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Investigating 3D Virtual World for Adult Basic Education

DISSERTATION

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Kurzfassung

Das exponentielle Wachstum in der Entwicklung der Informations- und Kommunikationstechnologie in der letzten Dekade hat den Menschen eine Reihe an neuen Möglichkeiten eröffnet, eine davon betrifft die Bildung. Insbesondere die Rolle von Computer und dem Internet für Unterricht und Lernen ist weitgehend ausgebildet in der e-Learning Domäne. Die Nutzung dieser Werkzeuge unterstützt mittlerweile alle möglichen Formen des Lernens von der Entwicklung des Allgemeinwissens bis hin zu formalen Ausbildung auf allen Bildungsstufen. Unzählige Web-basierte Anwendungen sind für diesen Zweck im Internet verfügbar. Noch wichtiger, in unserer Zeit ändern sich die Trends, und ein Übergang von 2-dimensionalen Anwendungen zu 3-dimensionalen virtuellen Welten findet statt. Universitäten und Institutionen verwenden 3D virtuelle Welten für Bildung und Pädagogik wegen der ihrer Überlegenheit über 2D Anwendungen, da 3D virtuelle Welten das Potential immersiver Umwelten anbieten, einfache Zusammenarbeit ermöglichen, anpassbar an Kultur und Kontext, eine Erfahrung bieten die sehr nah am Leben in der Realität bieten, wie z.B. "Learning by Doing" und Rollenspiel basierendem Lernen, etc. was in 2D Anwendungen schwer oder gar nicht möglich ist.

Die meisten Forschungsaktivitäten an Computerunterstütztem Lernen (sowohl 2D Anwendungen als auch 3D virtueller Welten) bisher konzentrieren sich auf etablierte Massenbildung. Nur wenige ernsthafte Versuche sind gemacht worden um das Problem des Analphabetismus im Erwachsenenalter durch Computerunterstützte Plattformen zu vermindern. Diejenigen Plattformen die existieren, bieten e-Learning nur für funktionelle Analphabeten und decken verschiedene Bereiche, wie das General Education Development (GED) ab, Hochschule Diplome, Allgemeinwissen, Nachrichten, andere alltägliche Fertigkeiten, Neuigkeiten und andere Kulturferigkeiten. Anderseits sind die vorhandene Ressourcen die sich mit den Grundlagen beschäftigen für Kinder gemacht oder sehr Text-lastig. Die text-lastigen Ressourcen sind wiederum passend für funktionale Analphabeten, und die Ressourcen für Kinder meistens nicht ansprechend für Erwachsene. Diese Voraussetzungen führen zum Design einer angepassten Lernplattform für Basisbildung von Erwachsen (Adult Basic Education, ABE). Um die Parame-

ter für die Anpassung der Computerunterstützten Lernplattform zu erforschen und eine optimale Nutzung neuer Technologien zu finden, ein Bezug zur modernen Lerntheorie ist nötig um die Ziele und Praxisumsetzung zum Erfolg führen zu können.

Diese Doktorarbeit nutzt die Lerntheorie umwichtige Eigenschaften für erwachsene Lerner zu identifizieren und in ABE Programmen die richtigen Technologie auszuwählen und ausgewählte Funktionalität anzubieten. Aufbauend auf dieser Basis, eine Architektur wird vorgeschlagen, die eine Computerunterstützte Lernplattform für ABE anpasst. Diese Architektur wird genutzt um eine Lernplattform in einer 3D virtuellen Welt umzusetzen, da hier mehrere Teile der Lerntheorie umgesetzt werden können. Es folgt eine Evaluation und ein Vergleich dieser Lernplattform. Der Vergleich zu einer 2D Webbasierten Anwendung wurde entworfen und für ABE umgesetzt. Zuletzt, die Evaluation sowohl der 2D als auch der 3D Lernplattform wurde durchgeführt auf Basis ihrer Auswirkung auf 1) verschiedene Intelligenzarten von Lernern, 2) Den Lernfortschritt von Lernern, und 3) die Zufriedenheit von Lernern. Für den Vergleich und die Evaluation eine Studie wurde entworfen und durchgeführt wo quantitative und qualitative Daten erhoben wurden und für formative und summative Assessments genutzt wurden.

Weiters ist systematische Anpassungsfähigkeit in 3D virtuellen Welten für Multiuser ein Kriterium. Bisher, alle Versuche der Anpassung von 3D virtuellen Welten konzentrieren sich auf den einzelnen Benutzer;keine Anwendung ist in der Literatur bekannt, die Anpassungsfähigkeit in 3D virtuellen Welten für Multi-user umsetzt. InMulti-user 3D virtuellen Welten, da der gleiche 3D Raum von allen gleichzeitig verwendet wird, erfordert die Anpassung der Inhalte die Auflösung von Konflikten in der Präsentation (wie etwa die Überlappung von Inhalten) und führt zu neuen Herausforderungen. Ähnlich die Unterstützung der Navigation in deren Anpassung an die einzelnen Benutzer ist eine Herausforderung. Um diese Herausforderungen zu nutzen, ein Ansatz der angepassten Inhaltspräsentation und -Navigation in einer 3D virtuellen Welt für Multi-user wird vorgeschlagen und umgesetzt als eine Erweiterung des Designs der Lernplattform für ABE.

Um die Wirkung von 2D und 3D Lernumgebungen auf die Lernenden im ABE Programmes herauszufinden, wurde eine empirische Studie in Pakistan durchgeführt. Die Ergebnisse sind vielversprechend. Die vorgeschlagene 3D Lernumgebung hat eine gute Wirkung auf den Lernfortschritt der Lerner gezeigt, es sind mehr positive Einflüsse auf die Entwicklung verschiedener Intelligenz-Aspekte festzustellen als in der vergleichbaren 2D Lernumgebung. In der Evaluation zeigten sich die Lernenden mehr angesprochen von der 3D Umgebung als von der 2D Umgebung.

Abstract

The exponential growth in the development of the Information and Communication Technologies over the last decade has provided numerous opportunities to the human, and one of them is education. More specifically role of computers and the internet for teaching and learning is well recognized on the landscape of e-learning. Exploiting these tools, now learning is possible from general knowledge development to the formal education at all levels. Countless, web-based applications are available on the internet for the said purpose. Moreover, in the present era trends are changing, and transition from two dimensional (2D) applications to three dimensional (3D) virtual worlds is in progress. Universities and institutions are adapting these 3D virtual worlds for education and pedagogy because of their superiority on 2D applications as 3D virtual worlds have potential to offer immersive environment, true collaborative activities, adept to imitate culture and context, and emulate experiences very close to real life such as learning by doing and role based learning etc., which is otherwise not possible through 2D applications.

Unfortunately, most of the research studies on technology enhanced or computer-assisted learning (either through 2D applications or 3D virtual worlds) to-date seem to target main stream education. Few serious attempts have been made to exploit computer-assisted learning platforms for the adult literacy. However majority of these platforms offer e-learning opportunities to the functional illiterates only and they cover various domains such as General Education Development (GED), high school diploma, general knowledge, news, and other life skills. On the other hand the resources that are customized for the basic education are either text dominant or classified for children. The text dominant resources are again suitable to the functional illiterates, and the resources classified for children are rarely inspiring the adult absolute illiterate for their basic education. These indicators argue to design the customized learning platforms for the adult basic education (ABE). To explore the bases for this customization of computer-assisted learning platforms, and to optimally exploit the emerging technologies, there is a need to revisit the learning theories because theories provide guidance

to realize the goals and practice without theory is blind.

This thesis revisits the learning theories to select the features important for adult learners in ABE programs, and choose appropriate technologies that can provide the selected features. Consequently on these bases, architecture is proposed to realize the computer-assisted learning platforms customized for the ABE. Exploiting the proposed architecture a learning platform is implemented using 3D virtual world as it can offer more features selected from learning theories. Later on, evaluation and comparison of the realized learning platform is carried out. For comparison 2D web-based applications are designed and implemented for the ABE. Finally the evaluation of both 2D and 3D learning platforms is performed on the basis of their impact on; 1) multiple intelligences of the learners, 2) learning gain of the learners, and 3) satisfaction of the learners. For comparison and evaluation a study was designed and conducted where quantitative and qualitative data were collected and exploited for formative and summative assessment.

Furthermore, adaptivity in 3D virtual worlds for multi-user is an issue. In multi-user 3D virtual worlds, as the same 3D space is shared by more than one user simultaneously, adaptive content presentation for all users in the same 3D space raises conflicts in content presentation (like overlapping of contents). Similarly navigational support cannot be customized for an individual user because other users are sharing the same 3D space and demarcation in navigational cues for each individual user is a difficult job. To address these challenges, an approach for adaptive content presentation and navigation in 3D virtual world for multi-user is proposed, and implemented as an extension of the designed and developed platform for the ABE.

In order to find impact of both 2D and 3D learning environments on the learners of ABE program, an empirical study was conducted in Pakistan. The findings were quite promising. The proposed 3D learning environment had good impact on the learning gain of the learners, it positively influenced more intelligences of the learners than 2D learning environment, and the learners were more satisfied to work in 3D learning environment as compared to 2D learning environment.

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1

Introduction

In the present era, role of technology for teaching and learning is well recognized on the landscape of e-learning (Askov et al., 2003). There are numerous alternatives, on the continuum of computer-assisted learning environments, such as two dimensional (2D) web-based applications and more lucrative three dimensional (3D) virtual worlds with immersive learning experiences. However, most of the research studies on technology enhanced or computer-assisted learning to-date seem to target main stream education (Nwosu, 2010), and few serious attempts have been made to exploit computer-assisted learning platforms for the adult basic education (ABE). According to Sabatini, only one fourth of the adult literacy programs use technology for the delivery of instructions (Sabatini, 2001), although there are numerous reasons to use it for the adult literacy programs revealed through literature (Hope, 1998; Rosen, 2009; Sivin-Kachala and Bialo, 1992). The main objective of this thesis is to exploit emerging technologies such as 3D virtual worlds for the ABE and to explore the impact of 3D virtual worlds and 2D web-based computer-assisted learning platforms on the intelligences of the adult learners. Also a comparative analysis of learner's learning gain across two different learning environments and evaluation of their satisfaction and behavioral intention towards future use of these learning environments are carried out in this research.

Although there are numerous projects, commercial products and online resources are functioning for the adult literacy (CDLP, 2011; Funbrain, 2011; Hello-World, 2011; LitLink, 1996; LexiaReading, 2009; ReadingHorizons, 1984; WordBuilder, 2011). However interfaces they offer are text dominant and are suitable for a person already have basic education, or in other words they are more suitable for functional illiterates (who have small vocabulary of words but unable to comprehend the sentences) instead of absolute illiterates (those who are unable to read and write). On the other hand resources that offer image dominant interfaces are rarely customized for the adult learners. This thesis revisits the learning theories to select the features important for adult learners in ABE programs, selects appropriate technologies that can provide the selected features, and proposes an architecture to realize the computer-assisted learning platforms customized for ABE. The main emphasis of this thesis is on emerging 3D virtual worlds to realize the selected features, and for the sake of comparison 2D web-based technologies are used. The thesis evaluates both 3D and 2D learning environments using formative and summative assessment techniques. Formative assessment, first investigates the impact of both learning environments on the intelligences of the adult learners, and secondly it probes learners' perceived satisfaction, behavioral intention, and effectiveness of computer-based 2D and 3D learning environments. Summative assessment investigates the learning gain of each learner in the two different learning environments and ends up again with formative assessment where increase in learning gain is investigated across 2D and 3D learning environments designed specifically for this research. Moreover, an approach for adaptive content presentation and navigation in 3D virtual world for multi-user is proposed, and implemented as an extension of the designed and developed platform for the ABE.

1.1 Motivation and Justification

Illiteracy is a big problem, almost one in five of the adult population do not have basic literacy and numeracy skills and these statistics leads towards alarming figure of more than 774 million adults illiterate in the world (Rechmond et al., 2004). There are several reasons for illiteracy such as, lack of resources, poverty, high population rate, lack of educational awareness and ABE programs etc; these reasons may vary across different continents. Apart from these varying reasons, one common goal of all nations is to eradicate illiteracy from the world. In order to achieve this goal, numerous literacy programs are functioning for more than 55 years, and UNESCO is at the forefront in these efforts since its foundation (UNESCO, 2004).

According to Director General of UNESCO, "Literacy rates are rising, and there is a stronger awareness that literacy needs everywhere are changing and must be addressed in innovative ways" (Rechmond et al., 2004). On the one hand, this statement recognizes the efforts of literacy programs, whereas on the other hand it raises the question, what are these innovative ways? Of course, these innovative ways have many facets, one of them is technology. In the present era, role of technology for learning and teaching is well recognized on the landscape of e-learning (Askov et al., 2003). However, literacy programs have been last to access a new technology sometimes because of lack of funding and sometimes due to lack of vision of practitioners towards the effectiveness of technology (Turner, 1998). Turner further extended his findings as:

> *"Historically, literacy programs have been the last to access a new technology.......Failure to conceive how new technologies could be used in the classroom or tutoring situation often results in their arrival in literacy pro-*

> *grams at the point when they were being discarded as obsolete by other educators. To be at forefront of advocating for new technologies in the literacy field, practitioners must be able to articulate what the potential of the new technologies is for their learners."*

In spite of numerous benefits of technology to mankind in all fields of life, it has rarely been exploited with its full potential for the programs of ABE. Although Hopey in his book, "Technology, Basic Skills, and Adult Education: Getting Ready and Moving Forward" (Hope, 1998) explained that technology has great potential to improve learning by adults; the only need is to exploit it, in a smart and effective way. However most of the technology using ABE programs used it only for administrative support, such as record keeping, and report writing etc., (Sivin-Kachala and Bialo, 1992; Turner, 1998), and only one fourth of the adult literacy programs used it for delivery of instructions (Sabatini, 2001). In the present era trends are changing, according to Wagner, "IT is now too cheap to ignore" and there are several reasons for the selection of technology; few vital reasons derived from his research study are; 1) capacity of technology to approach geographically dispersed community in a country or across countries, 2) it has potential to provide interactive informal and time flexible learning platforms for those who are unable to regularly attend formal educational systems, 3) technology is able to provide individual-customized solutions based on language, gender and ethnicity etc., those are otherwise difficult to manage, and 4) network of educational experts can be extended by IT-supplemented training courses (Rosen, 2000). It is not the case that technology has never been used to provide solutions to adult illiterates; rather technology has been exploited to provide both supportive solution and literacy solution to the community of adult illiterates.

A lot of research has been done on the technology-based supportive dimensions for the adult illiterates. The prime purpose of these supportive solutions is to make the illiterates able to easily access the information in their surroundings. Nowadays the internet is a major source of information for everyone; and illiteracy is a major barrier for the illiterates to access this information. Thanks to the researchers of this dimension, who provided research based solutions to access this information using multimodal interfaces such a text-free, audio-visual and tangible interfaces. Few examples are, Job Information Systems (Medhi et al., 2007), Basic Health Systems (Akan et al., 2006), City Navigation Systems (Akan et al., 2006), e-government Portals (Taoufik et al., 2007), and Agriculture Information Systems (Plauche et al., 2006; Wirastuti et al., 2008). Furthermore, many other supportive applications such as; World Wide Telecom Web (WWTW) (Rajput et al., 2008), Text-to-Speech Tools (Walsh and Meade, 2003), Video-email (Prasad et al., 2008a), Mobile Phonebooks (Joshi et al., 2008), and

CAPTCHA (Shirali-Shahreza and Shirali-Shahreza, 2007) etc., are common for adult illiterates to make them able to access the information and to be part of the present society.

Also there are many examples and inferences of technology-based literacy solutions for adult illiterates explained by several research studies (Askov et al., 2003; Wagner and Kozma, 2003; Rosen, 2000; Sabatini, 2001; Stites, 2004; Wagner and Hopey, 1998; Wagner, 2001). Many known platforms, such as; The National Center for Adult Literacy (NCAL), International Literacy Institution (ILI), National Center of the Study of Adult Learning and Literacy (NCSALL), working for adult literacy and using technology for real application at national and international levels. And at last but not least, the role of United Nation, Scientific and Cultural Organization (UNESCO) is remarkable for its efforts to eradicate illiteracy from the world and to introduce technology enhanced programs to give new spirit to the literacy programs. Not all of these studies but few applied formative assessment technique and reported very positive results of use of technology in these adult literacy programs. Also the qualitative analysis explained the motivational and enticing role of technology. Following the established recommendation from these studies, there are many online instructional tools available for adult literacy that assist illiterates in the critical process of learning, such as; WordCue (WordCue, 2010), ReadPlease (ReadPlease, 2010), FunBrain Spelling (FunBrain-Spelling, 2010), NewUserTutorial (NewUserTutorial, 2010), Wikihow.com (WikiHow, 2010), HOTCHALK (HOTCHALK, 2010), HippoCampus (HippoCampus, 2010) and many others. Furthermore, David J. Rosen a known educationist recommended some popular online resources for adult literacy (Rosen, 2009). Prominent feature of all these technology-based literacy applications is audio-visual support. However, primarily they are heavily text dominant; consequently these resources are not suitable for illiterates who want to use these resources for basic education. On the same time, if some of these resources offer audio-visual aid, nonetheless these are customized for children; hence these resources have least potential to be suitable for the ABE programs. It is important to consider and introduce the critical features, recommended by known learning theories so that full potential of emerging technologies could be exploited and enhanced computer-based application could be provided keeping in view the needs of adult illiterates.

In order to design and customize computer-based learning environments for adult illiterates, first it is important to understand basic process of learning for effective learning to be take place. Two major schools of thought from psychology of learning are behaviorism and constructivism (Pritchard, 2009). According to behaviorism, learning is acquisition of new behavior. It is based on stimulus-response relationship however ignores much of the hidden mental processes (Pritchard, 2009). According to constructivism (a branch of cognitive science), learning take place when new knowledge is added up into the previous structure of knowledge of an individual (Duffy and Johnassen, 1992). Under the umbrella of these two schools of thoughts and motivational theories, different learning features are considered important to augment the learning process of an individual. These features are, situated learning, problem-based learning, collaborative learning, experimental learning explained and recommended in learning theories (Elizabeth et al., 2005; Hmelo-Silver and Barrows, 2006; Kolb, 1984; Lave and Wenger, 1990). Also the aspect of learners' preferences is deemed vital in the learning process, described in the literature on learning styles and theory of Multiple Intelligences (Gardner, 1983; Pritchard, 2009). This important dimension highlights the need of learner-centered learning, multimodal interfaces, immersive environments, interpersonal and intrapersonal support. Furthermore, there is a need to customize learning environments for adults, but keeping in mind the fact from Cyril Houle that, change in learning environment on the basis of categorization of adult and child is not justified, rather characteristics of the learners are important determinant for the change in learning environment (Houle, 1996).

Technologies in the present era such as web 2.0 and 3D multi-user virtual worlds together have great potential. Only a systematic approach is required that will bridge the gap between theories and practice; and will set the directions to fully exploit technology to provide augmented learning environment for ABE by providing the said features. Furthermore, there is a need of formative assessment techniques along with summative assessment techniques to determine the efficacy of these computer-based application programs to optimize the provided solutions and to set the new directions for the future research.

1.2 Research Questions

For the ABE programs, there is a need to determine the differences of intelligences between learners and their association with different learning environments based on possessed intelligences; because these association leads towards learning gain and learners' satisfaction, behavioral intention towards future use of the learning environment. This research sought to understand and describe the said association in order to provide better computer-based learning environments to the adult illiterate learners, and to augment their learning experiences and finally to motivate and entice them towards technology without fear. There are several questions regarding the realization of techno-literacy solutions for ABE. Among those, the questions which are prime focus of this thesis are as follows:

1. Do emerging technologies such as 3D virtual worlds have more potential to offer additional features (important in learning) recommended by various theories than 2D web-based applications?

2. How much does a 3D learning environment increases learning gain in comparison to 2D learning environment, in case of ABE?

3. Do different learning environments (2D and 3D) effect multiple intelligences (MI) inventory score of learners? If yes which type of MI quotients will increase most in 2D and 3D learning environments?

4. What is the relationship between quotients of multiple intelligences of the learners and their assessment score in two different learning environments?

