and the magnitude of the earthquake were 9.2. Florida and North Dakota have the smallest amount of earthquakes in the United States of America. The largest recorded earthquake in the world was in Chile in 1960. The magnitude of the earthquake was 9.5. Such earthquakes also occur in Indonesia, Japan and Azores in Portugal.

The majority of earthquakes occur along the plate boundaries. The Pacific Plate is known as the Pacific Plate of Fire because it is one of the most active plate boundaries where earthquakes as well as eruptions are frequent.

Lesson 3: Types of Rocks

Rocks and Minerals

Let's start off with an explanation that rocks and minerals are different things. Rocks are groups of different minerals pushed together and combined. They don't have easy chemical formulas to describe their makeup. A ruby is considered a mineral. It's a nice pretty crystal with the same compounds throughout the object. But the rock that surrounds that ruby has many different compounds (and even a few pieces of ruby mixed in). There's an easier example that many people can relate to. Think about quartz. On its own (as a mineral) it's a nice pretty crystal. But a piece of granite often has loads of quartz. It's ground up and crushed, but its still bits of quartz. Granite is a rock and quartz is a mineral.

Igneous Rocks

Igneous rocks are the ones that were **superheated** and originally liquid. They come from the center of the Earth! Not really the center, but they often start their lives below the crust and then get pumped out. There are two basic types of igneous rocks. There are the rocks that make it to the surface (extrusive) and the ones that are stuck in the crust just below the surface (intrusive). These igneous types have all hardened after being molten rock. If you walk around a volcano, you will find those **extrusive** types. The **intrusive** types are usually found in areas called dikes, big old pools of molten rock that were just beneath the surface. Some examples of igneous rock are granite, all volcanic rock, basalt, and obsidian.

Metamorphic Rocks

This rock type is created by heat and/or pressure. Even though heat is involved, they didn't start off as molten rock. But you often find metamorphic rock near volcanoes and sources of super hot rock. The heat from the magma changes all of the rock around it. Try another explanation. Look at the name 'metamorphic.' It looks like the word used to describe insects that go through a **metamorphosis**. It's the same concept. Some force (heat/pressure) has changed these rocks from one type into a new type. The result is a metamorphic rock. Some examples are marble, jade, slate, and gneiss. Because pressure and heat are involved, these rock types are usually found deep beneath the surface. They are also found near **fault lines** where plates push against each other and create enormous pressures. Over time, because of the movement of the crust, these metamorphic rocks are pushed to the surface where you can find them every day.

Sedimentary Rocks

The last of the big three rock types is probably the rarest... unless you live near the coast. Sedimentary rock types are created when **sediment compresses**. It's pretty simple. Here's the setup... A river flows through a canyon and picks up a bunch of silt. That sediment and silt runs downstream and deposits where the river ends. It could be in a flood plain or a valley, but we're using a coastline as an example. When that material gets to the beach, it sits there. Now if you watch this happen over millions of years, more and more sediment builds up and **compacts**. That compacted sediment eventually becomes a type of rock. Examples of sedimentary rock include sandstone, amber, anthracite, and limestone.

Lesson 4: How Oil Is Formed

Oil has formed throughout much of the Earth's history 10-600 million years ago; in fact, oil is being formed in some parts of the Earth today. The term ‘Petroleum’ derived from Latin language which means ‘rock oil’, this umbrella term also covers natural gas as well as oil.

Almost all oil and gas comes from tiny decayed plants, algae, bacteria, and microscopic plants. When these died they slowly sank to the bottom forming thick layers of organic material. This in turn became covered in layers of mud that trapped the organic material.

The layers of mud prevented air from reaching the organic material. Without air, the organic material couldn't rot in the same way as organic material rots away in a compost heap. As the layers of mud grew in thickness, they pushed down on the organic material with increasing pressure. The temperature of the organic material also increased as it heat by other processes going on inside the Earth.

Very slowly, increasing temperature, pressure and anaerobic bacteria - micro-organisms that can live without oxygen - started acting on the organic material. As this happened the material was slowly cooked and altered, like food in a pressure cooker. The energy first given to the plants by the sun is transferred and the organic matter is changed into crude oil and gas. Oil forms first, then as the temperature and pressure increase at greater depth gas begins to form.

Temperatures within the Earth's crust increase with depth so that the sediments, and any plant materials they contain, warm up as they become buried under more sediment. Increasing heat and pressure first cause the buried algae, bacteria, spores and cuticles (leaf skin) to join their wax, fat and oil to form dark specks called kerogen.

The cellulose and woody part of plants are converted to coal and woody kerogen. Rocks containing sufficient organic substances to generate oil and gas in this way are known as source rocks. When the source rock starts to generate oil or gas it is said to be mature. As the source rock gets hotter, chains of hydrocarbon chemicals use this heat energy to break away from the kerogen to form waxy and viscous heavy oil. At greater depth, the temperature rises. At higher temperatures the chains of hydrocarbons become shorter and break away to give light oil and gas. Oil and gas are called 'hydrocarbons' because they mostly contain molecules of the elements hydrogen and carbon.

What we commonly refer to simply as ‘oil’ is properly known as mineral oil or crude oil. Crude oil is a complex mixture of hydrocarbons with small amounts of other chemical compounds that contain sulphur, nitrogen and oxygen. Not all crude oil is the same and its characteristics and chemical composition depend entirely on the type of matter that it is derived from and the environmental conditions it has been subjected to during its formation. As a result of these differing characteristics and chemical compositions, some crude oil is more desirable than others. In all cases the base material needs to be refined to separate out the various constituents, who vary from light compounds that can be further refined into fuels, to heavy compounds such as bitumen and resins, which of course have their own uses.

Appendix C-3 : Frequency Table for Users' Profiles

Data Description		No. of Users	%
Age	18-24	5	10.87
	25-34	14	30.43
	35-44	25	54.35
	45-54	2	4.35
	Total	46	100.00
Gender	Male	46	100.00
	Female	0	0.00
	Total	46	100.00
Educational Level	PhD	27	58.70
	Master	19	41.30
	Undergraduate	0	0.00
	Total	46	100.00
Area of study	Computer	18	39.13
	Engineering	10	21.74
	Geography	3	6.52
	Agriculture	3	6.52
	Biology	3	6.52
	Chemistry	2	4.35
	Environment	0	0.00
	Communication	7	15.22
	Mathematics	0	0.00
	Total	46	100.00
Use of computer/week	6 -10 hours	0	0.00
	1 - 5 hours	0	0.00
	10 +hours	46	100.00
	Total	46	100.00
Use of Internet/week	6 -10 hours	2	4.35
	1 - 5 hours	0	0.00
	10 +hours	44	95.65
	Total	46	100.00
Knowledge about Geology	Excellent	2	4.35
	Good	11	23.91
	Limited	27	58.70
	No	6	13.04
	Total	46	100.00
Prior experience in E-Learning applications?	yes	13	28.26
	No	33	71.74
	Total	46.00	100.00
Experience on avatars and facial expressions	Excellent	0	0.00
	Good	4	8.70
	Limited	13	28.26
	No	29	63.04
	Total	46.00	100.00

Appendix C-4 : Time and Incorrectness Row Data for the Game with text + Speech only (TS)

T = Time & W= No. of incorrect answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4	
USERS	**T**	**W**	**T**	**W**	**T**	**W**	**T**	**W**
U1	20	0	22	1	5	0	40	1
U2	18.1	1	20	1	7.25	0	/	
U3	17.4	0	32.5	1	12	0	17.5	1
U4	26.11	0	15.8	0	23.6	0	10.16	0
U5	11.1	0	18.17	0	31	0	27.9	0
U6	22.08	1	13.5	0	21.4	0	37.2	2
U7	26.1	0	25.1	0	25	0	32.1	0
U8	15.5	1	11.1	0	10.9	0	17.26	0
U9	27.2	1	/	/	17.7	0	13.24	0
U10	/	/	15.16	1	19.1	0	18.1	0
U11	22.7	1	25.7	1	21.3	0	39.2	0
U12	12.28	0	13.01	0	12.5	0	11.36	0
U13	47.6	0	24.2	1	10.11	0	21.02	0
U14	30	1	28.6	0	22.13	1	24.3	0
U15	29.4	0	22	0	17	0	12.1	0
U16	17.3	0	27.8	0	39	0	25.7	1
U17	11.1	2	8.15	1	25.16	0	33.3	0
U18	35.16	0	33	1	/	/	20.4	0
U19	10.15	0	21.14	0	11.9	1	22.17	0
U20	40	1	5	0	22	1	20	0
U21	/	/	7.25	0	20	1	18.1	1
U22	17.5	1	12	0	32.5	1	17.4	0
U23	10.16	0	23.6	0	15.8	0	26.11	0
U24	27.9	1		/	18.17	0	11.1	0
U25	37.2	2	21.4	0	13.5	0	22.08	1
U26	32.1	0	25	0	25.1	1	26.1	0
U27	17.26	0	10.9	0	11.1	0	15.5	0
U28	13.24	0	17.7	0	17.2	0	27.2	0
U29	18.1	0	19.1	0	15.16	1	31.02	0
U30	/	/	21.3	0	25.7	1	22.7	0
U31	11.36	1	12.5	1	13.01	0	12.28	0
U32	21.02	0	10.11	0	24.2	0	47.6	0
U33	24.3	0	22.13	1	28.6	0	30	1
U34	12.1	1	17	0	22	0	29.4	0
U35	25.7	1	39	0	27.8	0	17.3	0
U36	33.3	0	25.16	0	8.15	1	11.1	0
U37	20.4	0	13.8	0	33	1	35.16	0
U38	22.17	0	11.9	1	21.14	0	10.15	0
U39	/	/	13.01	0	11.36	0	25.16	1
U40	10.11	0	24.2	1	21.02	1	13.8	0
U41	22.13	0	28.6	0	24.3	0	11.9	0
U42	17	0	22	0	12.1	1	22	1
U43	39	0	27.8	0	25.7	0	20	1
U44	25.16	0	8.15	1	33.3	0	32.5	0
U45	13.8	2	33	1	20.4	0	15.8	0
U46	11.9	1	21.14	0	22.17	0	18.17	0
SUM	21.96	6.88	19.77	5.07	19.92	4.35	22.50	3.99

Std dev	9.30	93.1	7.86	94.9	7.69	95.6	9.08	96.01
Min	10.11		5.00		5.00		10.15	
Median	20.71		21.14		21.02		21.02	
Max	47.60		39.00		39.00		47.60	

Appendix C-5 : Time and Incorrectness Row Data for the Game with text + Earcon only (TE)

T = Time & W= No. of incorrect answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4	
USERS	T	W	T	W	T	W	T	W
U1	6.14	0	26.2	0	36	1	10	0
U2	10.26	0	29.1	1	17	1	11.3	0
U3	14.7	0	23.3	0	15.9	0	15	2
U4	30.19	1	16	0	19	0	28.5	0
U5	37.3	0	10	0	28.3	0	12.26	0
U6	42.5	1	55	3	20.7	0	25.46	0
U7	18.8	1	11.8	0	/	/	35.8	0
U8	15.29	0	43.9	2	32.5	0	16.1	0
U9	32.11	0	25.1	0	37.2	0	18.9	0
U10	26.4	0	33.4	1	16.5	0	14	0
U11	15.1	0	36.6	0	22.3	0	10.15	4
U12	/	/	19.2	0	42.8	0	33.6	0
U13	49.4	2	52.3	3	56.6	4	45.4	2
U14	35.25	0	49.15	0	39.16	1	36	0
U15	28.1	3	16	0	17.33	0	29.7	0
U16	20.13	0	29.1	4	23.8	0	21.12	0
U17	40.1	0	18.3	0	26.19	3	13.1	0
U18	12.2	0	14.3	0	/	/	19.3	1
U19	19.5	2	13.33	0	20.17	0	9.27	0
U20	10	0	36	1	26.2	0	6.14	0
U21	11.3	0	17	1	29.1	1	10.26	0
U22	15	2	15.9	0	23.3	0	14.7	0
U23	28.5	0	19	0	16	0	30.19	1
U24	12.26	0	28.3	0	10	0	37.3	0
U25	25.46	0	20.7	0	55	3	42.5	1
U26	35.8	0	41.1	1	11.8	0	18.8	1
U27	16.1	0	32.5	0	43.9	2	15.29	0
U28	18.9	0	37.2	0	25.1	0	32.11	0
U29	14	0	16.5	0	33.4	1	26.4	0
U30	10.15	4	22.3	0	36.6	0	15.1	0
U31	33.6	0	42.8	0	19.2	0	43.11	1
U32	45.4	2	56.6	4	52.3	3	49.4	2
U33	36	0	39.16	1	49.15	0	35.25	0
U34	29.7	0	17.33	0	16	0	28.1	3
U35	/	/	23.8	0	29.1	4	20.13	0
U36	13.1	0	26.19	3	18.3	0	/	/
U37	19.3	1	15.01	0	14.3	0	12.2	0
U38	9.27	0	20.17	0	13.33	0	19.5	2
U39	49.15	0	28.1	0	28.1	0	10.26	0

U40	16	1	20.13	2	20.13	0	14.7	0
U41	29.1	0	40.1	0	40.1	0	30.19	4
U42	18.3	0	12.2	0	12.2	0	37.3	0
U43	14.3	0	19.5	0	19.5	1	42.5	0
U44	13.33	3	29.1	0	/	/	18.8	0
U45	19.2	0	23.3	0	11.3	0	15.29	0
U46	52.3	2	37.2	0	17.33	1	16.6	0
SUM	23.841	9.058	27.375	9.7826	26.563	9.4203	23.27	8.6957
Std dev	12.40		12.17		12.47		11.59	
Min	6.14		10.00		10.00		6.14	
Median	19.25		24.45		23.30		19.30	
Max	52.30		56.60		56.60		49.40	

Appendix C-6 : Time and Incorrectness Row Data for the Game with text + Speech + Earcon only (TSE)