5. Do learners' satisfaction and behavioral intention increase when they learn in 3D learning environment as compared to 2D learning environment?

1.3 Proposed Solution

This thesis is an attempt to bridge the gap between theories and practice. Available technologies in the present era are targeted to provide best learning environment to adult illiterates keeping in view the theoretical landscape and its provided directions, vital to be considered in learning environments for the ABE programs. More specifically, as a first step the features that are important to be considered in learning environment for adult learners are explored from the two major schools of thoughts behaviorism and constructivism. Then in a second step, emerging technologies such as Web 2.0 and 3D virtual worlds are considered for the provision of these underpinned features. As a result of these two steps, an architecture is proposed that has potential to provide all said features through a multimodal interface based on Gardner's theory of Multiple Intelligences. Apart from providing multiple interface channels, this architecture also considers interest and previous knowledge of learners and able to provide customized contents to different adult learners according to their interest and previous knowledge. Finally summative and formative assessment techniques are carried out to answer the research questions.

In summary, an effort has been made to provide computer-based 3D learning environments to the absolute illiterate; which is a step forward from the current state of the art in computer-based learning environments for intended community of learners.

1.4 Scope and Limitations

Since the objective is to show the potential of different emerging technologies for the ABE programs based on the features described in the learning theories. Therefore it was not the intention to exhaustively cover all the facet of technology and full range of features described in the theoretic domain. However, the proposed architecture and the learning environments developed can be enhanced further by adding up more features proven by learning theories and by adopting different mediums, other than the computer-based education.

Accessibility and Usability are other important dimensions to be considered while designing interfaces especially when the audience is absolute illiterate. Although, in this research multimodal interfaces are offered however learning platform may not fulfill the accessibility standards described in (w3C, 2011). Whereas usability, as defined by ISO 9421, “Usability is a measure of the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment” (Alexander, 2006). In this concern, the designed and implemented learning environments in this research use pictorial and iconic navigational buttons to make the interface more user friendly, and to augmnet learners’s experiences and satisfaction level. However, still training part is important to be covered before using the designed learning environments. The usability is also one of the parameters of user’s satisfaction; it is investigated and explained in the results.

A study in a real environment was conducted to best investigate the impact of technology on the learners of ABE program in Pakistan. During investigation process to find the change in intelligences, multiple intelligences inventory of Christison and Armstrong (Armstrong, 1999) is used and to determine the learners’ satisfaction, a questionnaire designed by Liaw (Liaw, 2008) is used. It is assumed that selected multiple intelligences inventory to determine intelligences, and questionnaire to find out satisfaction of learners are valid instruments. Also execution of both of the instruments is done through interviews because intended learners were absolute illiterates. It is also assumed that learners responded honestly to the asked questions. It was really a hard experience to mobilize the adult illiterates due to their routine schedule of daily life; however selected participants presented themselves voluntarily. Due to limited resources to establish proper labs and difficulties in seeking participants, the sample size was limited to 40 that decreased to 32 after Grapheme Test. Thus findings from this study can be considerable indicators; however generalization of the results may not be justifiable.

1.5 Structure of the Thesis

This thesis is organized in 7 chapters. In the next chapter literature review is covered. It includes core concepts about ABE, need of exploiting technology in the intended area, and known theories which set the foundation for learning. It also covers the literature on differences in adult and child learning, individual difference and role of multiple intelligences. Finally it explores few state of the art computer-assisted learning platforms available for the ABE programs. Parts of this chapter were published as jounal paper (Iqbal et al., 2011b).

Chapter 3 describes how we can move from theory to practice. Firstly, it describes the theory of Multiple Intelligences, and selection of features important in learning process from the theories discussed in the chapter 2. Secondly it explains the mapping process of the selected features to the multiple intelligences, learning content and computer-assisted learning platforms. It also explains the realization of different intelligences through emerging computer-assisted learning environments such as 3D virtual environment, and selection process of 3D virtual environment for this research. Parts of this chapter were published as journal paper and conference paper (Iqbal et al., 2009, 2010, 2011b).

Chapter 4 describes the architecture and implementation of learning environment in 3D space for the ABE. It also outlines the issues of adaptivity in 3D space especially in case of multi-user, and describes a customized Adaptive WEB 3D (AWE3D) architecture to address the highlighted issues. Finally it explains learning process in the proposed 3D learning environment using practical scenarios. Parts of this chapter were published as conference paper (Iqbal et al., 2011a).

Chapter 5 describes the design of experimental studies that were carried out to determine the impact of computer-assisted learning environments on the intelligences of the learners, and on their assessment scores. It outlines the research methodology exploited in this research, instructional material used and their validation; assessment instruments and their reliability and validity; information about participants and a procedure followed in this experimental study.

Chapter 6 presents an analysis and discussion on the experimental results. The results primarily covers four dimensions, 1) comparison of assessment scores in 2D and 3D learning environments, 2) impact of 2D and 3D learning environments on the intelligences of the learners, 3) correlation between assessment score of the learners and their MI quotients, and 4) comparison of the learners' satisfaction, behavioral intention, and effectiveness of 2D and 3D learning environments. Apart from the quantitative analysis, the results also include qualitative feedback of the learners regarding computer-assisted learning environments, and effectiveness of adaptive support in these environments.

Chapter 7 concludes the thesis by highlighting the contribution, and discussing limitations and directions for future work.

2

Adult Basic Education, Learning Theories and Technology

The diverse nature of this thesis claims to address the problem from more than one angles. Therefore, areas closely related with the core of Adult Basic Education (ABE), importance of learning theories for adult learning, role of technology in ABE programs are investigated.

2.1 Adult Basic Education - Core Concepts

The state of being uneducated or condition of being unable to read and write is referred as illiteracy; and a person who is unable to read and write is considered as illiterate. There are 774 million adults (age 15+) illiterate in present era, and this figure is believed to be underestimation (Rechmond et al., 2004). Around 27% of the population of developing countries is illiterate, as compared to developed nations where this figure is only 1.4%. Even these figures are more challenging in South and West Asia, Arab and Sub-Saharan African countries, 44%, 39% and 38% respectively, and more than half of these figures consists of women (UN, 2002).

In year 2003, the United Nations General Assembly officially launched the years 2003-2012 to be the United Nations Literacy Decade, in which a commitment was made to realize 50% improvement in adult literacy by year 2015 (UN, 2002). However the question is what is meant by adult literacy, ABE and learners of the ABE?

There are various contemporary definitions of literacy are reported in literature (Wagner and Kozma, 2003), the most accepted definition published in the report of an Expert Meeting on Literacy assessment by UNESCO is, “Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve his or her goals, develop his or her knowledge and potential and participate fully in community and wider society” (UNESCO, 2003).

The definition explains many facets of literacy ranging from basic education for adults to adults functional literacy important for each individual to excel successfully in the society. In this definition, on the one side of continuum, ABE is discussed that focuses on minimal education skills required for an adult such as basic reading, writing and computational skills; whereas on the other extreme of continuum the adult literacy is described, that focuses to further enhance already developed skill so that an adult can fully participate in the society . Savage's categorization of literates further explains these concepts. According to Savage there are four types of literates; 1) "Preliterate – Students speak a language whose written form is rare or does not exist", 2) "Non-Literate – students (formerly illiterate) speak a language that has a written form, but they have not learned to read or write it themselves", 3) "Semi-illiterate – students have some formal education and are able to read and write at an elementary level (usually up to grade 4 elementary level)", and 4) "Literate in a non-Roman alphabet – students who are literate in a non-Roman alphabet are functionally literate in their native language, which uses characters or non-Roman alphabet; they therefore need to learn the formation of the Roman alphabet and the sound/symbol relationship in English" (Savage, 1993). Also the definition of Absolute Illiterates – those who are unable to read and write (CompactOxfordDictionary, 2009; OnlineEncyclopedia, 2009; WorldReference, 2009); and definition of Functional Illiterates – those who have small vocabulary of words but unable to comprehend the sentences (WorldReference, 2009); further draws a line between ABE and Adult Literacy (AL). Thus ABE is meant for absolute illiterates and AL is meant for functional illiterates. As most of the time AL and ABE are used interchangeably; this thesis may also use both term but always meant to ABE for adult absolute illiterates – who are either preliterate or non-literate.

2.2 Adult Basic Education – from Theory to Practice

Socrates expresses his sorrow about "written text". He describes written text would reduce memory skill and the ability to engage in active dialogues. Wagner explains, "He [Socrates] felt that written text was inferior to oral discourse because of its lack of interactivity- the reader could not engage in dialog with it" (Wagner and Kozma, 2003). According to Wagner, as written text is a kind of encoding of knowledge, thus to comprehend it, one should need to decode it first that leads toward the concept of literacy. Previously discussed, the definition of literacy focuses on the skills of reading and communicating printed material or text. This reading of text is cognitively demanding task for new readers as it comprises of processes of decoding and comprehension (Wagner and Kozma, 2003; Just and Carpenter, 1987; Perfetti, 1989; Sabatini, 1999; Snow and

Strucker, 2000). It shows that the reader need decoding skills to convert the text into mental equivalent of spoken words and also need to construct mental understanding of what these words mean (Wagner and Kozma, 2003). In contrast to fluent readers, the process is slow for readers with limited cognitive skills because more of their cognitive resources engaged in the decoding process; as a result fewer resources are left for understanding the meanings of words. Similarly in writing process, even complex cognitive skills are required (Bereiter and Scardamalia, 1987). Thus adult illiterates when join ABE programs, and start to read and write, they feel cognitive load at early stages, however technology as a tool has potential to support development of cognitive processes and basic skills involved in literacy , for instance, Computer Assisted Instructions (CAI) consists of variety of forms such as text, sound, pictures and video has potential to provide the learners with interaction that is otherwise possible through human tutors (Wagner and Kozma, 2003).

In order to provide learning environments to adult illiterates for their basic education, the consideration of underlying learning theories, comparison of adult and child learning and influence of individual differences appear to be crucial that act as foundation for the effective use of technology. Significant theories that explain underpin learning processes and technology enhanced learning environments that can help in learning process are included in this thesis to explain the said concern.

2.3 Learning Theories

Learning is something of which we all are aware and we all went through this process and experience. This process of learning keeps going right from birth to death of each individual. However someone rarely notice this process explicitly, it must be true to say that people rarely focuses upon learning about "learning". Particularly to know learning about "learning" appears more important for the people related with education sector especially instructor or teachers. According to Pritchard (Pritchard, 2009), in teacher education programs, there is a decrease in the emphasis given to learning about "learning" due to various reasons such as emergence of alternative entry channels etc. He further focused on the need of balance between theory and practice, because theories can provide the way to explain the process to achieve particular learning outcomes (Pritchard, 2009). Similarly when, we want technology to emulate the role of instructor and teacher, it becomes more important to consider the theories that explain the learning and furthermore theories that describe the need of technology supported learning.

This section describes commonly used learning theories, and theories that pose the need of technology supported learning. The selection of these theories is based on their influence on describing learning process, importance in the field, their widespread use, and more particularly their applicability in technology enhanced learning. Since this thesis focuses on to probe the features important in learning process of adult illiterates, availability of these features in emerging technology, and influence of highlighted features on learners' intelligences, thus theories beyond the scope are not considered.

2.3.1 Behaviorism

One of the branches of psychology of learning is Behaviorism. John B. Watson, first time coined the term "Behaviorism". Behaviorism is based on notion of a stimulus and a response (Pritchard, 2009). Thus it appears to be more concerned with behavior than with explaining the process of learning. According to Pritchard, to respond correctly against a question raised in the classroom does not ensure the underlying understanding. It focuses on visible behavior and discounts any mental activity (Pritchard, 2009). This method of learning is called "Conditioning", further divided into "Classical Conditioning" and "Operant Conditioning".

The classical conditioning involves reinforcement of a behavior which occurs as a response to a certain stimulus. Most popular example of classical conditioning is salivation of dog at the sound of bell (Pavlov, 1927) describe the concept of classical conditioning. Pavlov (Pavlov, 1927) described four stages of the classical conditioning; 1) Acquisition – phase of initial learning of the conditional response, for example sound of the bell, 2) Extinction – this phase describes disappearance of the conditioned responses because a conditioned response will not remain forever, for example presenting food without sound of the bell, 3) Generalization – it explains once a conditioned response is learnt to one stimulus, it is workable for other similar stimuli, for example if a child bitten by a dog, may feel fear from all dogs, and 4) Discrimination – it is opposite of generalization, a person learn to produce conditioned response to one certain stimulus, but may not produce for other similar stimuli, for example a child may not feel fear from all dogs but from one specific which bite him. The classical conditioning explains learning mechanism by stimulus-response theory, how a certain response is conditioned to one certain stimulus.

On the other hand, the Operant Conditioning explains reinforcing of a behavior by rewarding it. For example a student in a class is always praised whenever he score good grades in his class tests. In such a situation behavior of scoring good grades increases because it is rewarded and this rewarding is known as "reinforcement". Skinner a known psychologist (Skinner, 1953) described that operant conditioning can explain human learning because the reward and punishment control the majority of human behavior. The reward refers to positive reinforcement, exercised to increase desirable behavior.

Whereas punishment refers to negative reinforcement, used to eliminate or reduce the unwanted behavior. In Operant Conditioning, positive reinforcement can be a good tool in educational setting to increase the desirable behavior of the students. However critics of behaviorism raised two main points. Pritchard (Pritchard, 2009) summarized these points as; 1) rewarding children every time in learning, may cause children to lose interest in learning for their own sake, 2) giving reward or special attention to one child in the class may cause effect on the others. He further extends his view as "There is a place for learning in classrooms that relies on the principles of behaviorism. However, since behaviorism gives little importance to the mental activity, concept formation or understanding, there are difficult problems to overcome when setting out philosophies of teaching and learning that depend wholly upon behaviorist approach" (Pritchard, 2009).

Apart from all this criticism, behaviorism has potential to motivate the students who have history of academic failure and where there is no other approach workable, the stimulus-response theory using repetition of a particular action make them able to at least learn a particular phenomenon at the cost of underlying true understanding of the phenomenon. Using the same notion, different computer supported applications such as Drill and Practice (DP) software and Integrated Learning System (ILS) developed and exercised. In DP software students are asked to select one correct answer out of several answers against a single question. On each correct response, using positive reinforcement approach a reward is given to student in the form of smiley-faces, stars, and points etc. Whereas on each incorrect answer, students are given another chance to attempt the question. In some DP software, on each incorrect response, students are punished by giving non-smiley-face or reduction in points etc. Self-assessment modules in different tutors follow the same notion of Drill and Practice approach (Drill&Practice, 2011), because computer supported assessment are objective in nature and has certain limitation about true assessment of the students. Also the ILS follows the view point of behaviorism and based on Skinner theory of Programmed Learning (Becker, 1993). The ILS are computer-based systems perform two major tasks; delivery of computer-aided instructions and management of contents and records of students or learners. Each student has individualized learning interface and material is delivered to the student in small chunk with increasing level of difficulty as the student progress in the delivered material. Immediate feedback, self-assessment, and keeping track of what the student has learned and what to be presented next are important features of ILS. It allows to access student data to the teachers to monitor the activities of the students using this environment. Although ILS also unable to ensure true understanding of the material being taught however some studies (Underwood and Brown, 1997) have shown effectiveness of the ILS when evaluated. Behaviorist model of learning is a foundation of most of the children and elder games also, such as (MarioGames, 2011). For instance, during expedition, fight and adventure, one has to escape some items and sometimes has to dig up or take some items. While playing game, if someone lose the life while interacting with a certain object, next time would avoid to interact with it and, in contrast if get some points or prizes while interacting with some specific object or item, would prefer to acquire or find that item next time.

Finally Pritchard suggested behaviorist approach for establishing classroom behavior using positive reinforcement. Also use of self-paced learning modules, frequent feedback, presentation and repetition of material in small chunks etc., is recommended by him that is core of behaviorist theory (Pritchard, 2009).

2.3.2 Cognitivism

In 1960, a dominant paradigm of cognitivist replaced the behaviorism. In contrast to behaviorism where mind is considered as black box, cognitive school of thought describes about inner mind processes. It focuses on how people learn. Different theories under the umbrella of cognitivism are explained in this section.

Jean Piaget, a known psychologist was one of the early most influential advocates of cognitivism. He presented a Stage Theory of development (White et al., 2005) that describes cognitive development as four distinct stages in children. Since the focus of this research is to explore adult learning processes, this thesis covers Piaget's contribution about assimilation and accommodation which is not restricted to young learners rather explains the process of learning for learners of all ages. According to him learning is a process of adjustment to environmental influences. This adjustment process consists of two basic processes of assimilation and accommodation. In assimilation process new knowledge is added into existing knowledge bank and in accommodation process, existing structure of knowledge alters to accommodate the new knowledge. Finally it reaches to the equilibrium stage when all conflicts are removed. These processes set the foundation of constructivism, which will be discussed in the next section.

Since the cognitive science deals with process of learning, how people learn, remember and interact; it also addresses the issues of cognitive load in the process of learning. John Sweller, in his cognitive theory of load described the human cognitive architecture and significance of instructional design based on knowledge of brain and memory (Sweller et al., 1998). He first described about two different types of memories that are short-term memory and long-term memory. Then he explained that schemas and structures of knowledge held in long-term memory directly effects the manner in which information is synthesized in short-term or working memory. Furthermore, he emphasized that instructional design should be capable to provide substitute for learners to develop either own schemas. He also explained three types of cognitive load which are 1) intrinsic load, 2) extraneous load and 3) germane load. Inherited instructional difficulties such as calculation of number define the intrinsic cognitive load. This inherited difficulty cannot be reduced through instructions however larger schemas can be broken down into small sub-schemas to explain the instructions and later on, combined back to explain the whole concept. On the other hand, extraneous cognitive load is controllable through instructional design. It is generated by the manner in which material is presented to learners. It points towards the fact that more than one ways should be used to present same kind of information for enhanced learning. Finally the germane load is an effective cognitive load caused by successful schema construction. This theory not only explains the cognitive load but also raises the need of presenting information to learner in different ways.

Cognitive theory of multimedia learning presented by Richard Mayer (Mayer, 2001) further highlighted the importance of presenting material in different ways and two different channels of brain for processing of the information are explained. These are auditory and visual channels and each has limited capacity to process the information. Moreover learning is an active process of filtering, selecting, organizing and integrated information based on previous knowledge. Considering the two channels for processing of the information, Mayer presented a set of principles for multimedia learning (Mayer, 2001). In order to preserve the originality of the Mayer's work, these principles are presented as it is. These seven principles are listed below:

- Principle of Multimedia: People learn better from words and pictures than from words.
- Principle of Spatial Contiguity: People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.
- Principle of Temporal Contiguity: People learn better when words and pictures are presented simultaneously rather than successively.
- Principle of Coherence: People learn better when extraneous material is excluded rather than included.
- Principle of Modality: People can better learn from animation and narration than from animation and on-screen text; that is, people learn better when words in a multimedia message are presented as spoken text rather than printed text.
- Principle of Redundancy: People learn better from animation and narration than from animation, narration and text.

- Principle of Individual Differences: Design effects are stronger for low-prior knowledge learners than for high-prior knowledge learners and for high-spatial learners than for low-spatial learners.

In the present era, paradigm is shifting from teacher-centered instructions to learner-centered instructions and this credit goes to the Charles Reigeluth who presented the Elaboration Theory (Reigeluth, 1999). The thesis of elaboration theory consist of four points; 1) instruction must be in a sequence to express proper meanings and to motivate the learners, 2) during learning process, learners should be allowed to make decision about suitable sequencing, 3) core of theory facilitates rapid prototyping in instructional design process, and 4) to scope and sequence coherent design theory, it integrates viable approaches. According to this theory, early task in contents should be simplest most and there should be gradual increase in difficulty level. However theory does explained primarily effective contents and also failed to provide the authentic and situated learning.