T = Time & W= No. of incorrect answer & / = Missing or No answer

	Task 1		Task 2		Task 3		Task 4	
USERS	T	W	T	W	T	W	T	W
U1	5.4	0	25.1	0	15.3	0	10.1	0
U2	13	1	18.29	0	19.8	0	20.15	0
U3	25.1	0	12.23	0	12.3	0	14.22	2
U4	32.11	0	20.1	0	24.34	3	22.5	0
U5	19.2	1	39.6	0	10.28	0	12.3	0
U6	/	/	34	1	25.14	0	18.6	0
U7	10.13	0	15.21	1	20.14	0	29.17	0
U8	15.22	0	30	0	31.8	2	33	0
U9	34.6	0	26.22	0	17.6	0	38.21	0
U10	30.28	0	19.11	0	26.15	0	24.6	0
U11	9.35	1	28.18	0	22.25	0	16.35	0
U12	22.17	0	40.1	0	27.12	0	20.1	0
U13	16.5	0	55.4	3	40.2	0	27.6	0
U14	13.24	0	23.17	2	21.7	0	15.24	1
U15	35.1	0	43.5	0	41.1	0	28.9	0
U16	26.28	0	11.43	0	35.12	0	13.12	0
U17	12.14	0	33.4	3	31.29	0	25.7	0
U18	19.1	0	27.21	0	12.31	0	26.11	0
U19	20.11	2	/	/	11.25	0	10.38	0
U20	10.1	0	15.3	0	25.1	0	5.4	0
U21	20.15	0	19.8	0	18.29	0	13	1
U22	14.22	2	12.3	0	12.23	0	25.1	0
U23	22.5	0	24.34	3	20.1	0	32.11	0
U24	12.3	0	10.28	0	39.6	0	19.2	1
U25	18.6	0	25.14	0	34	1	24.62	0
U26	29.17	0	20.14	0	15.21	1	10.13	0
U27	33	0	31.8	2	/	/	15.22	0
U28	38.21	0	17.6	0	26.22	0	34.6	0
U29	24.6	0	26.15	0	19.11	0	30.28	0
U30	16.35	0	22.25	0	28.18	0	9.35	1

U31	20.1	0	27.12	0	40.1	0	22.17	0
U32	27.6	0	40.2	0	55.4	3	16.5	0
U33	15.24	1	21.7	0	23.17	2	13.24	0
U34	28.9	0	41.1	0	43.5	0	35.1	0
U35	13.12	0	35.12	0	11.43	0	26.28	0
U36	25.7	0	31.29	0	33.4	3	12.14	0
U37	26.11	0	12.31	0	27.21	0	19.1	0
U38	10.38	0	11.25	0	35.9	0	20.11	2
U39	35.12	0	28.9	0	11.43	0	26.28	0
U40	31.29	0	13.12	0	33.4	0	12.14	0
U41	12.31	0	25.7	0	27.21	3	19.1	0
U42	11.25	0	26.11	0	35.9	0	20.11	2
U43	25.1	0	10.38	0	15.3	0	10.1	0
U44	18.29	0	5.4	0	19.8	0	20.15	0
U45	12.23	1	13	0	12.3	0	/	/
U46	20.1	0	25.1	0	24.34	0	22.5	0
SUM	20.69	3.26	24.337	5.43	25.178	6.52	20.453	3.62
Std dev	8.43		10.62		10.48		7.96	
Min	5.40		5.40		10.28		5.40	
Median	20.10		25.10		24.34		20.11	
Max	38.21		55.40		55.40		38.21	

Appendix C-7 : Time and Incorrectness Row Data for the Game with Text, Speech, Earcons and Avatar (TSEA).

T = Time & W= No. of incorrect answer & / = Missing or No answer

	Task 1		Task		Task 3		Task 4	
USERS	T	W	T	W	T	W	T	W
U1	16.1	1	18	0	8.45	0	35.1	0
U2	10.25	0	20.37	0	22.9	0	14.2	0
U3	25	0	12.34	0	14.23	0	30.17	0
U4	17.35	0	23.1	0	27.12	0	12.41	0
U5	23.21	0	15.16	0	21.28	2	25.7	1
U6	14.74	0	24	1	26.71	0	6	2
U7	29.31	0	30.21	0	18.27	0	21.15	0
U8	11.25	0	19.29	1	30.42	0	13.31	0
U9	31.15	1	10.44	0	33.48	0	9.4	0
U10	26.7	0	33.3	0	28.15	0	20.38	0
U11	24.12	0	15.22	0	19.3	0	15.22	0
U12	39.1	0	40.5	0	10.41	0	35	0
U13	21.19	0	56.1	0	11.19	0	/	/
U14	30.27	0	/	/	15.5	0	26.9	0
U15	16.2	0	14.13	0	23.21	0	16.17	0
U16	13.4	0	21.3	1	31.37	0	33.2	1
U17	35.1	0	32.8	0	39.11	0	23.13	0
U18	18.33	3	29.25	0	41.33	0	14.36	0
U19	27.38	0	9.49	0	9.49	0	13.45	0
U20	35.1	0	8.45	0	18	0	16.1	1
U21	14.2	0	22.9	0	20.37	0	10.25	0

U22	30.17	0	14.23	0	12.34	0	25	0
U23	12.41	0	27.12	0	23.1	0	17.35	0
U24	25.7	1	21.28	2	15.16	0	23.21	0
U25	6	3	26.71	0	24	1	14.74	0
U26	21.15	0	18.27	0	30.21	0	29.31	0
U27	13.31	0	30.42	0	19.29	1	11.25	0
U28	/	/	33.48	0	10.44	0	31.15	1
U29	20.38	0	28.15	0	33.3	0	26.7	0
U30	15.22	0	19.3	0	15.22	0	24.12	0
U31	35	0	10.41	0	40.5	0	39.1	0
U32	49.3	1	11.19	0	56.1	0	21.19	0
U33	26.9	0	15.5	0	38	0	30.27	0
U34	16.17	0	23.21	0	14.13	0	16.2	0
U35	33.2	0	31.37	0	21.3	1	13.4	0
U36	23.13	0	39.11	0	32.8	0	/	/
U37	14.36	0	41.33	0	29.25	0	18.33	3
U38	13.45	0	9.49	0	9.49	0	27.38	0
U39	31.37	0	33.2	0	21.3	1	13.4	0
U40	39.11	0	23.13	0	32.8	0	35.1	0
U41	41.33	0	14.36	0	29.25	0	/	/
U42	9.49	0	13.45	0	9.49	0	27.38	0
U43	18	1	16.1	0	8.45	0	35.1	0
U44	20.37	0	10.25	0	22.9	0	14.2	0
U45	12.34	0	/	/	14.23	0	30.17	0
U46	23.1	0	17.35	0	27.12	0	12.41	0
SUM	22.89	3.98	22.38	1.81	23.05	2.17	21.58	3.26
Std dev	9.80		10.40		10.54		8.64	
Min	6.00		8.45		8.45		6.00	
Median	21.19		20.83		22.10		21.15	
Max	49.30		56.10		56.10		39.10	

Appendix C-8 : Users' Satisfaction Raw Data for the Game with text + Speech only (TS)