2.3.3 Constructivism

Jean Piaget is one the most leading proponents of constructivism. According to constructivism (Smith, 1993), in learning process new information is added onto current structure of knowledge, understanding and skills of a learner. A learner actively constructs his own knowledge through experience and hypotheses from outside world. However this construction process and interpretation of knowledge may vary from person to person (Smith, 1993). The underlying complexities of constructing knowledge and interpretation is further explained by Schema Theory (Mandler, 1984). It describes that knowledge, understanding and skills are presented through schemas stored in long-term memory. An adult may have hundreds of thousands such schemas in memory which are interconnected in many ways. New schemas are created and previously developed schemas are updated whenever a person gets input from the external environment. These inputs can be in the form of reading, listening, and observing some scenes etc. It is important to focus here that prior knowledge of a person play a critical part in constructivist learning approach (Pritchard, 2009). According to Piaget's early work, the underpinned mechanism in schema development is the processes assimilation and accommodation (Smith, 1993). In case of similar new information previously developed schemas are updated and in case of entirely new information new schemas are created, however for effective learning it is important to teach the learners relevancy between new and old topic for establishing new links in schemas. In other words, if new information is presented in such a way that it matches with previously developed schemas then it would be more helpful for learners; especially in case of adult learners those have large number of schemas already in their long-term memory.

Another dimension of constructivism is known as social constructivism. Vygotsky's theory of social development (Vygotsky, 1978) is considered as foundation of constructivism. The social development theory argues the consciousness and cognitions are the main products of social interaction and it leads towards learning and development. Three major premises of the theory are, 1) social interaction plays an important role in the process of social development, 2) it coins the concept of More Knowledgeable Other (MKO) refers to any person has more knowledge than a learner in a particular concept. MKO can be adult, peer, teacher or parents, and finally 3) the notion of Zone of Proximal Development (ZPD). The ZPD, is the distance between what a learner can do without the help of others and what he can do with the help of others. According Vygotsky's during a particular task, a child follows MKO's guidance and with the passage of time develops ability to do that task without any help (Vygotsky, 1978). The theory gives three major constructs which are social interaction, concept of scaffolding and gradual development from working with some support to working without any support. As discussed earlier, social interaction is an activity proceeds between a learner and others. When the others are more knowledgeable it leads toward concept of scaffolding (giving support to others). Scaffolding is possible through discussion, provision of material (such as practical apparatus or computer-based stuff) and designing tasks which match and help appropriate to the learner (Pritchard, 2009).

Also the notion of Lave's Situated Learning theory (Lave and Wenger, 1990) describes that learning can be situated in social and cultural settings. Social interaction and collaboration are essential components of situated learning. It relates to Vygotsky's notion of social development. Pritchard explains this concept as if a learning activity falls beyond the cultural understanding of the learner would be less successful than if it would be situated in a more familiar setting (Pritchard, 2009), because core of the situated learning theory is authentic task, context and culture. Authentic task are the task that learners can relate to their experiences and context inside or outside of school (Selinger, 2001). When learning process entails authentic task, it is more likely that learners would pay more attention and their interest would lead towards engagement and consequently they would be more motivated towards the learning (Pritchard, 2009).

Another important perspective regarding instruction design is well explained in Problem-Based Learning (Hmelo-Silver and Barrows, 2006). Problem-based learning is a learner-centered pedagogic approach. According to problem-based learning, real-world problems are crucial in effective learning, because they actively engage the learners in knowledge construction and hence overcome many of deficits of the traditional classroom. Most prominent features of problem-based learning are provision of challenging problems, context specific problem, learners' self-directedness, orientation towards teachers' role as facilitators (Hmelo-Silver and Barrows, 2006).

2.3.4 Humanism

Humanists on the other hand have different view point. The focal point of humanism is to study needs and interest of human. About humanism, Huitt (Huitt, 2009) states, "This is in contrast to the beliefs of operant conditioning theorists who believe that all behavior is the result of the application of consequences or to the beliefs of cognitive psychologists who hold that the discovery of concepts or processing of information is a primary factor in human learning" . According to humanist believe, person as a whole is necessary to be studied, and over the lifespan an individual grows and develops (Huitt, 2009). Main summits of humanist are personalized and student-centered learning, self-actualization, and instructor roles as facilitator. Hence study of self, goal-setting and motivation are major areas of interest for humanists. Some known theories related to humanism such as Keller's ARCS Motivational Design Model, Kolb's Experimental Learning and Maslow's Hierarchy of needs are discussed in this section.

John Keller's ARCS model of motivational design describes four steps essential for promoting and sustaining motivation in the learning process, these are Attention, Relevance, Confidence, and Satisfaction (Keller, 1983). Keller's also suggested methods, guidelines and ways to establish the four essential components of ARCS model. In order to grab learner's attention, ARCS model describes few important methods. The first method is active participation – such as game-based learning and role playing to involve learners with subject material. The second method focuses on individual learning styles and highlights the need of use of multimodal presentation of contents. The third method suggests some humor while presenting material. The fourth method recommends the use of conflicting statements to catch the learners' attention in subject material. The fifth method argues to add some specific examples using visual stimuli and story etc. The last method suggests problems for the learners to increase the brainstorming activities. To increase the learners' motivation, relevance is an essential component. Keller suggested few strategies to establish relevance. Firstly, learners must be informed that how learning will exploit their experiences. Secondly, importance of the material to be taught must be described in advance. Thirdly, worth and future use of material must be communicated. Fourthly, allow learners to use different ways to practice their task. Confidence is third component of Keller's model. To achieve confidence in learners, Keller suggested another set of guidelines. These are 1) learner control, 2) feedback, 3) grow learners through small steps, 4) learners must be aware of evaluation criteria and performance requirements. Finally, satisfaction is an important component in the ARCS model, normally satisfaction of learners determines their future intention to use whatever experienced by them, for instance learning material, educational program, or computer-based learning environments. In order to increase learners' satisfaction, it is important to provide them feedback; they must be rewarded; and rewards on easy task should be avoided (Keller, 1983, 1984).

Experimental Learning theory of Kolb combines experience, perception, cognition and behavior, and argues that "learning is the process whereby knowledge is created through the transformation of experience" (Kolb, 1984). It explains four cyclic stages, 1) concrete experience – where learners actively experience an activity, 2) reflective observation – when learners reflect back on the experience of previous stage, 3) abstract conceptualization – where attempt is made to conceptualize the underpinned theory, and 4) active experience – where learners try to test theory for next experience. Kolb further identified four learning styles associated with the four stages. The first is assimilators – who learn better when sound logical theories are presented. The second is convergers - who learn better when practical application of underpinned theory is described. The third is accommodators – who learn better when experience thing themselves. The fourth is divergers – who learn better when presented with broader information.

Maslow's hierarchy of needs explains that when basic needs of people are met, they further seek to meet higher needs successively in a hierarchical fashion (Maslow, 1943). This hierarchy of needs consist of five levels, where four lower-level needs are considered physiological needs whereas top level highlights growth needs. These needs from lower to top level are explained by Maslow are, physiological needs includes food, shelter, sex, and sleep; safety needs includes environmental security, resources and health etc; belongingness includes love, friendship and relationship etc; self-esteem includes confidence, achievement etc; self-actualization includes creativity, morality etc. According to Maslow once lower level needs are satisfied, people proceed to seek higher level successively.

2.4 Differences in Adult and Child Learning - Andragogy Vs Pedagogy

Some theorist argued that child and adult learning is fundamentally the same (Houle, 1996), where as some others stated adult learning is different from child learning (Knowles, 1970). In this section, literature landscape is revisited to understand basic concepts and to find notions, important for adult learning.

Adult educationists point out that the term "pedagogy" means "child" or "lead to", that comes up with meanings "to lead the child". It is also referred as Directed-Learning

(Herod, 2011). On the other hand the term "andragogy" in contrast to the "pedagogy" is defined as "art and science of teaching adults" (Knowles, 1990). This andragogy approach also called as Facilitated-Learning (Herod, 2011). According to Knowles theory of andragogy (Knowles, 1990), adult learners come up with some experiences; they are self motivated; they want to learn in independent fashion; they need problem oriented learning; and they want to know why they are learning. So the compelling contrast between andragogy and pedagogy appears as; 1) adult learners come with life experiences however child learners have little or no experience, 2) adults are self motivated while child learners need motivation, 3) adults prefer to learner in independent fashion in contrast to child learners, 4) adult learners want problem-oriented learning whereas child learning is subject-oriented, and finally 5) adult learners want to know why they are learning some stuff in contrast to child learners (Herod, 2011). All these contrasting arguments are sound to differentiate andragogy from pedagogy, however the way in which adults are characterized in andragogy is not as the actually adults are (Kerka, 2002). This is main criticism on andragogy. For example, it is possible that some children after little guidance are better able to learn things independently, in similar way; some adults even has past experience of life, self-motivated but want learning under continuous supervision of instructors. Thus relating andragogy to adults learning and pedagogy to children learning is a false distinction (Herod, 2011).

Another adult educationist, Cyril Houle (Houle, 1996) explained the same findings that learning process of adults and children is basically the same, however in four different concerns it can be differentiated; these are 1) the characteristics of the learner, 2) the goals to be achieved, 3) the environment or context of learning, and 4) the techniques or ways of teaching or learning. The characteristics of adult learners are well explained through Knowles's theory of andragogy (Knowles, 1990) and contrast with child learners is drawn in (Herod, 2011). According to authors, characteristics of the learners are important determinant for change in learning process, whereas change in learning process on the basis of categorization of adult and child is not justified. The goals to be achieved, is the second concern that differentiate adult and child learning. Following the Paulo Freire aim, Jack Mezirow's transformation theory (Mezirow, 1995) highlights the goals raising consciousness in adults as cited in (Stites, 1998). According to these theorists, goal of education is to raise consciousness of social inequities and motivating adults for action to achieve social transformation. This argument explains that different learning goals influence the leaning process. The third concern, the environment and context of learning, is well described by Lauren Resnick (Resnick, 2006); he explains how the change in learning environment influences the learning process. To concretize the argument, author also described the reason that how learning environment vary within and out of school. Moreover Eberle and Robinson conducted

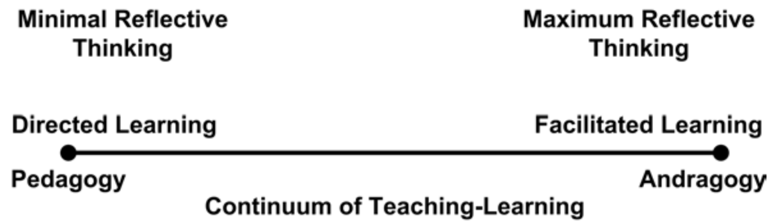

Figure 2.1: Teaching-Learning Continuum

a survey and reported preference of adults about their best learning place (Eberle and Robinson, 1980); according to survey, 55% people preferred learning at home, 19% preferred learning at job place and only 3.5% adults desired to learn at school. However they [authors] are not agreed that home is an ideal place for learning because of numerous family and social issues. These findings focus on the need of informal learning environment and non-school places for better learning experience for adult education. Some other studies also described that many adult illiterates have bad experiences with their school life so the similar milieu cannot entice them to go ahead and learn (Eberle and Robinson, 1980; Imel, 1996). Furthermore Laves and Wenger described in theory of Situated Learning that, "learning is embedded within activity, context and culture" (Lave and Wenger, 1990). According to situated learning theory, knowledge should be presented in valid context, in contrast to class room learning where knowledge is delivered out of context. Finally, the techniques and ways to teach the learners, is the concern that differentiate adult and child learning. These techniques for adult education may includes traditional efforts that are being fostered from many year to eradicate the illiteracy from society or may encompasses some technology-based solution to further augment learning process. However whatever the techniques are being used, needs of adult and child learners matter a lot with consideration of their due respect.

Thus, instead of drawing a boundary line between andragogy for adults and pedagogy for children, the major distinction may be the objectives of learning. For example, in case of novice learners, where directed learning is more important to transmit surface knowledge, the pedagogy is best option; on the other hand for advance learners, where facilitated learning is required to transmit deeper knowledge, the andragogy is an appropriate choice. Rather to consider, andragogy and pedagogy as two separate approaches, they are effectively viewed as teaching-learning continuum, with pedagogy at one end, and andragogy on the other end of the continuum (Herod, 2011), as shown in Figure 2.1.

To facilitate the learning in adult education, different theorist presented many approaches. Herod described four main approaches such as; self-directed learning, transformative learning, contextualized learning and experimental learning (Herod, 2011).

Almost similar approaches are suggested by Cyril Houle (Houle, 1996) while differentiating the ways of adult and child learning. Some other studies raised the importance of problem-based, discursive and, situated-learning environments for adult education (Lave and Wenger, 1990; Stites, 1998). Also many studies highlighted the need of learner-centered environment (Brusilovsky and Millan, 2007; Herod, 2011; Stites, 1998). In these environments, learner's preferences are considered and range of choices with different learning styles and modalities are provided; this continuum of modalities points toward use of mix of text, audio and visual support (Stites, 1998). Moreover, Visual Literacy states that, "visual images are language" (Aanstoos, 2003). According to Burmark, curriculum that exploits images can reach more learners and in contrast to traditional text-based and verbal approach it can teach them better (Burmark, 2002). In this study author further highlighted the need of integration of art, music and drama into curriculum for better results. Eberle and Robinson, while describing their findings of study (Eberle and Robinson, 1980), stated that, when one of the illiterates during a study interviewed, he said, "I can listen. I learn things just by sitting and talking and listening to other people talk." It shows that people who can easily learn the things around them by listening, they should be provided with learning environment that also facilitate them learning by listening stuff. Similarly, support of real world problem solving milieu and situation-specific environments for problem-based and contextualized learning respectively; and facility of synchronous (chat or discussion forums) and asynchronous (e-mail) communications for discursive learning justifies the need of technology. These conclusive findings from theories call upon technology-supported learning environments for adult education.

2.5 Individual Differences

The term cognition deals with mental activities that serve different processes such as acquisition, storage, retrieval, and use of knowledge. The term that explains knowledge about the knowledge of these mental activities referred as metacognition. It was first coined by the Flavell in 1979 (Flavell, 1979). According to Flavell "Metacognition refers to one's knowledge concerning one's cognitive processes and products or anything relating to them" (Flavell, 1976). A simpler version of this was offered by Brown (Brown, 1987), he says that "Metacognition refers loosely to one's knowledge and control of [one's] own cognitive system".

The essence of metacognition fosters that one should know about the ways in which he or she feels comfortable during learning. It is not necessary that if one person learns spelling by repeatedly saying them aloud, this method would also easy for others. One may learn through pictures, other may be by saying them aloud and yet another may be by writing and rewriting them (Pritchard, 2009). However it is not surprising that different people learns in different ways because both notions that learners have different multiple intelligences (Gardner, 1983), and different learners possess different learning preferences or styles (Felder, 1996) well explain underlying facts of this variation. Or other way around, it will be true to say that study of metacognition well describes the underpinned reasons for considering different intelligences and different learning styles while presenting the contents to the learners during learning process.

2.5.1 Learning Styles

A large body of research in education is agreed on the fact that, it is more likely to achieve success when learners are 'actively' engaged in the learning process (Hartman, 1995; LeadershipProject, 1995). According to Pritchard, once learners are actively engaged in their own learning process, it will improve their self-esteem and motivation. Thus learners' awareness about their learning preference and metacognition will lead towards enhanced learning outcomes (Pritchard, 2009). It highlights the significance that one should know about their learning preference and it opens the field of learning styles. A lot of research has been done in the field of learning styles in last 30 years. However, to date, no single definition of the term learning styles has been recognized. One of the most commonly used definitions is Felder's definition, who define learning styles as "characteristic strengths and preferences in the ways they [learners] take in and process information" (Felder, 1996). In order to well categorize the learners preferences, numerous learning style models exist in the literature. According to Coffield, there are 71 different models of learning styles exist to date, however 13 of them are more influential due to their theoretical importance in the field and their widespread use (Coffield et al., 2004). Few of these most influential and commonly used models are describes in this section.

Myers-Briggs defined personality types based on Jung's theory of psychological types (Jung, 1923) and presented four dichotomies of learning styles, these are extrovert/introvert, sensing/intuitive, thinking/feeling, and judging/perceiving (Briggs Myers, 1962). These pairs lead toward 16 possible combinations of types. In the first pair, extroverts are those who focus on environment such as people or thing whereas introverts preferred focus on their own thoughts. In the second pair, sensing people prefer their five senses to perceive data whereas others use their intuition to perceive the data. In the third pair, the judgment about the perceived data categorizes thinking (judgment is based on logical connections such as "true or false" and "if-then") and feeling (refers to evaluation through "better-worse" and "more-less"). The last pair explains those who are extroverts in his judgment function (thinking/feeling) or perceiving function (sensing/intuition).

According to Entwistle learners' approaches to learning affect learners' orientations and conceptions. Focusing on learners' intentions, goals and motivation, he categorized learning approaches into deep, surface and strategic learning (Entwistle, 1981; Entwistle et al., 2001). The essence of this model is based on the work of Pask (Pask, 1976) and Biggs (Biggs, 1979). Learners who apply deep learning approach are intrinsically motivated and want to learn ideas by themselves. They have potential to develop an understanding of the subject matter, examine arguments critically, and actively interested in contents of the course. On the other hand, surface learners only desire to meet the requirements of the course and they are extrinsically motivated. They normally focus on easily assessable items of the course and try to memorize them and find difficult to grasp new ideas, if presented. They rarely prefer to go into details and feel undue pressure and worry about their work. Finally the strategic learners combine the both deep and surface approaches to accomplish the best outcome. They find the right conditions and material for studying. They always used to put consist efforts into studying and keen to assessment requirements and criteria.

Another learning style model based on learners' social interaction with peers and teachers in the classroom environment was presented by Grasha and Riechmann, named Grasha-Riechmann model (Grasha and Riechmann, 1975; Riechmann and Grasha, 1974). They identified three paired dimensions based on learners' interactional behavior: the participant/avoidant, collaborative/competitive, and dependent/independent. In the first dimension, learners who participate, and enjoy attending the class exhibit participatory behavior, whereas those who do not participate in class activities and do not take responsibility for their learning are considered as avoidant learners. The second paired dimension identifies learners' collaborative behavior. Those who prefer to work in collaborative environment with peers in the form of groups or team and enjoy class sessions are referred as collaborative learners, whereas those who prefer to work alone and feel competition with their peers in the class are called competitive learners. In the last dimension of this model, dependent learners are those who want to be told what to do next by teachers and see teacher as authority for the information, whereas independent learners are those who prefer to think and do by themselves and feel confident while working on different tasks.

The Dunn and Dunn learning style model was first proposed in 1974 (Dunn and Dunn, 1974; Dunn and Griggs, 2003). This model includes five variables and each variable consists of several factors. Another important aspect of the model is its distinguishing feature between adult and child learners. The environmental variable includes factors such as sound, light, seating/furniture arrangement and temperature. The sociology variable focuses on preference for learning alone or in groups. It further includes motivation from teachers/parents for children as a factor. The emotional variable incorporates factors of motivation, persistence, conformity and responsibility. The physical variable consists of factors regarding perception/modality preferences (auditory, visual, tactile/kinesthetic external, kinesthetic internal), intake of food and drinks, mobility and the time. The last variable is psychological variable includes factors regarding impulsive/reflective preferences, global/analytical preferences and right or left hemisphericity.

Kolb's learning style model is based on the Kolb's Experimental Learning theory(Kolb, 1984). Kolb's states that, "as a result of our hereditary equipment, our particular past life experience, and the demand of our present environment, most of us develop learning styles that emphasize some learning abilities over others" (Kolb, 1981). Based on this statement, Kolb proposed four learning styles as discussed earlier in section 2.3.4.

Another most influential and most widely used learning style model is Felder-Silverman learning style model (Felder and Silverman, 1988). It identified four paired dimensions to explain the different learning styles. These dimensions deal with how learners prefer to: process (active/reflective), perceive (sensing/intuitive), receive (verbal/visual), and understand (sequential/global) information. Active learners prefer to do work actively, try to do different new things, and prefer working in groups in collaborative fashion; whereas reflective learners prefer to work alone, with one close friend, or in small groups. Sensing learners like to learn concrete material, most often use standard approaches to solve problems, and they are more realistic and sensible; whereas intuitive learners like abstract material such as theories, look into different possibilities and try to relate different things, and exhibit more creative and innovative behavior. The third dimension deals with modalities of input. Visual learners in this dimension, best remember the material when presented in pictorial or diagrammatic formats; whereas verbal learners prefer more textual representation of the material in written or spoken forms. In the last dimension, sequential learners prefer to learn when information is presented in small chunks in serial fashion, and they are more interested in stepwise details; whereas global learners like holistic view of information first to proceed further.

2.5.2 Individual Differences beyond Learning Styles

In order to provide better learning environments, consideration of individual differences appears as crucial dimension. Previously discussed the field of learning styles highlights one of the different facets of individual differences. To find the other facets, it is important to further explore the literature in the field of individual difference. The branch of psychology that deals with individual differences involves the study of psychological constructs, environmental stimuli and resulting behaviors (Boyle and Saklofske, 2004). According to Cooper, these psychological constructs can be divided into traits and states. The traits are long lasting and referred to as an ability of a person; whereas the states such as joy and sadness are short term, may change after certain period of time (Cooper, 2002). These two constructs, traits (intellectual abilities and personality traits) and states (dynamic motivational and transitory mood states) are vital to describe individual behavior as the function of individual differences (Anastasi, 1965; Boyle, 1988). Intellectual ability traits refer to thinking skills such as how well a person can perform in different tasks; whereas personality traits describes a style of person's behavior such as extrovert or introvert. The motivational states are short term and influence a person's behavior; whereas moods or emotions are transient feelings. Similarly in learning paradigm, educationists are concerned in individual differences with respect to performance. Exploiting intellectual abilities and learning styles as concepts of traits they sought to find individual differences (Kelly, 2005). Intellectual abilities are considered predictor of school performance, and learners' differences are measured through their expressed intelligences and abilities (Neisser et al., 1996). In educational setting, also the learning styles as personality traits imitate a person's style of behavior while learning (Sternberg and Grigorenko, 2001). Some research studies report that learning styles also can predict performance in ways that go beyond abilities (Marton and Booth, 1997). Messick, further explain these concepts as, abilities refer to things one can do ("how much") and styles refer to the preference ("how") while using the abilities (Kelly, 2005; Messick, 1996). Role and significance of learning styles in educational paradigm are previously discussed in section 2.5.1, the following three sections provide a brief overview of the abilities and intelligences.

2.5.3 On the Continuum of Intelligence

To identify the individual differences and to find what is meant to be intelligent, different concepts of "intelligences" have been proposed (Kelly, 2005). However in year 1994, the first definition of "intelligence" that have consensus of 52 experts was presented (Gottfredson, 1997). It defines intelligence as a very general capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. In order to establish the term "intelligence" two main approaches are used: the psychometric approach and cognitive approach.

The psychometric approach is an empirical approach that attempts to understand the structure of intelligences. The main thesis of this approach is to find whether intelligence is one general ability or many specific abilities. Numerous research studies come up with different specific abilities and they defined relationships among these abilities. They also agreed on a fact that a test consist of questions that are clearly either right or wrong is the best way to learn about the intelligences of an individual. In this test performance of an individual on different tasks is measured, and later on correlated and analyzed to determine the underlying structure and main dimensions of abilities (Wechsler, 1991). Spearman was the first who carried out empirical study of the structure of abilities using factor analysis (Spearman, 1904). According to Spearman, there is some basic thinking ability that determines the level of performance across all learning circumstances, and despite the variation in a person's abilities, he proposed a single intelligence factor called "g" (general ability). Later on Thurstone carried out another study and concluded that there are 12 basic abilities such as spatial ability, word fluency, numerical facility, perceptual speed, induction and deduction etc (Thurstone, 1938). Other research studies even proposed more primary mental abilities. Hakstian and Cattell proposed a hierarchical model of intelligences with three levels (Hakstian and Cattel, 1978). He defined first level with more general ability "g", middle level with six second order intelligences and finally last level with 20 primary abilities. These primary abilities include such as verbal ability, numerical ability, fluency of ideas, perceptual speed, reasoning, spelling and aesthetic judgment. More recently, Carroll also proposed hierarchical model of intelligences with three levels (Carroll, 1993). According to this model, there are 70 primary abilities at the lowest level of the hierarchy that define eight second order intelligences and they lead to define a general intelligence "g".

In contrast to psychometric approach, the prime focus of cognitive approach is to understand the process of intelligence. The proponents of cognitive approach believe that instead of finding the structural details of different intelligences, it is important to understand underlying processes of intelligence. Furthermore, they argue that standard test to explore the nature of intelligence is not a best way; rather there is a need to examine the process that a person uses to solve different problems.

Gardner's Theory of Multiple Intelligences (Gardner, 1983), is one of the popular theories in the support of cognitive approach to establish intelligence. Gardner defines intelligence as "biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture" (Gardner, 2000). The definition describes that different intelligences are used in different domains and different cultural settings to solve problems and to create something new. According to Gardner, to solve all human problems, no single model of cognitive functioning will be found; rather cognitive process will vary for different tasks. He proposed eight different intelligences, each have its own unique characteristics, tools and processes for thinking and learning, and to solve problems. These intelligences are linguistic/verbal, logical/mathematical, visual/spatial, bodily/kinesthetic, musical, interpersonal and intrapersonal. Gardner's main argument is that, everybody has different types of intelligences to different degrees and operates them together in orchestrated fashion. He also argues that some persons are stronger in one type of intelligence and some others are in other intelligence. Furthermore, weaker intelligences can be improved with the passage of time. The Gardner's theory of Multiple Intelligences highlights the need of presenting contents using different modalities to the learners to augment their learning process through multiple intelligences and to strong their weaker intelligences.

Sternberg, another leading proponent of the cognitive approach presented a new model (Sternberg, 1989, 1990). He argues that regardless of the type and domain of the problem being dealt by the people, a common set of cognitive processes is always used to solve the problem. According to Sternberg, whether the problems involve linguistic, musical, kinesthetic or interpersonal issues, the same cognitive process are used. He believes that for every type of problem, three factors play a central role: the context, the role of novelty and experience, and the underlying process of intelligent behavior. Sternberg further contributed by proposing his tri-archic theory that includes three fundamental aspects of intelligence: Analytical, Creative and Practical. He argues that traditional intelligence tests did not adequately measure intelligence rather they only focus on "Analytical" aspect of intelligence as mostly comprises of analytical problems only and have only single right answer.

Two other aspects of intelligences are Social and Emotional Intelligence. The social intelligence is an ability to understand (internal states, motives and behavior) and manage people, was first coined by Thorndike (Thorndike and Stein, 1937). After the failure of social intelligence, a subset of social intelligence known as emotional intelligence was revived by Goleman (Cronbach, 1960). The emotional intelligence is an ability to monitor one's own and other feelings, to discriminate among them and to use this information to guide one's thinking and action (Salovey and Mayer, 1990). The emotional intelligence is also subset of Gardner's theory of multiple intelligences, because it has similar view point as interpersonal and intrapersonal intelligences incorporate information about one's own and others (Gardner, 1983).

2.5.4 Intelligence or Multiple Intelligences: a Debate

The main debate between classical and modern schools of thoughts is whether, there is a general intelligence for all type of tasks or specific intelligences for some specific task. Classical school of thought argues that there is a general intelligence called "g" that designates all level of performance in all areas (Kelly, 2005). According to proponents of classical viewpoint, intelligence can be measured by tests that is IQ test score (Cronbach, 1960). Furthermore they argue that, the test is a predictor of school performance of an individual (Brody, 1992; Cattel, 1987) and test score remain stable in childhood and adolescence (Moffitt et al., 1993). Critics of concept of general intelligence do not challenge the stability of the test scores or its association with as predictor of school performance, rather they argue that concept of intelligence on the base of test scores alone ignores many other concepts of mental abilities. For instance, Sternberg concludes that traditional intelligence tests does not adequately measure intelligence rather they only focus on "Analytical" aspect of intelligence as mostly comprises of analytical problems and have only single right answer; hence they ignore other aspects such as creativity and practicality. Furthermore, they believe that people can vary in their aptitude or intelligence for learning, and specific ways are used to deliver specific type of knowledge; thus there are more than one ways, instead of single general intelligence "g", where all abilities correlated with each other (Gardner, 1983; Snow, 1992; Sternberg, 1996).

2.5.5 Multiple Intelligences and Learning Styles: a Debate

The most challenging question, an educationist or an instructor has to face is, whether multiple intelligence and learning styles are two enumerations of same thing or both are entirely different concepts. This is a critical debate and may not have a discrete answer. According to Dunn and his colleagues, these two concepts distinct but they are not opposing, and work together to contribute to learning (Dunn et al., 2001). Some other studies reported that multiple intelligences and learning styles are not the same concepts and they are not interchangeable. They argue that "multiple intelligences" is an OUTPUT function of information intake whereas learning styles as an INPUT function describes intake capabilities of learners (Prashnig, 2005). Gardner, the father of multiple Intelligences stresses the need to change instruction to capitalize on learners' abilities; whereas Dunn, a main proponent of learning styles, proposes changing instructions to capitalize on learners' learning styles (Denig, 2004). Thus multiple intelligences are the abilities whereas learning styles are the preferences of learners. Nelson bridges these two aspects by explaining that some people are smart in some specific intelligence and they learn best when associated method are used to deliver the contents (Nelson, 1999). Denig highlights the need to find the correlation between multiple intelligences and learning styles so that it can be defined, which learning style elements appear to be characteristic of a person who exhibits certain intelligence (Denig, 2004). It describes that a particular intelligence can be strengthened by considering specific learning preference associated with that intelligence, for a particular learner. In this context, Gardner states that, "each intelligence may require its own specific educational theory" (Gardner, 1993). Following this statement, Denig suggests that a synthesis of multiple intelligences with learning styles will be helpful in recognizing the "specific education theory" required by each intelligence (Denig, 2004). This argument further fortifies the Nelson's proposal that people who are smart in some specific intelligence learn best when supported methods are used to teach (Nelson, 1999). Since this thesis focuses to find intelligences of a learner, exploit stronger intelligences and an attempt to develop the weaker intelligences using technological support, therefore multiple intelligences and learning theories are at the core and learning styles are partially exploited to establish the proposed learning framework for the adult illiterates.

2.6 Technology Enhanced Learning Environments for ABE

Advances in merger of computing and communication technologies, the availability of multimedia communication, and especially declining cost have drawn the attention of educationist towards the use of technology (Liang and McQueen, 1999). However, most of the research studies on technology enhanced learning to-date seem to target mainstream education (Nwosu, 2010). Still there is a need to realize the implications of technology for ABE. Although technology has variety of media but here in this research technology refers to computer as primary tool and its realization in ABE programs. Thus, following subsections revisit the literature on computer-assited learning in ABE, different available supportive and techno-literacy solutions and web-based resources for adult illiterates.

2.6.1 Literacy Solutions

Technology has never been used with its full potential, sometime because of funding constraints and sometime due to lack of vision (Turner, 1998). Turner further extended his finding as:

Explaining the importance of technology, Hopey says that technology has great potential to improve learning by adults; the only need is to exploit it, in a smart and effective way(Hope, 1998). However most of the technology using ABE programs used it only for administrative support (Sivin-Kachala and Bialo, 1992; Turner, 1998), and only one fourth of the adult literacy programs used it for delivery of instructions (Sabatini, 2001). Still there are many examples and inferences of technology-based literacy solutions for Adult illiterates explained by several research studies (Askov et al., 2003; Wagner and Kozma, 2003; Rosen, 2000; Sabatini, 2001; Stites, 2004; Wagner and

Hopey, 1998; Wagner, 2001).

Ginsburg describes four approaches to integrate technology into adult learning and instructions (Ginsburg, 1998). These four approaches are technology as, 1) Curriculum, 2) Delivery Mechanism, 3) Complement to Instruction and 4) Instructional Tool. In the first approach, when technology is used as curriculum, the focus is on to teach computer skills to illiterates like, word-processing skills, spreadsheets skills, internet use and surfing skills etc, apart from its numerous benefits to become familiar with technology, it does not consider those people who have other educational needs than technology only. In the second approach, when technology is used as delivery mechanism, it exploits Individualized Learning Systems (ILS) where customized contents are presented to learners, where learner needs are consider and these systems are accessible around the clock, however these system are customized and high-cost. In the third approach, when technology is used as complement to instructions, computers are used along with the traditional classroom learning as an additional learning support, it includes commercially developed software, however due to cost, high budget is required to acquire these software and sometimes instructor also have to rethink and modify the class contents and activities according to needs of these software. In the last approach, when technology is used as instructional tool, technology is exploited in classroom setting, as other tools in classrooms are used like blackboard, workbooks etc., instructor may use whenever it required, most promising benefit of this approach is that instructor is able to control the contents as per requirements of curriculum. While describing the pros and cons of each application area author stated that, "Instructional tool has the greatest impact on the classroom environment, learners and teachers" (Ginsburg, 1998).

For adult literacy, various projects, commercial computer-based products and web-based resources are available and come under the one or other technology integration approach described by the Ginsburg (Ginsburg, 1998). In this thesis, few leading literacy project (operational to-date), widely used commercial products and web-resources are revisited. The selection of these literacy solutions is based on review of David J. Rosen (Rosen, 2009).

2.6.1.1 Projects and Commercial Products

Sivin-Kachala and Bialo reported that (at least) in United States till year 1992, technology was being used as administrative purpose in most of adult education programs (Sivin-Kachala and Bialo, 1992). However last decade of 20th century was a revolutionary decade. One of the early projects launched in the decade was LitLink(LitLink, 1996). The project started to help adults to receive literacy instructions and gain high school diplomas or equivalencies in United States and operational to-date. As an online

Lifelong learning system, it has full multimedia support and includes videos and print material. It offers a complete environment for learning as it includes Forum, Message Center, Profile and Portfolio management, Teachers' support, various learning resources in the form of courses and dictionary and many other features. Two major goals of this project are; 1) increasing adult access to learning opportunities to enable them to obtain their high school diploma, and 2) improving quality of instructions and staff development. As it targets the adult learners of high school diploma, the environment of online resources is fully text-based, in order to browse and navigate through online resources one should need English language skills and basic internet skills. Another most influential project is California Distance Learning Project (CDLP, 2011), it offers online resources to provide access to various interactive and online reading materials and stories. CDLP covers numerous life skills and focused to improve reading skills, general knowledge and offers general educational development (GED) instructional material. The purpose of the project is to provide platform for distance learning and test new methods for delivery of material to the target audience. The online resources provide audio-visual material to the target audience, however the prime mode of the web-site is fully text-based, and it does not seem supportive for the pure ABE program except the general knowledge delivery. Other known projects working for adult literacy, GED and ESL are; Professional Development Kit (PDK) (LRC, 2011), Project CONNECT (projectCONNECT, 2011), TECH21 (NTLAE, 2011), and ESL Civics Link (PBS, 2011) etc.

Few of the most widely used commercial products available for adult literacy especially about reading skills are discussed here. All of these are designed for the learners of English language. Lexia Reading (LexiaReading, 2009) is a research-based interactive educational software for improving reading and phonetic skills. It fulfills the academic needs of elementary, middle, secondary schools, pre-school and day care centers. This research based commercial product is based on recommendations of National Reading Panel. Lexia Reading Strategies for Older Students is developed for the learners of ages 9 and above. The software offers a mature interface. It includes activities such as practice in decoding skills, early comprehension, and keyboard skills. Learners control their own activities. They have to show competency and fluency in each skill before moving on to the next skill. Another known commercial product is Reading Horizons curriculum and interactive computer software to improve reading skills (ReadingHorizons, 1984). This solution includes teacher training, direct instructions and computer software. The software is designed for the age group 10 and above to improve their reading skills. It uses two types of instructions. In the first type, it uses on board multi-sensory direct instructions that are helpful to learn in classroom in groups. Other type uses interactive computer software for individual learning. The combination of both approaches provides balance of group and individual study. Learners can work themselves on interactive software and on board instruction are delivered through instructors. It is helpful for all levels of adult learners even at level zero, with inadequate spelling skill and even with learning disabilities like dyslexia. The software curriculum can be completed in 60 hours of instructions that take less than six months. It is easy and fun to learn and instruct. It contains different assessment tests. Reading Horizons curriculum and software is a good source for intensive English learning and for the learners of ESOL. AIT READ! (AIT-READ!, 1962) is a reading skill CDs-based program developed by Agency of Instructional Technology (AIT). It offers intensive English reading skills (for Beginners) curriculum consists of three books about Letter Logic (upper and lower case alphabet, letter sounds etc), Letter Locator (includes consonants identification) and Letter together (consists of plural words, consonants blending and combination) available on three CDs for Window and MAC platforms. Using computer graphics and audio-visual aid, this software provides exciting and challenging activities to the learners. Basic Life Skills at Work (ESL.net, 1995) is also CDs-based software provides training to adult learners in ABE, ESL and workplace literacy program. It includes 9 independent modules of Karen's Letter, Comma Sense, Write it Right, From ABE to Z, Clear Statements, The Automatic Teller, Getting Informed, The Numbers Game. It also includes game section provides the context for problem-solving activities. This is for the learners of Grade 3-5. It is designed for both Windows and MAC platforms. BLS-Tutorsystem (BLS, 2011) is design for Grade-7 to adult learners to master their basic skills in reading, grammar and mathematics. It consists of four processes, 1) Tests – to determine basic skills deficiencies, 2) Prescribes – to suggest lessons to cover the deficiencies, 3) Teaches – it teaches the required skills and finally 4) Test Again – to ensure skill mastery. It is used in ABE, GED, High schools, colleges, workplace literacy and in correctional education programs in Canada and United States. For the learners of ESL/ESOL there are numerous programs exists on CDs. The two more widely used programs are English Mastery and English for All (EFA). The English Mastery (ALC, 2011) is designed for the learners of English-as-a-Second-Language (ESL). This tutorial consists of four CDs. It offers practice in listening and reading comprehension, vocabulary, speaking and pronunciation. English Mastery also provides practice in writing, dictation and grammar. The English for All (EFA) is another resource for the learners of ESL/ESOL (EFA, 2011). It offers interactive web-site, 5 CD-ROM/5 stand-alone video tapes, each containing four 15-minutes programs, printable material for learners and instructors. Each unit of the material has video recording and related text to improve the English language skills.

2.6.1.2 Revisiting Web-Resources

There are numerous web-based resources for adult literacy. Most of them are for the general knowledge development, adult literacy skills and GED, however few resources exist that are designed for ABE.

For Basic Education

Word Builder (WordBuilder, 2011) is a web-based resource to enhance learners' reading, words building and pronunciation skills for Grade 1-6. It includes game like activities for the learners, and it is equally suitable for the children and adults. In the all activities a person (in a application) reads aloud words and provides hints on each step for learners. The environment of the web-site is text-based however it is user friendly. Hello World English (Hello-World, 2011) is another web-based solution. It offers a platform to improve reading skills through interactive game-based activities. It includes pictorial presentations however these are more suitable for child learners and has least fascination for adult learners. Navigation through the web-site is easy because of iconic support, however still main constructs are text-based. Enchanted Learning (EnchantedLearning, 2011) is a good web-based resource serves as dictionary of different subjects such as Biology, Physics, Crafts and numerous other areas. Each area further divided into sub groups to facilitate learners. The most special aspect of this resource is to define items in English language along with pictorial representation. Funbrain Reading (Funbrain, 2011) offers reading material in English language. The reading skills are taught through diaries of different persons and games. These games include Word confusion, Plural Girls, Grammar Gorillas, Stay Afloat etc. Words confusion in which confusing pair of words are given to complete sentences (such as bass or base, ad or add, hare or hair etc). The environment is fully text-based and classified for child learners and this resource is recommended for Grade 1-8.

For General Educational Development (GED)

Numerous online resources for GED and for high school diplomas are available. McGraw online learning center for GED learners is most widely used resource (McGrawHill, 2011). It offers different web-sites for reading, writing, science, math, and social studies. The target audience is GED learners and instructors. Each web-site offers chapter overview, outlines, flashcards (for quick learning), chapter review quiz and GED practice quiz. The environment of each web-site is fully text-based so it does not suit the adult learners of the basic education. It also does not provide any audio-visual support to the intended audience.