1 = STRONGLY DISAGREE **2 = DISAGREE** **3 = UNDECIDED** **4 = AGREE** **5 = STRONGLY AGREE**
S1 – S10: Statements of the satisfaction

	System Usability Scale (SUS) Statements												Additional Statements						
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	S16	Score
U1	4	2	4	1	4	1	5	1	5	1	70		4	4	5	1	5	4	3.83
U2	4	1	3	2	4	3	4	2	5	1	72.5		2	2	2	2	4	2	2.33
U3	5	1	4	2	4	2	4	2	4	1	72.5		4	4	4	2	4	4	3.67
U4	4	1	4	2	4	2	3	2	4	1	67.5		3	4	3	2	4	4	3.33
U5	4	1	3	2	5	1	4	2	4	2	70		2	5	4	1	5	4	3.50
U6	4	1	4	2	5	1	4	2	4	4	77.5		2	5	5	1	5	5	3.83
U7	4	2	5	1	3	2	3	2	3	1	65		4	4	4	3	4	4	3.83
U8	5	1	4	1	4	3	4	2	4	1	72.5		2	5	4	1	5	5	3.67
U9	5	1	4	1	3	3	4	1	4	1	67.5		5	5	5	1	4	4	4.00
U10	5	1	5	3	2	2	5	2	5	2	80		4	4	5	1	5	4	3.83
U11	3	2	3	1	3	1	5	3	4	1	65		2	3	4	1	5	4	3.17
U12	4	2	4	1	5	4	5	4	5	2	90		2	2	4	3	3	2	2.67
U13	4	1	5	2	4	1	4	2	5	1	72.5		5	4	5	1	3	4	3.67
U14	3	3	2	2	4	2	5	3	5	1	75		2	3	4	2	5	4	3.33
U15	4	4	4	2	4	2	4	4	4	1	82.5		5	4	4	2	4	5	4.00
U16	4	3	2	3	3	1	3	1	4	3	67.5		4	3	3	2	4	4	3.33
U17	5	2	1	1	4	2	5	2	3	1	65		1	2	4	4	5	3	3.17
U18	3	2	4	1	5	2	4	1	5	2	72.5		3	5	5	3	4	5	4.17
U19	3	2	4	4	3	1	4	3	4	2	75		2	2	4	1	5	4	3.00
U20	4	1	5	1	5	1	2	1	4	1	62.5		1	5	5	1	5	3	3.33
U21	3	1	5	3	5	2	3	3	4	2	77.5		1	2	5	1	4	2	2.50
U22	5	3	3	1	5	2	4	2	3	3	77.5		3	4	4	2	4	4	3.50
U23	5	2	4	2	5	1	4	1	5	2	77.5		2	4	3	2	4	3	3.00
U24	4	1	4	2	5	3	4	1	4	2	75		2	5	4	1	3	4	3.17
U25	2	1	4	3	5	2	5	1	5	1	72.5		5	5	5	1	4	3	3.83
U26	3	1	5	1	4	1	4	2	4	1	65		4	4	3	1	4	4	3.33
U27	4	2	2	2	4	1	4	2	4	1	65		3	5	4	1	5	5	3.83
U28	4	2	4	2	4	2	3	3	2	1	67.5		5	5	5	1	5	3	4.00
U29	4	1	5	1	3	3	4	2	4	2	72.5		4	4	5	2	4	3	3.67
U30	4	2	2	1	4	2	4	2	4	2	67.5		3	3	3	1	5	3	3.00
U31	5	2	3	1	2	1	3	1	5	1	60		4	2	4	3	4	2	3.17
U32	4	2	4	2	4	2	5	1	4	1	72.5		5	4	5	1	3	5	3.83
U33	4	2	4	1	5	1	4	1	5	1	70		2	3	4	2	2	3	2.67
U34	4	1	5	2	4	1	3	3	3	3	72.5		1	4	4	2	4	5	3.33
U35	4	3	5	1	4	2	4	2	5	1	77.5		4	3	3	1	5	3	3.17
U36	5	3	4	2	4	1	4	1	4	2	75		1	2	2	4	5	3	2.83
U37	5	1	4	2	5	2	4	1	4	2	75		3	5	5	1	5	4	3.83
U38	3	1	5	1	4	2	2	2	4	1	62.5		2	2	4	3	5	5	3.50
U39	4	2	4	3	5	3	4	3	4	1	82.5		1	5	5	1	4	4	3.33
U40	5	2	3	3	5	2	5	3	3	2	82.5		2	2	2	2	5	2	2.50
U41	4	1	3	1	3	1	4	3	5	2	67.5		4	3	4	2	4	4	3.50
U42	4	2	4	2	4	1	4	2	4	1	70		1	4	4	1	5	4	3.17
U43	2	1	3	3	3	2	5	2	3	2	65		1	3	4	1	4	3	2.67
U44	5	2	4	2	4	3	4	2	4	5	87.5		3	5	5	1	5	4	3.83
U45	4	2	4	2	5	3	4	1	4	1	75		2	3	4	2	5	3	3.17
U46	4	2	3	3	1	2	3	1	5	1	62.5		1	5	5	1	5	4	3.50
AVERAGE	4.02	1.72	3.78	1.83	4.00	1.85	3.96	1.96	4.13	1.61	**72.12**	AVERAGE	2.78	3.72	4.09	1.65	4.35	3.70	3.38
MEDIAN	4	2	4	2	4	2	4	2	4	1		MEDIAN	2.5	4	4	1	4	4	
MODE	4	2	4	2	4	2	4	2	4	1		MODE	2	4	4	1	5	4	
Min	2	1	1	1	1	1	2	1	2	1		Min	1	2	2	1	2	2	
Max	5	4	5	4	5	4	5	4	5	5		Max	5	5	5	4	5	5	

Appendix C-9 : Users' Satisfaction Raw Data for the Game with text + Earcon only (TE)