For Other Life Skills

The main proportion of resources available on internet for adults is about general knowledge, history, news and many other life skills. CNN learning resources (LiteracyWorks, 2011a) are one of them and offer web-based instructions using current and past CNN Sans Francisco bureau. Target audience is adult learners, instructors and general public. It includes stories on different topics. Each story provides different interactive activities such as vocabulary development, word selection (making sentences and filling-the-blank-spaces), multiple-choice test, and comprehension support through conclusion etc. The learner is allowed to listen the text and watch video clips. Basic mode of this web-site is also fully text-based, no audio-visual cues are provided for navigation and assistance of the learners. Discovery Channel (Discovery, 2011) is another web-based resource that offers news, various stories and documentaries on different topics. It has both videos and text information. General knowledge delivery is the prime purpose of this web-resource. The Learning Edge (TheLearningEdge, 2011) is an interactive online newspaper for improving reading skills designed for adult literacy. It also includes stories on different topics. When a learner clicks on a story, a man reads out slowly and the text is highlighted as he reads a sentence. Each story follows quiz, in which different fill-in-the-blanks type of questions are asked from the learners and feedback through text and voice is provided to the learners on each correct or incorrect reply. This is a good resource for improving reading skills of adult learners. The Learning Ladder (TheLearningLadder, 2011) tutorial covers different topic such as, children's literacy, parents and parents, observing and recording children behavior, health, family child care and basic computer skills. It is purely text-based and least suitable for adult illiterates. It also does not have audio-visual support. History wired (HistoryWired, 2011) provides a tour through the museum. Similar to a real tour in the museum, through this resource information is presented conversationally. The map-based interface provides good visualization to the visitors; it makes selection of the item very easy. However, it is not suitable for the illiterates because item selection needs good grip on English and internet skills.

2.6.1.3 Emerging Trends

In adult education programs, new technologies have not yet been adequately integrated (Rosen, 2000; Stites, 2004; Strawn, 2008). Warschauer and Liaw, in this concern explain the potential contribution of emerging technology to adult literacy (Warschauer and Liaw, 2010). They described technology use in adult education on the basis of its distinctive features such as 1) multimodal communication – it is meant to audio-visual features of technology, their application in adult literacy and language education, 2) collaborative writing – it uses blogs, wikis and forums for improving writing skills, 3) language analysis and structure - includes speech recognition, writing evaluation and online linguistic support to learners, 4) online networking - facilitate illiterates by providing virtual environment for immersion, social networking for contacts and relationships, and multi-player online games to augment learning process, and 5) one-to-one mobile computing - foster the need of anytime, anywhere and anybody use by exploiting mobile tools like cell phones, notebooks.

Combination of linguistic, visual, audio, gestural and spatial modes referred as multimodality (Kress and van Leeuwen, 2001). It has several reasons to be included in literacy programs, such as, increase learners' motivation and provide them multimodal scaffolding (Warschauer and Liaw, 2010). Most common examples are ESLpod.com, YouTube, and Glogster etc. One step ahead for writing purpose they suggested to exploit blogs such as LifeChoice, wikis such as the most famous Wikipedia, Forums, real-time chat etc. Tool for language analysis and structure suggested by Warschauer and Liaw includes text-scaffolding software such as e-Lective, Speech recognition applications such as Reading Companion by IBM etc. Online networking is one of the most worthy dimensions of technology that offer multi-user virtual environments such as Second Life, Massive Multiplayer Online Role Playing Games (MMORPGs) such as Everquest II and World of Warcraft. At last but not least Mobile computing has more opportunities of learning for adults. In present era, smart phones are best choice for learning. They have potential to provide anytime, anywhere learning (Warschauer and Liaw, 2010).

According to Warschauer and Liaw, however these dimensions of technologies are rarely exploited for adult literacy programs (Warschauer and Liaw, 2010). Furthermore Wrigley draws attention towards the use of related theories of adult learning in research studies to be carried out for adult literacy programs (Wrigley, 2004).

2.6.2 Supportive Solutions

A lot of research has been done on the technology-based supportive dimensions for the adult illiterates. The prime purpose of these supportive solutions is to make the illiterate able to easily access the information in their surroundings. Nowaday internet is a major source of information for everyone; and illiteracy is a major barrier for the illiterates to access this information. Thanks to the researchers of this dimension, who provided research based solutions to access this information using multimodal interfaces such a text-free, audio-visual and tangible interfaces.

An e-government portal was proposed by Taoufik and his colleagues for the city of Fez in Morocco (Taoufik et al., 2007). It allows citizens to get their official documents such as birth certificate and provide them other information about recent government services. The interface uses audio-visual support to navigate through the application and results showed that it is equally accessible for both literate and illiterate users. A computer-based electronic screening tool developed by the University of Virginia (Akan et al., 2006). It screens alcohol and depression of rural patient. The eScreening tool provides graphical user interface with audio outputs (to direct the user) for functionally or computer illiterate users. It asks some question in recorded voice and user needs to answer it by clicking one of the multiple choices. It also offers visual cues (through colors) to the user while selecting a choice through mouse click. Another web-resource with text-free user interface for job information and City Navigation was proposed by Medhi and his colleagues (Medhi et al., 2007) for the illiterate community of India. It provides text-free user interface so that novice and illiterate users can seek jobs and locations in a city without intervention of anyone. Instead of text, the pictures are used to describe job timing, nature of job, salary etc. They believe that intended users need not any external assistance in order to operate the application. Findlater and his colleagues conducted a research studies and explained the importance of audio support in interface for illiterate user (Findlater et al., 2009). Multimodal interfaces with little or no text were presented to users in this study and results showed that text based interfaces with audio support are beneficial for semiliterate users and this reliance on audio support also decreases with the passage of time. It was also suggested in the study that needs of semiliterate and illiterate should be treated differently because interfaces with little or no text are proven to be more effective for the illiterate users. One step ahead, to make the access of illiterate further easier tangible user interfaces are used. In Bangladesh, an electronic voting machine was designed by Alam and his colleagues (Alam et al., 2008). The main purpose of this machine is to facilitate illiterate voters while casting their votes. It consists of two components, a control panel - with 9 keys to enter password and to reset machine, symbol panel – it has election symbols of each candidate, a user need to press the button against favorite candidate's symbol to cast the vote. It offers a tangible user interface, another application that provide tangible user interface is Personal Health Information System (Parmar et al., 2009).

Many other supporting applications, for example, video-email, mobile phonebook and CAPTCHA are designed for semiliterate and illiterate users. An asynchronous communication tool video-email is a novel application designed for users with little to no-literacy, fully augmented with graphics, animations and voice features and was proven to be best for the illiterate users (Prasad et al., 2008b). A phonebook named Rangoli (Joshi et al., 2008) is proposed for semiliterate or illiterate mobile phone users. It organizes contacts using colors and icons to save and find the contacts easily for special target users. A non-OCR based Completely Automated Public Turing test to tell Computer and Human Apart (CAPTCHA) was proposed by Shirali-Shahreza. It uses pictures instead of text to facilitate the illiterate target users (Shirali-Shahreza and Shirali-Shahreza, 2007).

2.6.3 Technology Enhanced Learning Environments - a Summary

In case of computer-based adult literacy solutions, the major proportion of available resources comprises of general knowledge ranging from current affairs, news to history and other life skills. Secondly various resources are focused on high school diploma and general educational development. Although these solutions are well equipped with audio-visual support, however as the target users of both of these resources are semi-illiterate or functional illiterates, the environment of these web-based or commercial products is mostly text-based. One should need basic reading skills to navigate through the web-resources, thus they are least suitable for absolute illiterates. Whereas, what absolute illiterates demand, are the resources for basic education. These resources are also discussed in section 2.6.1. Some of these provide audio-visual contents and navigational assistance to easily browse the contents. However most of them are commercial products or audio-visual contents and navigational cues are classified for child learners and have least fascination for the adult illiterates. On the other hand, in supportive solution for adult illiterates there are nice text-free interfaces available as discussed in section 2.6.2. In similar fashion, there is a need to include text-free interfaces, audio-visual contents (to exploit their multiple intelligences) as well as audio-visual navigational cues (to increase the usability) in adult literacy programs also. Their contents and environment should be customized for adults.

3

Bridging the Gap – from Theory to Practice

This chapter describes the selection of features from the learning theories, their mapping to the multiple intelligences, and realization of the selected features to the learning content and computer-assisted learning environment. Also the selection process of three dimensional (3D) virtual worlds as computer-assisted learning platform is discussed.

3.1 Theory of Multiple Intelligence

Gardner's Theory of Multiple Intelligences (Gardner, 1983), is one of the popular theories in the support of cognitive approach to establish intelligence. Gardner defines intelligence as "biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture" (Gardner, 2000). The definition describes that different intelligences are used in different domains and different cultural settings to solve problems and to create something new. According to Gardner, to solve all human problems, no single model of cognitive functioning will be found; rather cognitive process will vary for different tasks. Gardner in his theory of multiple intelligences broaden the scope of human potential beyond the limitations of the IQ score (Kelly, 2005). He proposed at first, the existence of seven basic intelligences in the book "Frames of Mind" (Gardner, 1983), then he added eighth intelligence (Gardner, 1999), and a year later discussed the possibility of ninth one (Gardner, 2000). Following are described seven basic intelligences from the Gardner's intial work:

- Linguistic-Verbal (LV): It involves the capacity to use words effectively, either orally (as a story teller, orator) or in writing (as a poet, or playwright). The persons who possess auditory skills, think in words, and prefer language to understand and express concepts are considered stronger in linguistic-verbal intelligence.

- Logical-Mathematical (LM): This includes abilities to deal with numbers, logical reasoning and problem solving. The persons who think conceptually, like experiments and puzzle solving are better taught through this style.
- Visual-Spatial (VS): The ability to perceive different things in visual-spatial parameters such as colors, pictures, and dimensions etc. The people who think in term of pictures and physical space possess visual-spatial intelligence.
- Musical (MU): The capability to deal with rhythms, melodies, tones, and sounds. The persons who love music and sensitive to listening have strong musical intelligence.
- Bodily-Kinesthetic (BK): The ability to understand things through role playing, body movements, and physical activities. The people who like physical activities and learning by doing are stronger in this intelligence.
- Interpersonal (IRP): The ability to work in collaborative environment, group discussions and mutual interaction are core properties of the interpersonal intelligence. The persons who have ability to communicate with other people and love to learn through discussion possess stronger interpersonal intelligence.
- Intrapersonal (IAP): The ability of knowledge about self. The people who are stronger in this type of intelligence prefer to live alone, work independently, and they rarely use to work in collaborative fashion unlike interpersonal intelligence.

Gardner and other proponents of theory of multiple intelligences believe that people can vary in their aptitude or intelligences for learning, and specific ways are used to deliver specific type of knowledge; thus there are more than one ways, instead of single general intelligence "g", where all abilities correlated with each other (Gardner, 1983; Snow, 1992; Sternberg, 1996). Also these multiple intelligences change over the time, Bruce Torff concludes this fact as, "The intelligences develop – they grow and change over time, which allows strengths to be exploited and weaker areas are remedied" (Torff, 1996). Thus, "if intelligences change with time and experience, they can be learned, if they can be learned, they can be taught" (Acosta, 2011). It shows learning can be augmented if stronger intelligences are exploited, and furthermore weaker intelligence can be taught to develop that intelligence. Gardner, further emphasize to consider learning theories to strengthen the weaker intelligences and to better exploit stronger intelligences of the learners. He states, "each intelligence may require its own specific educational theory" (Gardner, 1983). These educational and learning theories are revisited, the feature important for learning are selected and how these features map to the intelligences proposed by the Gardner theory are discussed in next two sections.

3.1.1 Criticism on the Theory

The fundamental criticism on theory of multiple intelligences is based on the argument that each of the seven multiple intelligences represent a cognitive style rather than a stand-alone construct (Morgan, 1996). Other critics argue that MI theory is incompatible with general intelligence "g", it is not empirical, and it meaninglessly broadens the construct of intelligence (Gilman, 2001). In response to this criticism, Gardner presented some myths which provide commentary on the criticism (Gardner, 1995). Also Morgan (1996) in this concern advocates that, MI theory supports the many factors of intelligence and it is a significant contribution. Furthermore, it is very beneficial for schools and teachers in curriculum design (Morgan, 1996). Apart from the criticism, the theory is in practice in various disciplines of life and education is at core.

3.2 Selection of Features from Learning Theories

For designing computer-assisted learning environment for adult basic education (ABE), features important for learning are selected from the learning theories. Previously discussed four major schools of thought are revisited for the selection of features. This section explains each of the selected features, their association with the learning theory and effectiveness in learning environments for ABE.

The domain of *behaviorism* and other studies based on this approach fosters to incorporate many features, such as positive reinforcement, self-paced learning, repetition, and frequent feedback etc (Pritchard, 2009; Skinner, 1953). A kind of symbolic reward (use of smiley picture and clapping) for *positive reinforcement* is crucial in learning process because it motivates the learners, and for these rewards the learners often use to repeat the desired actions (Skinner, 1953). Secondly, the *self-paced learning* referred as learners' control offers independent learning opportunities to the learners where they are allowed to make decisions at their own to browse the learning material. Theory of Elaboration from cognitivism and Keller's ARCS model from Humanism also highlights the need of disseminating control to the learners in the learning process (Keller, 1983; Reigeluth, 1999), because it assists to impart confidence in the learners (Keller, 1983). Thirdly, *repetition of contents* as being experienced in Drill and Practice software (Drill&Practice, 2011) is an important feature that may help to reduce the cognitive load of the learners and offer them flexible learning environment as claimed by Millar in his study (Millar, 1996). Finally the *feedback*, especially in facilitated learning approach appears to be crucial component because it points out the learners about their mistakes and right actions; as a result the learners feel more confident during the learning process (Keller, 1983).

The domain of *cognitivism* focuses on underlying processes while learning. It suggests introducing multimodal content such as text, picture and sounds, and sequencing of content in order of increasing difficulty level. To reduce the cognitive load of the learners, the use of *multimodal contents* and their *sequencing* in order of increasing difficulty plays critical role (Mayer, 2001; Sweller et al., 1998). Also the concept of visual literacy suggests the use of pictures and audio-visual support in content (Aanstoos, 2003). Similarly, Stites refers to the idea of mix of text, audio and visual support (Stites, 1998). The use of multimodal content in the learning exploits two channels of the brain of learners for processing the information and it helps to comprehend the intended material (Mayer, 2001). Consequently the sequencing of instruction helps to impart confidence in the learners (Keller, 1983) and multimodal content assist to reduce cognitive load (Sweller et al., 1998).

Features such as authentic task, social interaction, contextualized learning, consideration of cultural aspects, gradual development, relevance of contents to the learners, scaffolding, real world and problem-based learning for effective learning are at the core of *constructivism* (Hmelo-Silver, 2004; Lave and Wenger, 1990; Mandler, 1984; Vygotsky, 1978). For adult education authentic task, context and culture are very important features suggested by Lave and Wenger (Lave and Wenger, 1990). The *authentic task* is the task that learners can relate to their experiences and context inside or outside of the school (Selinger, 2001). It catches learners' attention and motivates them towards the learning activities (Pritchard, 2009). Secondly, there is a need to incorporate complete *contextual information* (Herod, 2011; Kurvers et al., 2009) and *cultural aspects* in the learning content, as they influence the sense of ownership and affiliation with the learning material. Similarly, the *relevance of content* to the learners' needs and previous knowledge domain is crucial because when the newly presented information matches with previously developed schemas learners can easily comprehend the presented content (Mandler, 1984). Also there is a need to incorporate *real world problems* in the educational platforms because adult learners come up with experience (Knowles, 1970) and have previously developed numerous schemas with them (Mandler, 1984). Thus instructions should have relevance to the previously developed schemas so that it could be easily absorbed and comprehended by the learners. Apart from the relevance of content, their *sequencing* in order of increasing difficulty is imperative during the learning process (Reigeluth, 1999). Consequently, this gradual development process enhances confidence in the learners (Keller, 1983). The *social interaction* which is referred as *collaborative learning*, is a critical parameter in present era learning. Most of the learners who prefer learning through discussion, collaborative learning approach is a suitable for them (Stites, 1998). The collaborative learning is also at the core of Vygotsky's theory of social development (Vygotsky, 1978), and it helps in scaffolding process through more knowledgeable others (MKO).

In contrast to other learning theories, *humanism* focuses on the needs and interest of human. Proponents of humanism suggest active participation in learning (game-based or role playing), relevance of content, self-actualization, instructor role as facilitator, experimental learning, frequent feedback, incremental learning approach, learners' control, consideration of motivational aspects and needs of the learners (Keller, 1983; Kolb, 1984). Most of the features are already discussed such as relevance of content, feedback, incremental learning approach, and learners' control. Keller in his ARCS model focuses on *active participation* by performing different roles or through some games to keep the learners engaged and develop their interest in the learning process (Keller, 1983). Also the *experimental learning* has similar stance and according to it, knowledge is created through transformation of experience during learning process (Kolb, 1984). Incorporating these features make the learners able to comprehend the concepts being learned. In such learning environment, *instructor role as facilitator* is also recommended where instructor only perform as moderator instead of spoon feeder, and it helps to build confidence in the learners (Keller, 1983). The most important, *learner's needs* and their *learning style* should also be considered while presenting the learning content and it leads towards the *personalized learning* material explained in (Brusilovsky and Millan, 2007).

There is another debate on the choice of *facilitated* and *directed* learning. In this debate, the proponents of andragogy emphasize the use of facilitated learning, where as the proponents of pedagogy foster to use directed learning as discussed in Chapter 2. Herod (Herod, 2011) in this context describes that drawing a boundary line between facilitated (andragogy) and directed (pedagogy) learning is not justified. According to him, it is possible that some children after little guidance are better able to learn things independently, in similar way some adult learners even has past experience of life and self-motivated but want learning under continuous supervision of instructors. Thus the learning process should start from the help of more knowledgeable others (MKOs) as directed by scaffolding and should end up with little or no assistance at all (Vygotsky, 1978).

Table 3.1: Implementation Techniques for the Selected Features

Features	**Theory/Study**	**Techniques**

Active Participation	Keller's ARCS Model (Humanism)	Providing Multimodal interface, Role based activities using 3D space, self-assessment using game-based activities.
Authentic Task	Lave Situated Learning (Constructivism)	Customizing contents for learners keeping in view their needs, culture, context and domain knowledge.
Collaboration	Vygotsky's Theory of Social Development (Constructivism), and (Stites, 1998)	Using interactive activities such as voice and text chats, group-based tasks.
Context	Lave Situated Learning (Constructivism), and (Herod, 2011)	Use of contextual information in metaphors along with the content.
Culture	Lave Situated Learning (Constructivism)	Customizing content for learners keeping in view their culture.
Directed learning	Pedagogy	Guiding learners all the way during learning process.
Experimental Learning	Kolb's Experimental Learning (Humanism), and (Herod, 2011)	Learning by doing, self-directed learning, role-based learning activities.
Facilitated learning	Andragogy, and (Herod, 2011)	Exploiting user-friendly and multimodal interfaces, collaborative learning, navigational cues, presenting content in order of increasing difficulty level, self-assessment.
Feedback	Behaviorism, and Keller's ARCS Model (Humanism)	Providing feedback on self-assessment tests, and using audio and visual cues in feedback.
Gradual Development	Elaboration Theory (Cognitivism), and Vygotsky's Theory of Social Development (Constructivism), and Keller's ARCS Model (Humanism)	Presenting content in order of increasing difficulty level, sequencing of contents.
Informal learning	(Eberle and Robinson, 1980)	Un-supervised learning, learners' control, computer-assisted education.
Instructor role as facilitator	Humanism	Limiting role of moderator/instructor to orientation and on demand help, technical assistance.