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

System Usability Scale (SUS) Statements											
USERS	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**SCORE**
U1	4	2	4	1	4	1	5	1	4	2	70
U2	4	1	4	2	4	1	4	2	3	1	65
U3	5	2	4	2	4	1	4	2	4	1	72.5
U4	3	1	4	2	5	1	3	2	3	3	67.5
U5	4	2	4	1	4	2	4	1	4	1	67.5
U6	4	3	4	1	4	2	4	1	4	1	70
U7	2	1	3	1	5	1	4	1	4	1	57.5
U8	4	2	5	3	5	3	5	1	5	1	85
U9	4	2	5	1	4	2	4	2	5	2	77.5
U10	3	2	5	1	5	2	4	2	4	1	72.5
U11	4	4	4	1	4	4	4	2	5	2	85
U12	4	1	5	2	4	1	5	1	4	1	70
U13	4	2	4	1	4	1	4	2	4	4	75
U14	3	2	4	1	2	2	5	3	5	2	72.5
U15	4	2	4	1	4	3	4	2	4	3	77.5
U16	3	2	4	1	3	2	4	1	4	2	65
U17	4	2	4	3	2	2	4	4	5	2	80
U18	4	4	4	1	4	1	4	1	4	2	72.5
U19	5	1	2	2	5	1	5	1	1	2	62.5
U20	5	2	5	3	5	1	3	1	3	1	72.5
U21	4	2	5	2	5	2	5	3	2	1	77.5
U22	3	2	4	1	4	1	5	1	5	3	72.5
U23	4	1	4	1	4	2	4	4	5	2	77.5
U24	4	2	4	1	4	1	5	3	3	3	75
U25	5	1	4	1	5	2	5	3	5	2	82.5
U26	5	2	5	1	5	2	5	3	4	3	87.5
U27	4	2	4	1	4	2	4	1	4	2	70
U28	3	1	4	4	5	2	4	1	4	1	72.5
U29	4	2	4	1	5	2	5	2	5	1	77.5
U30	5	1	3	2	5	1	5	3	4	1	75
U31	5	2	4	2	4	2	4	2	4	2	77.5
U32	4	2	4	2	4	2	3	3	4	3	77.5
U33	4	1	5	1	3	1	4	2	4	2	67.5
U34	5	1	5	2	4	1	4	4	4	2	80
U35	4	1	5	2	2	1	4	2	5	2	70
U36	3	1	4	1	4	1	4	2	4	1	62.5
U37	2	2	4	2	1	1	2	1	5	2	55
U38	1	3	4	1	3	1	5	3	5	1	67.5
U39	3	1	4	2	5	2	4	2	2	1	65
U40	5	2	4	2	3	2	4	1	5	1	72.5
U41	4	1	5	2	4	1	5	2	5	1	75
U42	4	2	4	1	4	2	5	3	3	3	77.5
U43	2	1	3	2	5	2	4	3	5	1	70
U44	5	2	1	2	1	1	4	2	3	1	55
U45	4	2	4	2	4	4	4	2	5	1	80
U46	5	2	4	1	2	3	4	1	5	1	70
AVERAGE	3.87	1.78	4.07	1.59	3.91	1.70	4.22	2.00	4.09	1.72	**72.34**
MEDIAN	4	2	4	1	4	2	4	2	4	2	
MODE	4	2	4	1	4	1	4	2	4	1	
Min	1	1	1	1	1	1	2	1	1	1	
Max	5	4	5	4	5	4	5	4	5	4	

	Additional Statements							
USERS	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**SCORE**
U1	4	4	4	2	5	2	4	3.57
U2	4	5	4	2	4	2	4	3.57
U3	2	4	5	2	4	2	3	3.14
U4	4	4	4	2	4	2	4	3.43
U5	5	5	5	1	4	1	3	3.43
U6	4	4	5	1	5	1	4	3.43
U7	4	4	5	2	4	3	5	3.86
U8	1	5	5	2	5	2	4	3.43
U9	4	4	4	1	4	1	3	3.00
U10	4	5	5	1	5	3	5	4.00
U11	5	4	4	1	3	4	4	3.57
U12	5	4	5	1	3	1	5	3.43
U13	4	5	5	1	4	1	5	3.57
U14	3	4	4	2	4	1	4	3.14
U15	1	3	5	2	5	3	5	3.43
U16	4	4	5	1	4	2	3	3.29
U17	4	5	3	1	5	3	4	3.57
U18	1	5	5	1	4	2	5	3.29
U19	2	3	4	1	5	2	5	3.14
U20	2	5	5	2	5	1	2	3.14
U21	4	3	4	2	5	1	4	3.29
U22	1	3	4	2	4	1	4	2.71
U23	4	4	5	2	4	2	3	3.43
U24	5	2	5	1	5	2	5	3.57
U25	1	4	4	1	5	2	4	3.00
U26	4	1	4	2	5	2	3	3.00
U27	4	1	5	2	4	3	4	3.29
U28	1	4	5	3	4	4	5	3.71
U29	4	1	5	1	5	3	5	3.43
U30	5	4	4	1	5	2	4	3.57
U31	5	1	4	1	5	2	3	3.00
U32	4	5	4	1	1	2	5	3.14
U33	1	3	4	2	2	1	4	2.43
U34	4	5	4	2	3	1	3	3.14
U35	2	2	4	3	4	1	4	2.86
U36	4	5	4	1	5	1	4	3.43
U37	2	2	5	1	5	2	3	2.86
U38	2	5	5	1	4	2	5	3.43
U39	3	2	5	2	4	3	3	3.14
U40	2	1	1	3	5	2	3	2.43
U41	2	3	3	2	4	2	4	2.86
U42	2	2	4	2	5	1	5	3.00
U43	5	2	3	1	4	2	5	3.14
U44	4	4	5	1	5	2	3	3.43
U45	4	4	4	2	4	1	5	3.43
U46	1	4	4	2	5	2	3	3.00
AVERAGE	3.20	3.54	4.33	1.59	4.28	1.91	4.00	3.26
MEDIAN	4	4	4	2	4	2	4	
MODE	4	4	4	1	5	2	4	
Min	1	1	1	1	1	1	2	
Max	5	5	5	3	5	4	5	

Appendix C-10 : Users' Satisfaction Raw Data for the Game with text + Speech +Earcon (TSE)

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

System Usability Scale (SUS) Statements													Additional Statements								
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	S16	S17	S18	SCORE
U1	5	1	5	1	5	1	5	1	5	1	75		5	5	5	1	5	5	2	5	4.13
U2	5	1	4	1	5	1	1	1	4	2	62.5		2	3	3	2	4	4	1	4	2.88
U3	5	2	4	2	5	1	4	1	4	2	75		4	2	4	1	4	4	1	4	3.00
U4	5	3	4	2	5	2	4	3	4	2	85		4	4	4	2	4	4	1	4	3.38
U5	4	1	4	2	5	2	4	2	4	2	75		4	4	4	1	4	3	1	3	3.00
U6	4	2	4	2	5	2	4	2	4	2	77.5		5	3	4	1	5	3	2	3	3.25
U7	5	1	5	3	5	3	3	3	3	3	85		3	4	4	2	5	4	2	4	3.50
U8	5	3	5	2	4	2	5	1	5	3	87.5		4	4	4	2	4	4	2	4	3.50
U9	4	2	5	2	4	3	1	2	4	1	70		4	3	5	2	5	5	1	5	3.75
U10	4	2	5	2	5	1	5	1	4	2	77.5		4	4	5	1	4	4	2	4	3.50
U11	3	1	4	1	4	2	3	2	4	1	62.5		3	3	4	2	5	5	1	5	3.50
U12	4	2	4	1	5	4	4	2	4	2	80		3	4	5	2	5	4	2	4	3.63
U13	3	2	4	2	5	2	5	3	3	2	77.5		5	5	5	1	5	5	1	5	4.00
U14	4	1	4	1	5	1	1	1	1	1	50		1	4	4	2	3	5	2	5	3.25
U15	1	1	5	2	4	1	5	1	4	3	67.5		2	2	4	3	3	5	2	5	3.25
U16	4	2	5	2	4	3	4	1	4	2	77.5		4	3	4	2	3	4	2	4	3.25
U17	4	2	5	3	3	2	2	2	3	1	67.5		2	3	3	1	4	4	3	4	3.00
U18	2	2	2	1	4	3	4	2	4	3	67.5		1	3	2	4	4	4	3	4	3.13
U19	4	1	5	1	4	2	5	2	5	1	75		2	2	4	1	5	4	3	4	3.13
U20	5	3	4	2	3	1	4	1	3	1	67.5		2	1	2	1	4	4	3	4	2.63
U21	5	2	4	1	4	1	3	1	4	1	65		2	3	3	2	2	5	3	5	3.13
U22	5	3	4	2	3	1	4	1	4	3	75		4	2	1	1	1	5	2	5	2.63
U23	5	1	4	2	3	1	5	2	4	1	70		4	4	4	2	1	5	2	5	3.38
U24	4	2	4	3	3	2	4	3	3	3	77.5		4	5	5	1	2	5	2	5	3.63
U25	4	1	4	2	1	3	4	2	5	2	70		5	4	4	1	4	5	2	5	3.75
U26	4	3	5	1	4	1	4	2	4	2	75		4	4	3	2	5	4	1	4	3.38
U27	3	2	2	1	4	3	2	2	4	2	62.5		4	4	4	2	5	4	1	4	3.50
U28	4	4	4	1	4	1	2	4	4	1	72.5		3	4	5	2	5	4	1	4	3.50
U29	4	2	5	1	4	2	3	1	4	1	67.5		4	4	4	1	4	4	2	4	3.38
U30	4	2	4	1	5	2	4	1	4	1	70		3	3	4	2	4	3	2	3	3.00
U31	3	2	5	2	4	2	5	3	4	2	80		4	4	5	2	4	3	3	3	3.50
U32	5	1	5	1	4	1	4	1	5	1	70		3	5	4	1	5	2	2	2	3.00
U33	5	1	4	2	4	1	3	2	3	2	67.5		2	4	4	2	4	2	3	2	2.88
U34	3	4	4	2	4	2	5	2	5	2	82.5		3	3	3	1	5	1	2	1	2.38
U35	5	2	4	2	4	2	5	1	4	1	75		4	2	4	2	2	3	4	3	3.00
U36	4	2	2	1	5	2	4	2	4	4	75		4	3	4	3	1	4	2	4	3.13
U37	5	1	5	1	4	2	4	2	5	1	75		1	3	3	4	4	5	2	5	3.38
U38	4	3	4	1	5	1	5	1	4	1	72.5		2	2	2	1	4	4	1	4	2.50
U39	4	2	4	1	5	1	5	1	4	1	70		2	2	4	1	5	4	3	4	3.13
U40	5	3	4	2	5	1	4	2	4	2	80		2	3	3	2	4	4	1	4	2.88
U41	4	2	4	2	5	2	4	2	4	2	77.5		4	2	4	1	2	4	1	4	2.75
U42	4	2	4	3	4	2	4	1	3	2	72.5		4	4	4	2	4	4	1	4	3.38
U43	4	1	4	1	2	1	5	3	4	3	70		5	2	5	1	4	5	2	5	3.63
U44	4	1	5	1	3	4	4	1	5	3	77.5		4	3	4	1	5	4	2	4	3.38
U45	5	1	4	1	3	2	3	2	4	1	65		4	4	3	2	4	4	1	4	3.25
U46	5	4	4	2	4	1	4	1	4	1	75		3	3	4	2	4	4	3	4	3.38
AVERAGE	4.15	1.93	4.20	1.63	4.11	1.80	3.83	1.74	3.96	1.80	72.88	AVERAGE	3.30	3.30	3.83	1.70	3.89	4.02	1.91	4.02	3.25
MEDIAN	4	2	4	2	4	2	4	2	4	2		MEDIAN	4	3	4	2	4	4	2	4	
MODE	4	2	4	1	4	1	4	1	4	1		MODE	4	4	4	2	4	4	2	4	
Min	1	1	2	1	1	1	1	1	1	1		Min	1	1	1	1	1	1	1	1	
Max	5	4	5	3	5	4	5	4	5	4		Max	5	5	5	4	5	5	4	5	

Appendix C-11 : Users' Satisfaction Raw Data for the Game with text + Speech +Earcon + avatar (TSEA)

1 = STRONGLY DISAGREE 2 = DISAGREE 3 = UNDECIDED 4 = AGREE 5 = STRONGLY AGREE
S1 – S10: Statements of the satisfaction