Learners' control	Behaviorism, Elaboration Theory (Cognitivism), Keller's ARCS Model (Humanism), and (Millar, 1996)	On click content presentation, no time constraints on content presentation, flexible navigation through all content units.
Motivational Aspects	Basic Notion (Humanism)	Presenting relevant content, presenting content in order of increasing difficulty level, multimodal content and interface, learners' control.
Multimodal contents	Cognitive Theory of Multimedia Learning, and Cognitive Theory of Load (Cognitivism), and (Stites, 1998), and (Aanstoos, 2003)	Using multimodal content (text, pictures, sound, music).
Personalization	Basic Notion (Humanism), Keller's ARCS Model (Humanism), and (Brusilovsky and Millan, 2007), (Herod, 2011), (Stites, 1998), and (Millar, 1996)	Providing adaptive support based on domain knowledge, learning styles and multiple intelligences.
Positive reinforcement	Operant Conditioning (Behaviorism)	Rewards in the form of clapping message at the end of self-assessment tests.
Privacy	(Millar, 1996)	Restricting access of other peers to the evaluation reports.
Problem-based Learning	Problem-based Learning (Constructivism), and (Stites, 1998)	Customizing content for learners keeping in view the learners' day to day needs.
Records Management	(Millar, 1996)	Keeping track of content units the learners learned, how much time they spent on each unit, tracking correct or incorrect answers.
Relevance of Contents	Schema Theory (Constructivism), and Keller's ARCS Model (Humanism)	Customizing content for learners keeping in view their domain knowledge.
Repetition	Behaviorism	Providing iterative support at unit level of content.

Scaffolding	Vygotsky's Theory of Social Development (Constructivism)	Providing mix of supervised to unsupervised learning.
Situated learning	(Stites, 1998)	Customizing contents for learners keeping in view their needs, culture, and context, designing learning environment that emulate real-world.

3.3 Mapping of the Features to the Intelligences

Gardner emphasizes to consider learning theories to strengthen the weaker intelligences and to better exploit stronger intelligences of the learners. He states, "each intelligence may require its own specific educational theory" (Gardner, 1993). In this section the features selected from the learning theories in the last section are mapped to each of the intelligence and reasons of this mapping are explained through the literature. For complete mapping see Table 3.2.

Multimodal learning content or instructions is a most important feature recommended by cognitive theory of multimedia learning, cognitive theory of load, theory of visual literacy and many other research studies as discussed in section 3.2. As multimodal content exploits different modes such as text, pictures, and sound thus it has potential to strengthen, 1) linguistic-verbal intelligence by means of written text and voice support, 2) visual-spatial by means of pictorial support, and 3) musical intelligence through voice support and music.

Cultural compatibility in instruction is another recommended feature. Gardner in this context says, "it is the culture that defines the stages and fixes the limits of individual achievement" (Gardner, 1983). It means that most common practices in a culture manipulate different intelligences of the members of society accordingly. Thus cultural aspect has potential to influence all of the intelligences.

Motivational aspects in the learning activities recommend by Humanists (Keller, 1983, 1984) are critical to attract the learners to the learning environment. If the learning environment has opportunities to offer the multimodal content, it can motivate the learners and able to strengthen their visual-spatial, musical, bodily-kinesthetic and interpersonal intelligences.

According to situated learning theory, learning is embedded within activity, context and culture (Lave and Wenger, 1990). The feature of context exploits spatial information, and activity uses kinesthetic action, thus situated learning has potential to strengthen visual-spatial and bodily-kinesthetic intelligences. However the context only assists to positively influence the visual-spatial intelligence.

Table 3.2: Mapping the Selected Features to the Intelligences

Intelligences	**Feature from Learning theories**
Linguistic/Verbal	Multimodal content (written text, and sound), Culture
Visual/Spatial	Multimodal content (metaphors), Situated Learning, Motivational aspects, Culture, context
Musical	Multimodal content (sound/music), Culture, Motivational aspects
Logical-Mathematical	Problem-based learning, Culture
Bodily-Kinesthetic	Active Participation, Experimental learning, Situated learning, Motivational aspects, Culture
Interpersonal	Directed learning, Facilitated learning, Scaffolding, Culture, Problem-based learning, Instructor as facilitator, Motivational aspects, Culture, Collaboration
Intrapersonal	Facilitated learning, Culture

Problem-based learning focuses on open-ended questions, and real world problems (Hmelo-Silver and Barrows, 2006). It has potential to influence the logical-mathematical intelligence primarily, and as it fosters to work in collaborative fashion, it may help to strengthen interpersonal intelligence.

Features such as active participation (Keller, 1983), and experimental learning (Kolb, 1984) demand learning by doing, and experiencing things. These features have potential to influence the intelligence of bodily-kinesthetic.

Directed learning requires some more knowledgeable others (MKO) (Vygotsky, 1978) like scaffolding (Pritchard, 2009) whereas facilitated learning (Knowles, 1970), and role of instructor as facilitator (Keller, 1984) requires little or no assistance thus all these features are supportive to strengthen the interpersonal intelligence. In facilitated learning as learners need very little assistance thus it can also influence intrapersonal intelligence.

3.4 Realization and Mapping of Features to the Learning Content and Technology

After the selection of features important for learning, techniques for the implementation of these features in the computer-assisted learning environment are derived from the research literature. Designing and developing computer-assisted learning material that may offer all the selected feature is a challenging task. In this research, strategies recommended by different research studies are exploited and summarized to realize different features either through learning material or technological support in computer-assisted learning environment. These strategies and techniques for each feature are described in Table 3.1. Summary of the source theories and research studies from which these features are selected is also given in the same table.

3.4.1 Learning Content

Exploiting the techniques discussed in Table 3.1, content are customized for learners keeping in view their needs, domain knowledge, culture, and context. Also selection of authentic task, proper sequencing of content units and multimodal content are realized at the content level. There are many features such as relevancy of material to be taught, consideration of culture, content, and selection of authentic task which lead toward customization of content for a specific target group of learners. As the study designed in this research was planned to be conducted in Pakistan (reasons for the selection of Pakistan as study point are described in Chapter 5), the mentioned features realized in content are centered at adult learners of basic education in Pakistan. In this concern, content for the intended target learners are designed in the national language of Pakistan called Urdu.

In Urdu language there are 51 alphabet letters in total. Following the previously developed content (LPF) (LPF, 2011), only 28 alphabet letters are selected that are used in the formation of 80% words of Urdu. The *sequencing* feature of content is achieved by designing two levels or phases of content. First phase consist of the discussed 28 alphabet letters, whereas second phase comprises of some commonly used words in Urdu whose formation is based on the 28 selected alphabet letters.

The techniques to realize the other features which are multimodal content, authentic task, culture, context, and relevancy of the content are based on numerous other studies. These studies focus on use of metaphors in the content, because images can reach more learners, and in contrast to traditional text-based and verbal approach it can teach the learner better (Aanstoos, 2003; Burmark, 2002; Peeck, 1974). These studies establish an opinion and put forward a strong recommendation about the use of *multimodal content* in curriculum. However the images or metaphors exploited for multimodal content should have some *relevancy* with the target learners. So the critical aspect is the selection of metaphors for the content to be taught. In this concern, Anne and her colleagues described that learning through daily life problems is an effective approach (Anne and Sandra, 1980). She conducted a comparative study on “material of interest” and “material from daily life”. In her study, one group was supposed to work with material of interest and other was provided with material from daily life, results showed that the group who was taught through “material from daily life” performed well than the other group (Anne and Sandra, 1980). It shows that contents should be designed such that fulfill urgent *needs of learners*. Also the print material around we people,

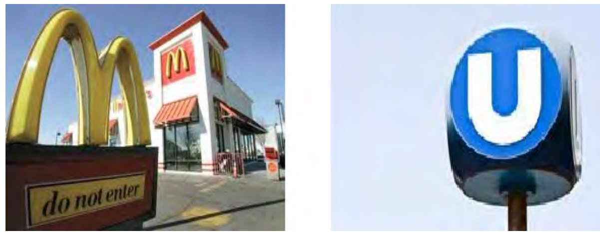

Figure 3.1: Famous Brand of McDonald and Inscription of Metro in Vienna (with Contexual and Visual Information) - an example

Figure 3.2: Famous Brand of McDonald amd Inscription of Metro in Vienna (without Contextual and Visual Information) - an example

invite us to read. For instance, different brand names, advertisement material and printing stuff that is very much known to everyone (at least in metaphoric form) can be used to design contents. Anne and her colleagues also suggested the same approach (Anne and Sandra, 1980).

Following the studies which focus on pictorial representations in curriculum and environmental print stuff, there is need to select most common advertisement material, brand name that everyone see around in daily life and the items which have some *cultural* values. This approach not only has potential to make the learners able to read the printed stuff around them, but also helpful to learn alphabet letters and words used in the provided stuff, and consequently will engage them in course contents; because authentic task, context and culture are important features for adult education (Lave and Wenger, 1990), and *authentic task* is the task that learners can relate to their experiences, context and culture inside or outside of the school (Selinger, 2001). In this concern Jeanne Kurvers and her colleagues (Kurvers et al., 2009) conducted a study on environmental print awareness of adult illiterates and results showed that when the original context and visual features are removed from the environmental print stuff the adult illiterates are unable to recognize it (Kurvers et al., 2009). These results describe that until the original *context* and visual features were available, adult illiterates have no problem in recognizing the print material. It shows that context and visual features are critical in print material around us. If the original context and visual features are added in the contents, it can not only help adult illiterates to recognize the material but can also be exploited to assist them in teaching alphabet letters/words used in this print material. For instance, if the original context and visual features are not removed from the environmental print stuff (like if inscription of underground metro in Vienna, Austria, presented with white alphabet letter “U” along with the blue background, and similarly the logo of McDonald is presented with yellow arcs that make alphabet letter “M” with red background - see Figures 3.1, and 3.2), illiterates will not only be able to recognize the print stuff but will be able to learn alphabet letter “U” and “M” in association with environmental print stuff that they normally use to see around, recognize it, but unable to spell out the written material in the environmental print stuff (such as inscriptions, logo, brand name of products etc). Furthermore this association will increase their recall result of the learned material. Thus for designing the contents, instead of traditional metaphors being used in the literacy material (Ahmad, 1995; EEF, 2007; Nabi, 2006), we exploited the support of environmental print stuff, known item having cultural value as metaphors, and contents are designed accordingly for adult learners. For instance, how these features are realized at content level is shown in Figure 3.3 and Figure 3.4.

In Figure 3.3, an alphabet letter pronounced as “ALIF” of Urdu language (National language of Pakistan) is given on the left side, and on the right side a picture of known newspaper of Pakistan is given. As the education material was designed for the ABE in Pakistan thus selection of this picture of newspaper has proper cultural value as print media, it has context because it presents a typical newspaper format in Pakistan, and need of the learners because illiterate people wish to read newspaper for information and current affairs. In Figure 3.4 on the left side is a word pronounced as “DAIG” of Urdu language (National language of Pakistan) is given, and on the right side a picture of known pot used for cooking in big fests in Pakistan. Everyone knows this pot in Pakistan, and it has a specific cultural values as it often used in traditional fests, it has context because it is shown in full contextual decorum with fire and bricks (as this pot normally used), need of the learners because everyone knows it in her daily life but unable to read the written word of “DAIG”, and this learning content unit is domain specific also, because intended learners of this study (ladies) used to use it as cooking pot.

3.4.2 Computer-assisted Platforms

Realization of the selected features in educational material follows implementation of rest of the features in computer-assisted environment. However it sets the challenge of selection of technology, the technology that has potential to provide all the features. Although both two dimensional (2D) and 3D spaces have potential to offer most of the features previously discussed in section 3.2. However, some of the features are

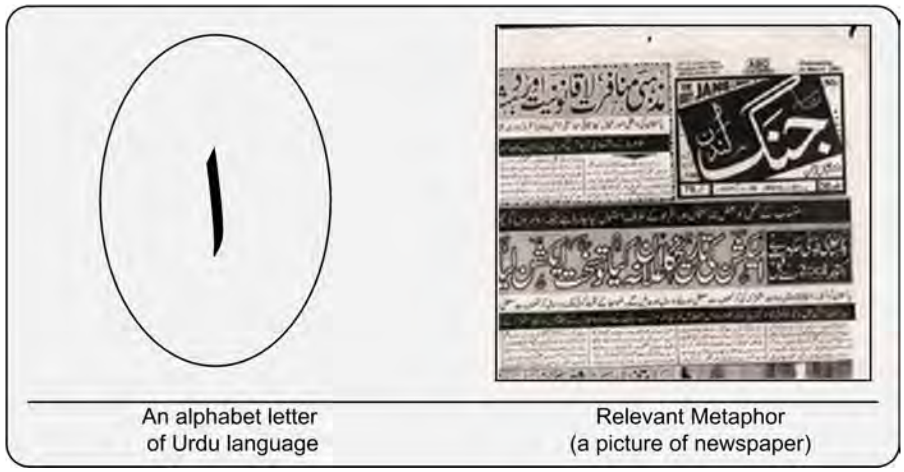

Figure 3.3: Mapping of Selected Features to Learning Content - an example from first phase

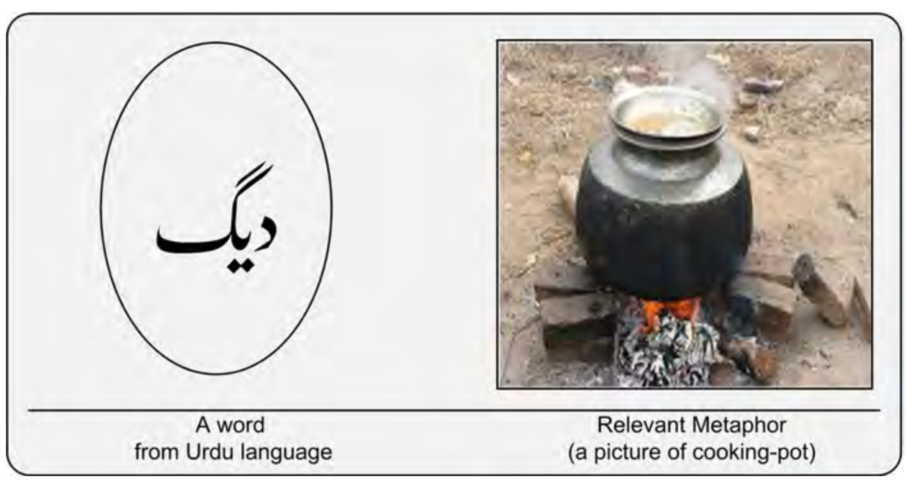

Figure 3.4: Mapping of Selected Features to Learning Content - an example from second phase

either best realized by 3D space than 2D space, or only achievable through 3D space. These features are situated learning, learning by doing, role based learning (facilitated learning), culture, context, best visual support such as immersive environment and motivational aspects. For the underpinned reason 3D space is selected as primary tool to implement the learning platform for the ABE. For comparative analysis 2D web-based application is also developed and exlpoited for the same purpose. Although there were numerous 3D spaces available, for this research 3D multi-user virtual environment (MUVE) of OpenSim (OpenSim, 2011) is selected. The selection process is described in section 3.6. Application of techniques to realize the features using technological support in computer-assisted learning environments is explained in this section (for summary of techniques see Table 3.1).

In the present era computer-assisted education has best platform to offer *multi-modal content* to the learners. Using text, picture, and sound support this feature can be realized in the form of text-free and image-dominant interfaces as witnessed in previous studies (Akan et al., 2006; Findlater et al., 2009; Medhi et al., 2007; Taoufik et al., 2007) of supportive solution for adult illiterates discussed in chapter 2. Furthermore cutting edge feature of 3D virtual worlds is to provide immersive learning environment which has compliance to *situated learning* experience where proper context, culture can be exploited. In this concern, spatial support in 3D virtual worlds has potential to be exploited to present authentic task, culture and context, whereas avatars in virtual worlds represent learners to feel situated learning experience. These avatars can communicate using voice-chat which is a best opportunity for *collaborative learning*. This collaboration can be among peers or instructor. In this way, essence of *directed learning* to *facilitated learning* can be provided that leads towards the concept of *scaffolding*. Furthermore *active participation* and *role based activities* of learners in discussion and collaborative sessions help in to achieve experiences such as learning by doing, *experimental* and *problem based learning*. Also the computer-assisted education provides control to the learners in case of facilitated learning where learners independently or with little assistance able to learn and make decision to follow different paths of learning from a set of options. On the other extreme, fully *personalized* content to learner may also helpful in contrast to the independent learners because some learner prefer to learn in complete guidance. The personalized content presentation can further be expended to interest, domain relevancy and knowledge of the learners and can be best realized through computer assisted learning environment. The personalization support will not only be able to present relevant content but will provide essence of directed learning. In order to understand and memorize the content presented in learning process, they need to be repeated. In traditional learning environment, it is hard for an instructor to repeat the material again and again for different learners, however in computer-assisted learning environment it is practicable where learners are able to *repeat learning content* as many time as they want until they have learned it. In such a fashion of independent learning, *feedback* is very crucial and it is possible through computer-assisted environment. It must be practiced after each iteration so that learners may learn from their mistakes. However feedback must use *positive reinforcement* approach by giving some enthusiastic remarks. Use of metaphors as remarks can be helpful during adult basic education programs. Finally exploiting computer-assisted platforms *records management* of learners' activities is quite easy as it was being practiced is past in these programs. Furthermore *privacy* of learners' records such as their activities, and shortcoming is another important aspect and manageable using computer's support. Thus computer-assisted learning environment can be best utilized to provide the selected features following the said techniques. These *informal learning* platforms with all of the mentioned features are able to *motivate* the adult illiterate, those who left education in their childhood due to bad experiences in formal learning environment. How these features are realized in both 2D and 3D computer-assisted learning environments is discussed in Figure 3.5 to Figure 3.12.

In Figure 3.5, a 3D learning environment is shown. An avatar of a learner represents her in the learning environment. A complete multimodal interface where content are presented in text, audio and visual modes, and background music support is also available. The learners can collaborate with each other through voice-chat, perform role-playing, and enjoy immersive learning experience in the selected 3D space (see Figure 3.6). The learning environment offers immersive environment close to real word where context and culture are preserved; also an opportunity of situated learning, and learning by doing is provided (see Figure 3.7 and Figure 3.8). All the units of content are displayed and learner can navigate through each unit using four arrow keys on the keyboard either walking or flying (offers learner's control), a learner is allowed to navigate through all units as many time as she wants. Visual cues for navigation are also provided (see Figure 3.9). Figure 3.10 shows a self-assessment where learner can submit her response using simple mouse click on the alphabet letter or word. The learning environment keeps track of all the learned content and assessment scores against each learner. Adaptive support incorporated in the 3D learning environment is explained in Chapter 4.

Similarly, Figure 3.11 shows a 2D learning environment. It is a simple web-based application. It also offers multimodal interface where content are presented in text, audio and visual modes. To navigate through the content, it provides two iconic buttons, one to move to next unit and one to move to previous unit. On mouse click, a learner can listen the voice of that unit of content. Once the learner is satisfied that he learned the unit of content, he need to click on the submit button to tell the system.

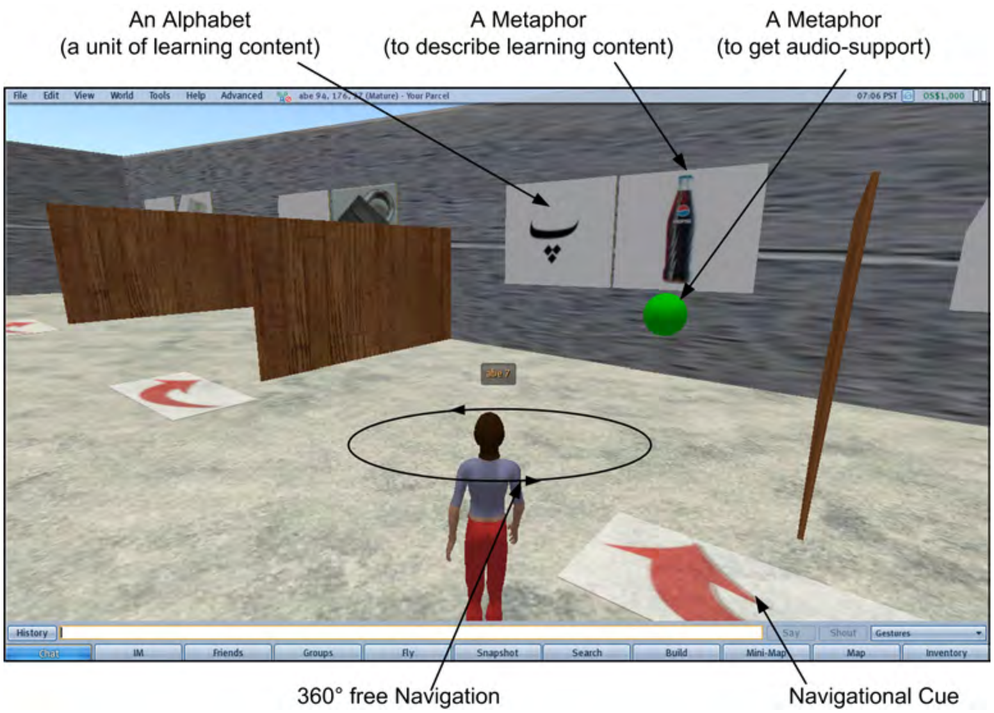

Figure 3.5: Realization of some of the Features in 3D Learning Environment

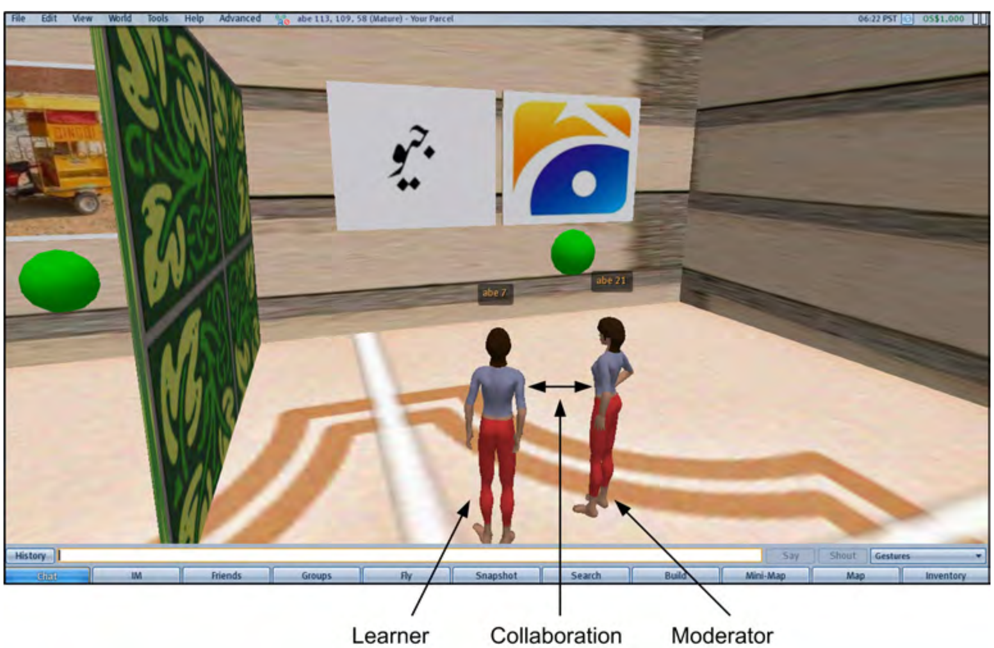

Figure 3.6: Collaborative learning in 3D Environment

Figure 3.7: A snapshot of Cultural and Contextual setting in 3D Environment

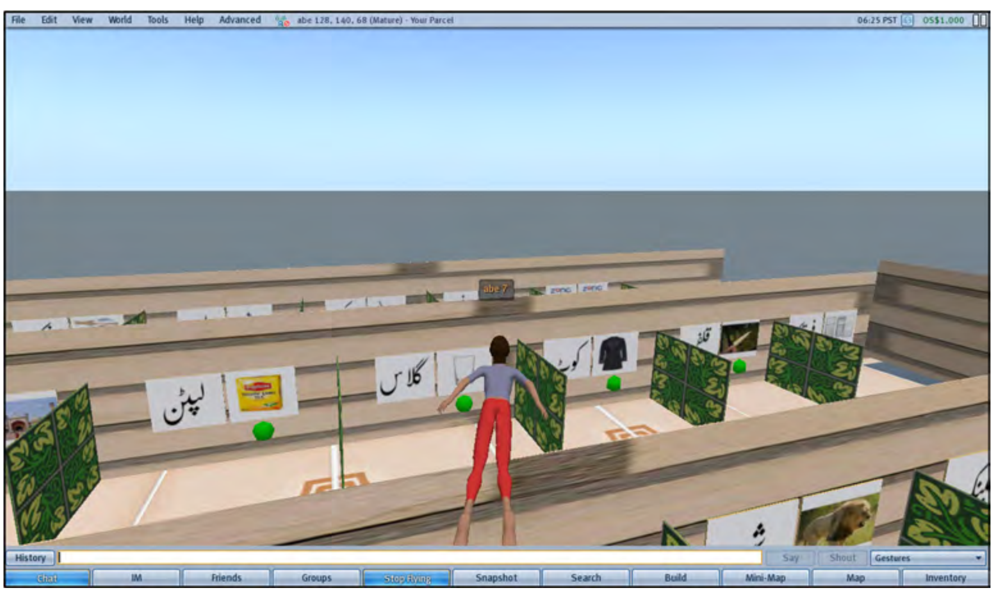

Figure 3.8: Learning-by-doing and Learner's Control in 3D Environment

Figure 3.9: Navigational Cues for Learners in 3D Environment

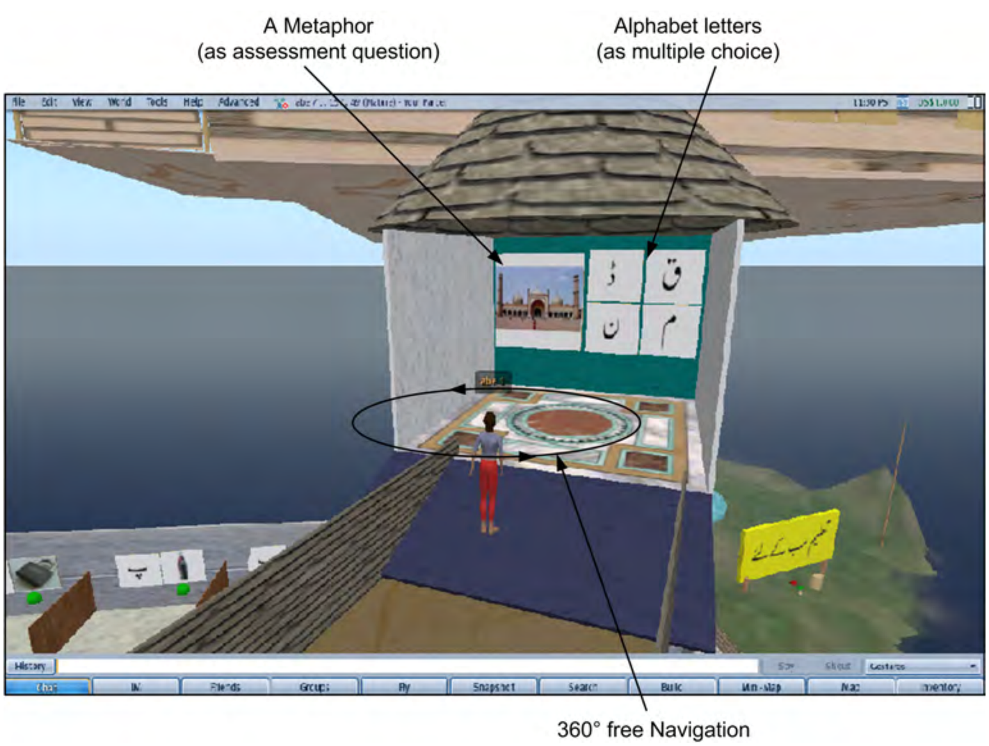

Figure 3.10: Realization of Selected Features in 3D Assessment Environment

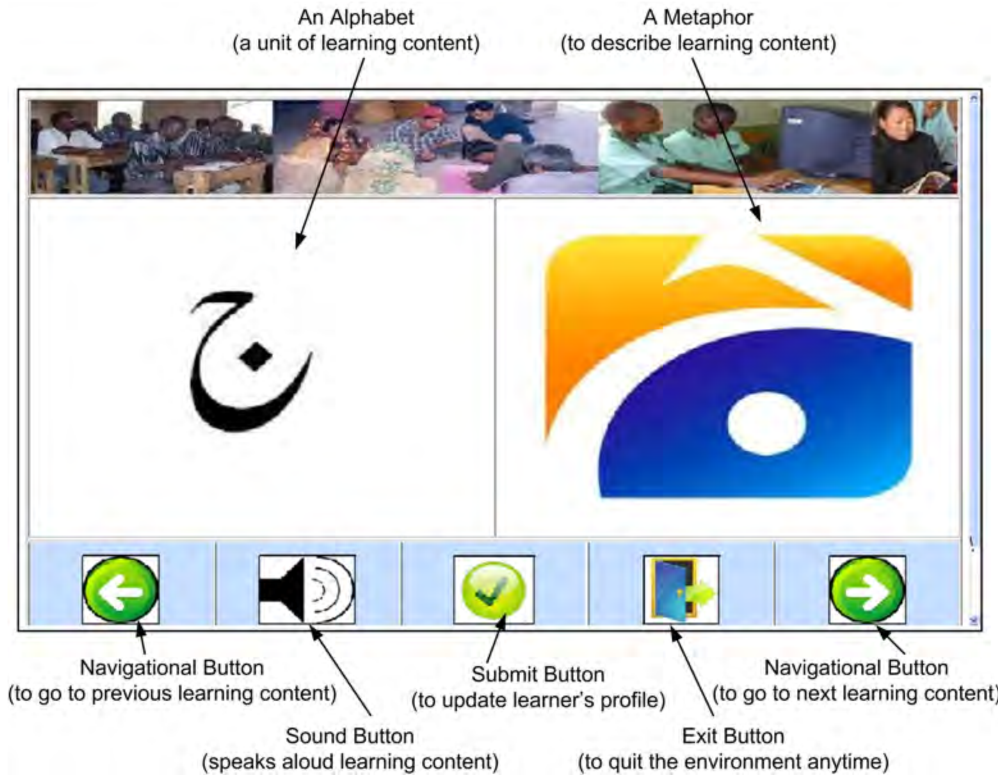

Figure 3.11: Realization of some of the Features in 2D Learning Environment

No inside environment collaboration is available in the form of avatars. A learner can repeat units of content as many times as she wants through navigational buttons. Figure 3.12 shows a self-assessment where learner can submit her response using simple mouse click on the alphabet letter or word. The learning environment keeps track of all the learned content and assessment scores against each learner. The environment also offers graphical feedback at the end of assessment tests. Adaptive support incorporated in the 2D learning environment is realized through page-variant.

3.5 Realization of Multiple Intelligences through Computer-assisted Learning

Either developing content based on multiple intelligences or realizing multiple intelligences through computer-assisted learning, it is important to remember that Multiple Intelligences is a theory that only elaborates broad range of abilities that different people possess (Kelly, 2005). It provides a set of principles, however does not explain specific strategies to realize these intelligences at content level or in technology. To answer these question considerable amount of research done that highlights different strategies to realize multiple intelligences (Kelly, 2005; Mckenzie, 2005). Developing

Figure 3.12: Realization of some of the Features in 2D Assessment Environment

computer-assisted learning material that supports multiple intelligences is a challenging task (Kelly, 2005). In this concern Mckenzie (Mckenzie, 2005) suggests some strategies to realize the multiple intelligences both in traditional and technology enhanced learning platforms as discussed under:

Linguistic-verbal intelligence is realized through traditional textbooks, newspapers, worksheets and similarly can be employed through text-based material in computer-assisted platforms. Logical-mathematical intelligence can be realized through problem solving, puzzles and using calculation on numbers in both traditional and computer-assisted environments. The use of pictures and visual effects are helping for visual-spatial intelligence, whereas use of music and sound can help in realizing musical intelligence. These both intelligences however can be best realized through computer-assisted platforms such as simulation, videos, and slide shows for visual-spatial and multimedia support for musical intelligence. Bodily-kinesthetic in traditional setting is realized through practical task, however in computer-assisted platform its realization needs virtual reality, and immersive learning settings etc. Interpersonal and intrapersonal intelligences need to be activated rather offered through material (Kelly, 2005). An isolated, independent or pure adaptive environment may help to realize the intrapersonal intelligence where as interpersonal intelligence can be achieved through different communication tools such as text and voice chat, forums, collaborative learning etc.

Table 3.3: Major Components of 3D Learning Environment and Supported Intelligences

Components of 3D Learning Environment	**Supported Intelligences**	**Technologies**
3D immersive MUVE	Bodily-Kinesthetic	Microcomputers with key board, mouse, display terminal, speakers, microphone, Local Area Network, 3D virtual environment of OpenSim
Written alphabet letters	Linguistic-Verbal	
3D metaphors for each alphabet letters	Visua-Spatial	
Avatar as learner's Representative	Bodily-kinesthetic	
Audio support	Linguistic-Verbal/ Partially Musical	
Voice-chat channels	Linguistic-Verbal/ Interpersonal	

In this research 2D and 3D spaces are exploited as computer-assisted platforms. Different intelligences are realized through each of the two spaces which are explained in following subsections.

3.5.1 3D Learning Environment

One of the computer-assisted learning environments exploits 3D virtual environment. The major features it offers are, 1) multi-user environment support, 2) text-based learning content in both alphabet and words learning phases, 3) 3D metaphors for both phases, 4) audio/voice support, 5) voice-chat channels, and 6) immersive environment. Each of these features it offers assists in realizing different intelligences in 3D space for details see Table 3.3.

3.5.2 2D Learning Environment

The other computer-assisted medium selected for instruction delivery is web 2.0 that offers 2D space. The major features that 2D learning environment offers are, 1) text-based learning content in both alphabet and words learning phases, 2) pictures for both phases, 3) audio/voice support, 4) voice-chat channels. These offered features assist in employing different intelligence as described in Table 3.4.

3.6 Selection of a 3D Virtual Environment

Present era technologies suggest more innovative learning and teaching platforms such as 3D virtual worlds that offer much more than text-based virtual environment and customized educational games (ActiveWorld, 2010; OpenSim, 2011; SecondLife, 2010).

Table 3.4: Major Components of 2D Learning Environment and Supported Intelligences

Components of 2D Learning Environment	**Supported Intelligences**	**Technologies**
Written alphabet letters	Linguistic-Verbal	Microcomputers with key board, mouse, display terminal, speakers and microphone, Local Area Network, 2D web-based setting
Pictures for each alphabet letters/words	Visual-Spatial	
Audio support	Linguistic-Verbal/ Partially Musical	
Voice chat channels	Linguistic-Verbal/ Interpersonal	

Table 3.5: Comparison of 3D Virtual Worlds on Minimum Criteria

Virtual Worlds	**Content Design**	**Content Scripting**	**Education Ready**	**Total Weight**
Active Worlds	Yes(1)	Yes(1)	Yes(1)	3
Entropia Universe	No(0)	No(0)	No(0)	0
Foterra	Can Code (0.5)	Yes(1)	Can Code (0.5)	2
Habbo	Yes(1)	No(0)	No(0)	1
OpenCroquet	Yes(1)	No(0)	Yes(1)	2
OpenSim	Yes(1)	Yes(1)	Yes(1)	3
Papermint	No(0)	No(0)	No(0)	0
Second Life (SL)	Yes(1)	Yes(1)	Yes(1)	3
There	Yes(1)	Limited (0.5)	No(0)	1.5
Whyville	No(0)	No(0)	Yes(1)	1

These 3D virtual environments are being used for a variety of activities like playing games, doing business, formal and informal learning, distance learning, collaboration, e-commerce etc (Judith and Mats, 2009). Numerous benefits of these virtual environments invite the educationist to exploit features of these environments to perk up the educational practices. However, there is a need to properly exploit the features of these virtual environments for the educational needs.

Numerous 3D virtual environments (VEIG, 2010) are available; each possesses varied strengths and weaknesses, and serves needs of different age groups. Few known 3D virtual environments along with their important features are discussed as under:

- Active World: Most popular Active World is AlphaWorld. It offers features like shopping, chat and playing online games. Also provides Active Worlds for the educational activities named AWEDU. It is dedicated to explore educational applications for institutions, teachers and students. Make them able to explore, learning theories, creative curriculum design and other concepts.

- Entropia Universe: It is massively multiplayer online virtual universe developed by MindArk. It offers a virtual universe for business and entertainment. It uses micropayment business model and Project Entropia Dollar (PED) is its currency.

- Forterra: Forterra uses On-Line Interactive Virtual Environment (OLIVE). It is a private, secure virtual world and available through license against payment. It is used for training, meeting and provides collaborative social environment. It has been used for military, medical and professional training purposes.

- Habbo: Habbo is animated rather a 3D virtual world. It is a social virtual environment (mostly used by teens) offers chat room and discussion forum.

- OpenCroquet: OpenCroquet is an open source development environment. It is based on Squeak and allows developers to create collaborative multiuser online applications. It offers collaboration, communication and document sharing between users.

- OpenSim: OpenSim 3D virtual environment reverse engineered from Second Life (SL) and allows users to run their own Second Life islands on their personal computers/Grids without firewall constraints as a standalone application.

- Papermint: Papermint is a social virtual world for the females of age 15-35. It offers various colorful games. As one walks through the papermint can discover unknown things and opportunities in the virtual world. It offers a paperLab to customize the avatar.

- Second Life: SL is one of the most popular 3D virtual worlds. It uses Linden Dollars as its currency unit. One can create own contents and avatars in SL. Text-chat, voice-chat and instant messaging are its salient features. It uses Linden Scripting Language (LSL) to deal with objects. It has biggest community of users, almost over 13 millions.

- There: It is discontinued in March 2010. It reopened for previous members in May 2011. “There” is a social world. It offers text chat, instant messaging and customizable avatars. Therebucks is a currency used in There.

- Whyville: Whyville is a social and more inclined towards educational activities world for children. It offers newspaper, beach and variety of games for millions of target users.

Selection of a particular 3D virtual environment is solely based on goals and requirements of educational institutions. “How to select virtual worlds and how best to

Table 3.6: Comparison of 3D Virtual Environments against Qualification Criteria

Characteristics/3D Virtual Worlds	**Second Life**	**OpenSim**	**ActiveWord**
Social Activities	Yes	Yes	Yes
Role Playing	Yes	Yes	Yes
Reliability	Lower	Higher	Lower
Contents Ownership	No	Yes	No
Voice-chat support	Yes	Yes	Yes
Text-chat Support	Yes	Yes	Yes
Server-side Management	Restricted	Not Restricted (for local PCs/Own Grid)	Restricted
Texture Upload Fee	Yes	No	Yes
Sound Upload Fee	Yes	No	Yes
Image Dominant	Yes	Yes	Yes
Lags	Yes	Rare	Rare
Primitive Support in a Region	Lower	Higher	Lower
Intrusion	Yes	Not for local PCs	Yes
Service Response Time	Fair (Every Script is served from Linden Lab Server)	Excellent (for local PCs/ Own Grids)	Yes
Customization/Adaptive support through scripting	Yes	Yes	Yes

design activities and experiences for learner?" is a challenge for both education and training sectors (de Freitas, 2008). Research studies describes different parameters and criteria that help to categories or assess and evaluate a virtual world (de Freitas, 2008; VEIG, 2010). In this research, general usage requirements that set minimum crtieria of selection for 3D virual environments are, 1) Education Ready – the ability to exploit 3D virtual environment for teaching purposes, 2) Design or Build Contents – the ability to create customized content without intensive programming skills, 3) Content Scripting – the ability to generate content through coding or scripts. During the selection process three weights are used for each of the criteria, for full support used 1, for partial support used 0.5 and for no support used 0 as described in Table 3.5. Finally these weights are summed up for each of the 3D virtual environments. At the beginning of the evaluation, 10 3D virtual environments were selected and evaluated according to the mentioned minimum creteria at first stage, and following three 3D virtual environments scored same total weight and met the criteria.

- Active World
- Second Life

- OpenSim

Although all three 3D virtual environments were quite appropriate as all three offer same features. However, for complete server-side management, free sound/texture uploading, content ownership, and for efficient client-server response time, these three 3D virtual environments were further verified against the characteristics derived from (Korolov, 2011) are listed in Table 3.6. Subsequently, a 3D virtual environment of OpenSim was qualified for the study.