System Usability Scale (SUS) Statements												Additional Statements								
USERS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	SCORE		S11	S12	S13	S14	S15	S16	S17	S18	SCORE
U1	5	1	5	1	5	1	5	1	5	1	75		4	4	5	1	5	1	1	4	3.13
U2	5	1	5	1	5	1	5	1	5	1	75		2	4	4	2	4	1	1	4	2.75
U3	5	1	5	1	5	1	5	1	5	1	75		2	2	5	1	4	1	2	4	2.63
U4	5	1	5	1	5	1	5	1	5	1	75		4	4	4	2	4	1	1	4	3.00
U5	5	1	5	1	5	1	5	1	5	1	75		1	4	5	1	4	2	2	4	2.88
U6	5	1	5	1	5	1	5	1	5	1	75		5	5	5	1	5	2	1	5	3.63
U7	5	1	5	1	5	1	5	1	5	1	75		4	5	4	2	5	2	2	4	3.50
U8	5	1	5	1	5	1	5	1	5	1	75		4	4	4	2	3	1	1	4	2.88
U9	5	1	5	1	5	1	5	1	5	1	75		1	5	5	2	4	1	1	5	3.00
U10	5	1	5	1	5	1	5	1	5	1	75		4	4	5	1	3	2	1	5	3.13
U11	5	1	5	1	5	1	5	1	5	1	75		3	5	4	2	4	2	1	4	3.13
U12	5	1	5	1	5	1	5	1	5	1	75		4	5	5	2	4	2	1	5	3.50
U13	5	1	5	1	5	1	5	1	5	1	75		5	5	5	1	4	3	1	4	3.50
U14	5	1	5	1	5	1	5	1	5	1	75		1	4	4	2	5	3	2	5	3.25
U15	5	1	5	1	5	1	5	1	5	1	75		3	2	4	3	5	1	1	5	3.00
U16	5	1	5	1	5	1	5	1	5	1	75		4	5	4	2	5	1	2	5	3.50
U17	5	1	5	1	5	1	5	1	5	1	75		4	5	5	1	4	1	1	5	3.25
U18	5	1	5	1	5	1	5	1	5	1	75		1	5	4	1	5	2	1	5	3.00
U19	5	1	5	1	5	1	5	1	5	1	75		2	5	5	1	5	2	1	4	3.13
U20	5	1	5	1	5	1	5	1	5	1	75		2	5	5	1	4	3	1	2	2.88
U21	5	1	5	1	5	1	5	1	5	1	75		1	5	5	2	4	4	2	4	3.38
U22	5	1	5	1	5	1	5	1	5	1	75		1	5	4	2	4	3	1	5	3.13
U23	5	1	5	1	5	1	5	1	5	1	75		4	4	4	2	5	2	1	4	3.25
U24	5	1	5	1	5	1	5	1	5	1	75		4	5	5	1	5	2	1	4	3.38
U25	5	1	5	1	5	1	5	1	5	1	75		5	4	4	1	4	2	2	5	3.38
U26	5	1	5	1	5	1	5	1	5	1	75		4	4	5	2	4	2	2	4	3.38
U27	5	1	5	1	5	1	5	1	5	1	75		1	4	4	2	3	1	1	4	2.50
U28	5	1	5	1	5	1	5	1	5	1	75		4	4	5	2	5	1	1	5	3.38
U29	5	1	5	1	5	1	5	1	5	1	75		4	4	4	1	3	1	1	5	2.88
U30	5	1	5	1	5	1	5	1	5	1	75		3	5	4	2	5	1	2	5	3.38
U31	5	1	5	1	5	1	5	1	5	1	75		4	4	5	2	5	2	2	5	3.63
U32	5	1	5	1	5	1	5	1	5	1	75		4	5	4	1	5	2	2	4	3.38
U33	5	1	5	1	5	1	5	1	5	1	75		1	4	5	2	4	2	1	4	2.88
U34	5	1	5	1	5	1	5	1	5	1	75		3	5	4	1	4	2	1	3	2.88
U35	5	1	5	1	5	1	5	1	5	1	75		1	5	4	2	4	1	1	4	2.75
U36	5	1	5	1	5	1	5	1	5	1	75		4	5	5	3	4	1	1	4	3.38
U37	5	1	5	1	5	1	5	1	5	1	75		1	5	4	1	4	2	1	5	2.88
U38	5	1	5	1	5	1	5	1	5	1	75		2	2	5	1	4	2	1	5	2.75
U39	5	1	5	1	5	1	5	1	5	1	75		2	5	5	1	5	2	1	5	3.25
U40	5	1	5	1	5	1	5	1	5	1	75		2	5	5	2	4	1	2	5	3.25
U41	5	1	5	1	5	1	5	1	5	1	75		2	4	5	1	5	2	1	5	3.13
U42	5	1	5	1	5	1	5	1	5	1	75		1	4	5	2	5	1	1	4	2.88
U43	5	1	5	1	5	1	5	1	5	1	75		3	5	5	1	4	2	2	5	3.38
U44	5	1	5	1	5	1	5	1	5	1	75		1	5	4	1	4	1	1	5	2.75
U45	5	1	5	1	5	1	5	1	5	1	75		4	4	5	2	4	1	1	4	3.13
U46	5	1	5	1	5	1	5	1	5	1	75		1	5	4	2	5	2	1	5	3.13
AVERAGE	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	75.00	AVERAGE	2.76	4.41	4.54	1.59	4.30	1.72	1.28	4.43	**3.13**
MEDIAN	5	1	5	1	5	1	5	1	5	1		MEDIAN	3	5	5	2	4	2	1	4.5	
MODE	5	1	5	1	5	1	5	1	5	1		MODE	4	5	5	2	4	2	1	5	
Min	5	1	5	1	5	1	5	1	5	1		Min	1	2	4	1	3	1	1	2	
Max	5	1	5	1	5	1	5	1	5	1		Max	5	5	5	3	5	4	2	5	

Appendix C-12 : Users Reactions Raw Data for the Game with text + Speech only (TS)

USERS	Brow rising	Compress	Draw	Hand	Expressing	Laugh	Smile
U1	0	0	0	0	0	1	4
U2	0	0	0	0	0	0	3
U3	0	0	0	0	0	2	5
U4	0	0	0	0	0	0	7
U5	0	0	0	0	1	0	4
U6	0	1	0	0	0	0	3
U7	0	0	0	1	0	1	7
U8	0	0	0	0	0	0	6
U9	0	0	0	0	2	0	11
U10	0	0	0	0	0	3	5
U11	0	0	0	0	0	2	5
U12	0	1	0	1	0	0	7
U13	0	0	0	0	0	0	6
U14	0	0	0	0	3	0	7
U15	0	0	0	0	0	1	5
U16	0	0	0	0	0	0	3
U17	0	0	0	0	0	0	3
U18	1	1	0	0	0	2	3
U19	0	0	0	0	0	1	5
U20	0	0	0	0	0	1	3
U21	0	0	0	0	1	2	2
U22	0	0	0	0	0	1	7
U23	0	0	0	0	0	1	9
U24	1	0	1	0	0	0	12
U25	0	0	0	0	0	2	3
U26	1	0	0	0	0	0	2
U27	0	0	0	0	0	4	7
U28	0	0	0	0	1	0	8
U29	0	0	0	0	0	1	13
U30	1	0	0	0	0	0	9
U31	0	0	0	0	0	0	8
U32	0	0	0	0	0	1	7
U33	1	0	1	0	0	2	10
U34	0	0	0	0	0	4	4
U35	0	0	0	0	0	1	8
U36	0	0	0	0	0	0	6
U37	0	0	0	0	0	1	8
U38	0	0	0	0	0	1	2
U39	0	0	0	0	0	1	6
U40	0	1	0	0	0	0	1
U41	0	0	0	0	0	0	6
U42	0	0	0	0	0	1	4
U43	0	0	0	0	0	0	3
U44	0	0	0	0	0	0	8
U45	0	1	0	0	0	2	7
U46	0	0	0	0	0	1	4
Total	**5**	**5**	**2**	**2**	**8**	**40**	**266**
%	1.88	1.88	0.75	0.75	3.01	15.04	100.00

Appendix C-13 : Users Reactions Raw Data for the Game with text + Earcon only (TE)

Users	Brow	Compress lip	Draw	Hand	Expressing	Laugh	Smile
U1	0	0	0	0	0	0	2
U2	0	0	0	0	3	0	1
U3	0	0	0	0	0	1	3
U4	1	0	0	0	0	0	4
U5	0	0	0	0	0	0	7
U6	0	0	0	0	0	0	3
U7	0	0	0	0	3	0	2
U8	0	0	0	0	0	2	1
U9	0	1	0	0	2	0	0
U10	0	0	0	0	0	0	0
U11	2	1	0	0	0	0	2
U12	0	0	0	0	0	0	1
U13	0	1	0	0	0	1	3
U14	0	0	0	0	0	0	4
U15	0	0	0	0	0	0	5
U16	0	0	0	0	2	2	1
U17	1	0	0	0	0	1	3
U18	0	1	0	0	1	0	6
U19	0	0	0	0	2	0	2
U20	0	0	0	0	0	0	1
U21	0	0	0	0	0	2	2
U22	1	0	0	0	0	3	3
U23	0	0	0	0	0	0	5
U24	0	1	0	0	1	1	4
U25	0	0	0	0	0	2	6
U26	0	0	0	0	0	0	9
U27	0	0	0	0	1	2	8
U28	0	0	0	0	0	0	6
U29	0	0	0	0	2	1	2
U30	1	1	0	0	0	2	2
U31	0	0	0	0	0	1	3
U32	1	0	0	0	0	3	3
U33	0	0	0	0	0	0	2
U34	0	0	0	0	0	1	3
U35	1	1	0	0	3	2	4
U36	0	0	0	0	0	1	6
U37	1	0	0	0	0	2	1
U38	0	0	0	0	1	2	3
U39	0	1	0	0	0	2	2
U40	1	0	0	0	0	3	2
U41	0	0	0	0	0	2	5
U42	0	0	0	0	0	2	4
U43	1	0	0	0	1	3	3
U44	0	1	0	0	0	2	7
U45	1	0	0	0	2	4	5
U46	0	0	0	0	0	0	0
Total	**12**	**9**	**0**	**0**	**24**	**50**	**151**
%	3.21	2.41	0.00	0.00	6.42	13.37	40.37

Appendix C-14 : Users Reactions Raw Data for the Game with text + Speech +Earcon (TSE)

Users	Brow	Compress	Draw	Hand	Expressing	Laugh	Smile
U1	1	0	1	0	0	0	2
U2	0	0	0	0	0	0	1
U3	0	0	0	0	0	0	3
U4	1	0	1	0	0	0	4
U5	0	0	0	0	0	0	7
U6	0	0	0	0	0	0	3
U7	0	0	1	0	0	0	2
U8	0	0	0	0	0	0	10
U9	0	0	0	0	0	0	9
U10	0	0	0	0	0	0	0
U11	0	0	0	0	0	0	8
U12	0	0	1	0	0	0	5
U13	1	0	0	0	0	0	3
U14	0	0	0	0	0	0	4
U15	0	0	0	0	0	0	9
U16	0	0	1	0	0	0	1
U17	0	0	0	0	0	0	4
U18	0	0	0	0	0	0	6
U19	0	0	1	0	0	0	2
U20	0	0	0	0	0	4	1
U21	0	0	0	0	0	0	3
U22	0	2	0	0	0	2	5
U23	1	0	0	0	0	3	5
U24	0	0	0	0	0	6	6
U25	0	0	0	0	0	4	8
U26	0	0	0	0	0	7	9
U27	0	0	0	0	0	9	8
U28	0	0	0	0	0	2	6
U29	0	1	0	0	0	1	3
U30	0	0	0	0	0	4	4
U31	0	0	0	0	0	6	2
U32	0	0	0	0	0	5	3
U33	0	0	0	0	0	3	5
U34	0	0	0	0	0	2	4
U35	0	0	0	0	0	6	4
U36	0	0	0	5	0	0	6
U37	0	0	0	0	1	0	1
U38	0	0	0	0	0	0	2
U39	0	0	0	0	0	0	2
U40	0	2	0	0	0	0	3
U41	0	0	0	0	2	0	4
U42	0	0	0	2	0	0	4
U43	0	0	0	0	0	0	3
U44	0	1	0	0	0	0	6
U45	0	0	0	2	0	0	6
U46	**4**	**6**	**6**	**9**	**3**	**64**	**196**
Total	2.04	3.06	12.00	2.41	0.80	17.11	52.41

Appendix C-15 : Users Reactions Raw Data for the Game with text + Speech +Earcon + avatar (TSEA)

Users	Brow	Compress	Draw	Hand	Expressing	Laugh	Smile
U1	0	0	0	0	0	1	4
U2	0	1	1	0	1	4	3
U3	3	0	0	0	3	2	5
U4	0	0	0	0	0	4	7
U5	0	0	0	0	1	0	10
U6	0	1	0	0	2	2	12
U7	0	0	0	1	0	3	7
U8	0	0	0	0	3	2	6
U9	0	0	0	0	2	0	11
U10	0	0	0	0	0	3	10
U11	0	0	0	0	4	5	5
U12	0	0	0	1	5	0	11
U13	0	0	0	0	6	0	10
U14	0	0	0	0	3	2	7
U15	0	0	0	0	5	4	5
U16	0	0	0	0	3	0	3
U17	0	0	0	0	0	0	3
U18	1	0	0	0	0	6	3
U19	0	0	0	0	3	1	5
U20	0	0	0	0	0	5	10
U21	0	0	0	0	1	2	11
U22	0	0	0	0	0	1	7
U23	0	0	0	0	0	3	12
U24	1	0	1	0	0	0	12
U25	1	0	0	0	0	2	8
U26	0	0	0	0	0	0	5
U27	1	0	0	0	0	4	6
U28	1	0	0	0	2	2	8
U29	0	0	0	0	2	7	9
U30	1	0	0	0	1	4	8
U31	0	0	0	0	1	3	8
U32	1	0	0	0	1	2	7
U33	1	0	1	0	4	2	15
U34	0	0	0	0	1	4	8
U35	1	0	0	0	7	1	4
U36	1	0	0	0	3	6	5
U37	0	0	0	0	4	1	11
U38	1	0	0	0	5	2	2
U39	0	0	0	0	6	2	6
U40	1	1	0	0	0	0	7
U41	0	0	0	0	3	3	5
U42	0	0	0	0	0	1	15
U43	1	0	0	0	4	0	3
U44	0	1	0	0	0	5	8
U45	1	0	0	0	4	5	3
U46	0	0	0	0	4	3	4
Total	**17**	**4**	**3**	**2**	**94**	**109**	**334**
%	5.09	1.20	0.90	0.60	28.14	32.63	100.00

Appendix C-16 : Users' Preferred Platform Experienced Raw Data between All Interfaces

TS = Game with Text and Speech only
TE = Game with Text and Earcon only
TSE = Game with Text + Speech + Earcon
TSEA = Game with Text + Speech + Earcon + Avatar
USER PREFER = 1 , NOT PREFER = 0

USERS	TS	TE	TSE	TSEA
U1	1	0	1	0
U2	0	0	1	0
U3	0	0	1	0
U4	0	1	1	1
U5	0	0	1	0
U6	0	0	1	0
U7	0	0	1	0
U8	0	1	1	1
U9	0	1	1	1
U10	0	1	0	1
U11	1	0	0	0
U12	0	1	0	1
U13	1	0	0	0
U14	1	1	0	1
U15	0	0	0	0
U16	0	0	0	1
U17	0	0	0	1
U18	0	0	0	1
U19	0	0	0	1
U20	0	0	0	1
U21	0	0	0	1
U22	0	0	0	1
U23	0	0	0	1
U24	0	0	0	1
U25	0	0	0	1
U26	0	0	0	1
U27	0	0	0	1
U28	0	0	0	1
U29	0	0	0	1
U30	0	0	0	1
U31	0	0	0	1
U32	0	0	0	0
U33	0	0	0	0
U34	0	0	0	0
U35	0	0	0	1
U36	0	0	0	0
U37	0	0	0	1
U38	0	0	0	0
U39	0	0	0	0
U40	0	0	0	0

U41	0	0	0	0
U42	0	0	0	0
U43	0	0	0	0
U44	0	0	0	0
U45	0	0	1	0
U46	1	0	1	0
Total	**5**	**6**	**11**	**24**
%	**10.87**	**13.04**	**23.91**	**52.17**

Appendix C-17 : Users' Interfaces Preference Order Final result for All Interfaces

TS = Game with Text and Speech only
TE = Game with Text and Earcon only
TSE = Game with Text + Speech + Earcon
TSEA = Game with Text + Speech + Earcon + Avatar

	TS	TE	TSE	TSEA
Total	**5**	**4**	**9**	**28**
%	10.87	8.70	19.57	60.87