OpenSim 3D virtual environment reverse engineered from Second Life and allow users to run their own Second Life islands on their personal computers/Grids without firewall constraints as a standalone application (de Freitas, 2008). Thus most of the characteristics they offer are similar to the Second Life except server-side management (restricted in case of Second Life and allowed in case of personal Grid in OpenSim). As both offer the same characteristics, to explain how OpenSim offer the features selected from theories taxonomy of Second Life are used (Robbins, 2007). Table 3.7 describes taxonomy of Second Life which is used (because both offer same features) to explain how a 3D virtual environment of OpenSim has potential to offer the selected features.

Table 3.7: Mapping the Selected Features to the Taxonomy of 3D Virtual Environment

Second Life's Taxonomy	**Selected Features**	**Remarks**
Multi-user	Collaboration, Directed learning, Facilitated learning	
Image Dominant/ Immersive	Situated Learning, Learning by doing, Multimodal content, Role Playing or Active Participation, Experimental Learning	Offer Sense of self-presence, social presence, embodied environment
Online Environment	Flexible schedule	Because of online nature, 1) technology expert are able to train the teacher as mentor, remotely, 2) teacher-centered approach is now switching to learner-centered style of learning.
Public Access	Collaboration, Self-esteem, Scaffolding	Immersive nature and collaboration provides self-esteem
Voice-chat	Assistance for absolute illiterate, Motivational aspects, Multimodal content	
Text-chat	Assistance for functional illiterate, Multimodal content	
Customized Scenarios	Learners' control, Adult-Oriented, Problem-centered learning, Culture, Context	
User Identity, Stigmergy, Object Ownership) -> Adaptivity	Personalization, Fast feedback	User Identity, Stigmergy & Object-Ownership take part in Adaptivity

4

A 3D Learning Platform

This chapter describes the architecture of three dimensional (3D) learning platform, adaptivity in 3D space for multi-user, and customized Adaptive Web 3D (AWE3D) architecture. Firstly, the components of proposed architecture of 3D learning space are described and explained through a practical learning scenario. Secondly, the short-comings in the proposed 3D architecture regarding adaptive support for multi-user are overcome through customized AWE3D architecture and are explained through the proposed adaptive approach and a practical scenario.

4.1 Learning Platform Architecture

In this section architecture of the proposed platform for adult basic education (ABE) is explained. It consists of seven components; three of these are part of client-side 3D space, while the other four combine to make server-side of the architecture as shown in Figure 4.1. These components are described in following subsections.

4.1.1 Activity Sensor Module

This module is responsible to sense and collect learners' interaction data in a 3D space of OpenSim. It is a part of client-side 3D space, and developed in Linden Scripting Language (LSL). This module exploits built-in functions of LSL for sensing the learners' interaction data in a 3D space. The learners' interaction data it sense includes, 1) identification of learner's avatar, 2) coordinate position of learner's avatar in a 3D space, 3) distance of avatar from the learning object, 4) learning object being touched by the avatar, 5) identification and details about the learning object being touched by the avatar, and 6) all statuses of the learner's avatar such as walking, flying, sitting, away. The activity sensor module collect this data using different sensors designed in LSL and forward it to the server-side using HTTP protocol.

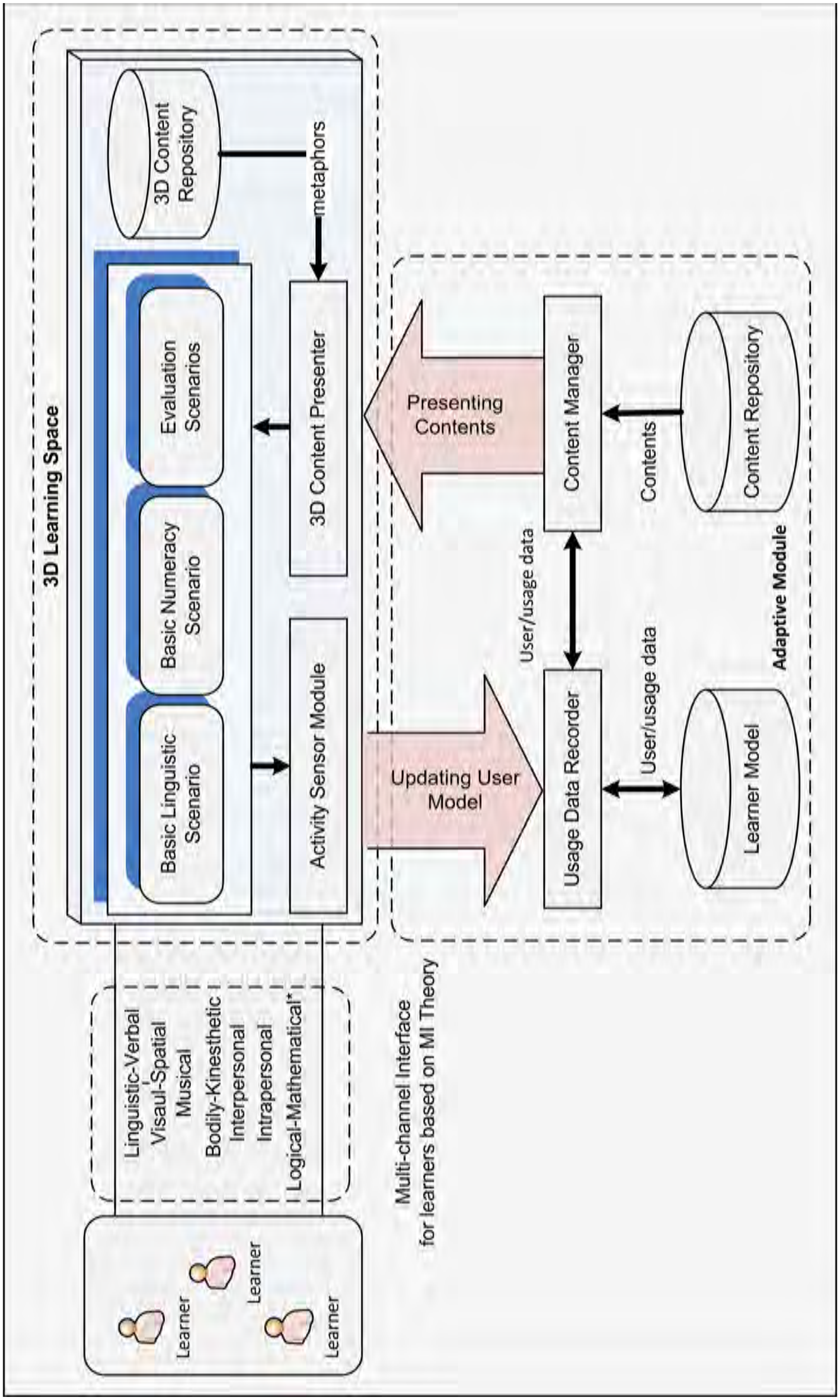

Figure 4.1: Platform Architecture

4.1.2 Usage Data Recorder Module

This is a server-side module; it receives the data sent by the activity sensor module from the client-side. This module receives the learners' interaction data and forwards it to the learner model. It exploits the PHP scripts to receive and forward the learners' interaction data.

4.1.3 Learner Model

This learner model is core for the adaptive support in the learning environment. It keeps track of the learners' data and usage data. The learner model has following characteristics:

- It keeps track of learner's knowledge level on learning units.
- It stores information about learner data (personal profile).
- It stores information about usage data (data about learner's interaction with different learning objects in 3D sapce) which is described in detail in the activity sensor module.
- It keeps track of different statuses of the learners.

4.1.4 Content Repository

Content repository is a database of learning objects, and it stores only text part of the learning contents. It is a server-side module. The content repository includes information about each of the learning content unit such as language of the learning content unit, its domain information (according to learner's background), either learning content unit is for basic learners or moderate learners (alphabet letters or words respectively), difficulty level of learning content unit, texture and sound information about the learning content unit, and information about its coordinate's in a 3D space.

4.1.5 3D Content Repository

Unlike the content repository, this 3D content repository on client-side is responsible to store 3D metaphors of all the learning objects. These 3D metaphors are populated manually into the repository through a user having administrative rights to deal with the 3D space. To realize 3D content repository in 3D space, inventory from the OpenSim is used to store all the metaphors.

4.1.6 Content Manager

This is a server-side module, and it interacts with three modules of the architecture; 1) Learner Model, 2) Content Repository, and 3) 3D Content Presenter. This module is responsible to select and forward a list of contents for the learners to the 3D space. On a request from the client-side 3D space, the content manager first interacts with the learner model for learners' profile. Finally the content manager forwards following information to the content presenter in 3D space regarding learning contents:

- Identification
- Texture
- Virtual world position
- Content language
- Domain information
- Learning phase
- Difficulty level.
- Recorded sound file

4.1.7 3D Content Presenter

This is a client-side module and responsible to present learning objects in 3D space. The 3D content presenter is developed in LSL. It receives the responses against the request made by the activity sensor module. On the basis of information it receives from the server-side, it selects the metaphors from the OpenSim inventory and presents to the learners. http_response() function is responsible to handle the information from the content manager.

4.2 Application of the Proposed Architecture

The learning environment realized through the proposed architecture has potential to present customized content to the learners. The customized presentation is based on background and knowledge of the learners. The background of the learners defines learners' profession, job responsibilities and related areas whereas knowledge defines skills in the related areas and it is a changeable feature that either may increase or decrease with the passage of time. The learning environment offers adaptive support

Figure 4.2: A snapshot of 3D Learning Environment

in content presentation exploiting both implicit and explicit information maintained by the learner model. Initially the explicit information helps to present domain specific contents to the learners, and implicit information traced by the learning environment assists to monitor the knowledge level of the learners. In the 3D learning space each learner is represented by an avatar (an embodied object of a learner) that can walk, fly, sit, speak and chat under the control of a learner. The learning scenarios are intended to educate the illiterate learners (target users of the proposed environment) and these scenarios are categorized into 1) linguistic scenario, 2) numeracy scenario and 3) game-based scenario. This research focuses on the linguistic learning and game-based evaluation scenarios.

When a learner joins the learning environment, she walks through different stage like classroom setting. In one learning environment there are four classrooms for alphabet-learning and four for words-learning. Using navigational cues a learner can approach to the desired classroom using four arrow keys on the keyboard. In each classroom there are two prims (prim is an object in a 3D space), one to display alphabet-letter/word whereas other to display metaphor along with the alphabet-letter/word (alphabet-letter in case of alphabet-learning and word in case of words-learning phase) (see Figure 4.2). If a classroom is free and a learner joins it, she needs to click on any of the two prims. The activity sensor module on this click event finds the learner's identification and forwards a request for contents to the server-side. As soon as this information is updated in the learner model through the usage data recorder module, the content manager takes the charge. The content manager on this click event of update, get a complete information about the learner from the learner model and accordingly select contents from

Figure 4.3: A snapshot of 3D Assessment Environment

the content repository and handover the list of contents to the client-side module called 3D content presenter. During the selection process the system takes care about background and knowledge of the learner. Thus the contents recommended by the adaptive system are based on background and knowledge of the learner. The 3D content presenter exploits this information and selects metaphors from 3D content repository against the list forwarded by the content manager, and finally presents contents along with the metaphors to the learner. For instance a learner joined the learning environment for the first time and when she clicks on the prim; in this case alphabet letters will be presented to her in a chronological order and learning will start from the first alphabet letter. However, if a learner has already joined the learning platform and later on logins for learning, when she clicks on the prim, the learning environment will present domain specific (background based adaptive support) learning content but will start from the learning content unit from where she left in the last session (knowledge based adaptive support). When a learner has learned a learning content unit, she needs to click on the prim to tell the learning environment, this action not only updates her profile but also present her the next learning content unit.

For evaluation in 3D space, a stage setting consists of five prims presents a question to the learners as shown in Figure 4.3. The larger object on the left displays a metaphor where as four smaller objects on the right present alphabet letters/words (against the metaphor and only one of them best defines it). A learner is required to select only one through mouse click. The adaptive system evaluates whether the learner's response is correct or incorrect and update learner's profile accordingly.

In order to ensure true learning/evaluation, to avoid accidental clicks through mouse and rapid guessing, five parameters from a 3D space are exploited which are; proximity of avatar from learning content unit being learned, flying status, sitting status, walking status, and away status of a learner's avatar. The activity sensor module is responsible to track this information using LSL as show in Figure 4.4. The touch-start() function with the help of llGetAgentInfo() senses various status of the learner's avatar, the llGetList2Vector() and llRot2Euler() determines position of avatar of the learner in the 3D space. A rule (see Figure 4.5) exploits this information and examine whether a learning content unit is learned by a learner or not (correct or incorrect answer in case of the evaluation phase). Finally all the information about a learner is forwarded to the learner model for future use. The flow of information between client-side and server-side of the learning environment is realized using llHTTPRequest() and http_response() (on client-side 3D space) and using PHP scripts (on server-side).

In such a scenario one classroom can serve only one learner, however in case of more than one learner it is feasible when all learners belong to the same domain and are at the same level during learning process. Also it is hard for a learner to find a classroom setting that is relevant to her (domain specific contents and at desired difficulty level). Furthermore, if a learner does not find any free classroom she is unable to continue in the learning environment. In order to overcome these shortcomings in the proposed architecture, it is further extended for multi-user adaptive support. Adaptive support for multi-user in 3D space is explained in next section.

4.3 Adaptivity in 3D space for Multi-user

All adaptive efforts in 3D spaces are focused on single-user; unfortunately no application is reported in literature that considers adaptivity in 3D spaces for multi-user (Chittaro and Ranon, 2007). In a single-user 3D space, it is relatively trivial to provide personalized content and navigational path according to the user's needs because there is no concept of space sharing, hence there are no conflicts in personalizing content, navigational paths and interaction. On the contrary, adaptivity in 3D space for multi-user is a complex and non-trivial job. In multi-user 3D spaces, as the same 3D space is shared by more than one user simultaneously, adaptive content presentation for all users in the same 3D space raises conflicts (like overlapping of contents) in content presentation that leads towards new challenges. Similarly navigational support cannot be customized for an individual user because other users are sharing the same 3D space and demarcation in navigational cues for each individual user is a difficult job (Chittaro and Ranon, 2007). In order to understand the concepts of content presentation and navigational support, there is a need to revisit the transition from two dimensional (2D) spaces to 3D spaces. Chitarro and Ronan (Chittaro and Ranon, 2007) in this context

```
// part of a code for Activity Sensor Module
 touch_start(integer number)
{
    //determines basic information
    //about learners and learning region
    key user = llDetectedKey(0);
    string name = llKey2Name(user);
    string region = llGetRegionName();
    vector size = llGetAgentSize(user);
    llSay (0, "user name------------------" + name) ;

    //determines position, rotation and velocity
    vector pos = llList2Vector(llGetObjectDetails(user, [OBJECT_POS]),0);
    vector rot = llRot2Euler(llList2Rot(llGetObjectDetails(user, [OBJECT_ROT]),0))*RAD_TO_DEG;
    vector vel = llList2Vector(llGetObjectDetails(user, [OBJECT_VELOCITY]),0);

   //determines learners usage data …few parameter as an example
   integer learnerDetail = llGetAgentInfo(user);
   string awayStatus = "No";
   string flyingStatus = " No";
   string mouselook = " No";
   string sittingStatus = "No";
   string typingStatus = "No";
   string walkingStatus = "No";

   if (learnerDetail & AGENT_FLYING)
     flyingStatus = "Yes";
   if (learnerDetail & AGENT_AWAY)
     awayStatus = "Yes";
   if (learnerDetail & AGENT_MOUSELOOK)
     mouselook = "Yes";
   if (learnerDetail & AGENT_SITTING)
     sittingStatus = "Yes";
   if (learnerDetail & AGENT_TYPING)
     typingStatus = "Yes";
   if (learnerDetail & AGENT_WALKING)
     walkingStatus = "Yes";

  }
```

Figure 4.4: Sensors used in 3D Learning Environment

```
IF distanceFromLearningObject (avatar) < Threshold AND
   flyingStatus (avatar) = “No” AND
   walkingStatus (avatar) = “No” AND
   sittingStatus (avatar) = “No” AND
   awayStatus (avatar) = “No” AND
   locationAvatar (avatar) = “sameZone” AND
   mouseClick (avatar) = “Yes”

THEN learnedTrue (avatar, LearningObject)
        RespnseTrue (avatar, Response)
```

Figure 4.5: A rule to avoid Rapid-guessing in 3D Learning Space

explain these concepts as:

- Presentation space in 2D setting is a simple web page where as in 3D environment it is a complex non-trivial 3D space.
- Content presentation in 2D spaces is a text-based and it may also contain images or videos; however 3D space poses extra provision of 3D metaphors and models.
- Structural organization in 2D environments consists of a set of pages whereas in 3D environment, it comprises of 3D spaces.
- For navigation across 2D web pages hyperlinks are used and in 3D milieu, navigation is possible through teleporting, walking and flying.
- Users' action in 2D environments may include reading and filling forms whereas in 3D space it includes movement (through avatars) and mouse clicks on metaphors or 3D objects.

For these reasons, techniques and tools used for adaptivity in 2D environments cannot be directly applied for content presentation and navigation in 3D spaces (Chittaro and Ranon, 2007). Following subsections explain differences in adaptive support across 2D and 3D space.

4.3.1 Content Presentation

Content Presentation in 2D web-based environments exploits two techniques, optional-fragments and altering-fragments. These techniques are used for contents' relevancy and their structuring (Chittaro and Ranon, 2007). An adaptive system that uses these fragment-based techniques, it selects and combines these fragments to build and present an adaptive web page to the user. The same techniques are being used in 3D space for content presentation, where appropriate metaphors are selected and presented to the user. However, a special care is required to avoid overlapping and intersection of metaphors with each other in the case of 3D space for meaningful and understandable information (Chittaro and Ranon, 2007). It shows that, these techniques are not so simple to be exploited for adaptive content presentation in 3D spaces.

4.3.2 Navigational Support

For navigation in a 2D environments hyperlinks are used (Hughes et al., 2002). Whereas in 3D space, navigation is a complex phenomenon where viewpoints are calculated using parameters of camera positions and faces (Hughes et al., 2002). These viewpoint based adaptive techniques are derived from link manipulation techniques that are direct guidance, hiding, sorting and annotation. Furthermore, for navigational support in 3D space, intelligent agents (Chittaro et al., 2004; Chittaro and Ranon, 2000) and patterns of interaction from usage data (Celentano and Pittarello, 2004) are being used. Museum Guide (Chittaro, Ieronutti and Ranon, 2004) and Walking Products (Chittaro and Ranon, 2000) are applications of these intelligent agents.

4.3.3 Frequency of Adaptivity

Frequency of adaptivity in 2D space is even promising within a session such as in (NavEx, 2011). Whereas in 3D space, metaphors are organized in a certain spatial order, if metaphors start changing so frequently (within a session) even after the recommendation of user model, adaptivity may come up with frustrating experiences for users (Chittaro and Ranon, 2007). (Dufresne, 2002) recommends stable adaptive frequency to avoid this confusion and frustration of a user.

For adaptivity in multi-user environments, an approach is presented in (Dieberger, 1996). However this approach is developed for textual Virtual Environment (VE) (environments based on imagined landscape where locations, objects, users and their interactions are described solely through text instead of metaphors). This approach exploits the concept of ‘read wears’ to provide adaptive support in multi-user textual VE, where description of objects is changed in imagined landscape according to frequency of their usage (e.g., usage frequency of room exits and posting on bulletin boards).

4.4 The Proposed Approach for Multi-user Adaptivity

In multi-user 3D space as more than one user share a same 3D space and it causes conflicts in adaptive content presentation, navigation and interaction. To reduce these conflicts an approach is proposed in this section. This approach reduces the conflicts by optimizing the best common adaptation strategy, where a group of learners able to share a partition of 3D space that is customized according to their preferences. The approach, first presents a technique to create partitions of a 3D space, and it follows a set of steps to exploit the partitions for multi-user adaptivity in a 3D space.

In order to optimize best common adaptation strategy, firstly, a 3D space is divided into multiple logical partitions based on common preferences. These common preferences are defined through the features which set the basis for adaptive support such as, the user’s knowledge, interest, background, individual differences, and goals

$$\text{Total Partitions} = \prod_{i}^{N} n_i$$

n_i = number of variations in feature **i**

Figure 4.6: A Formula to Calculate Partitions of 3D Space

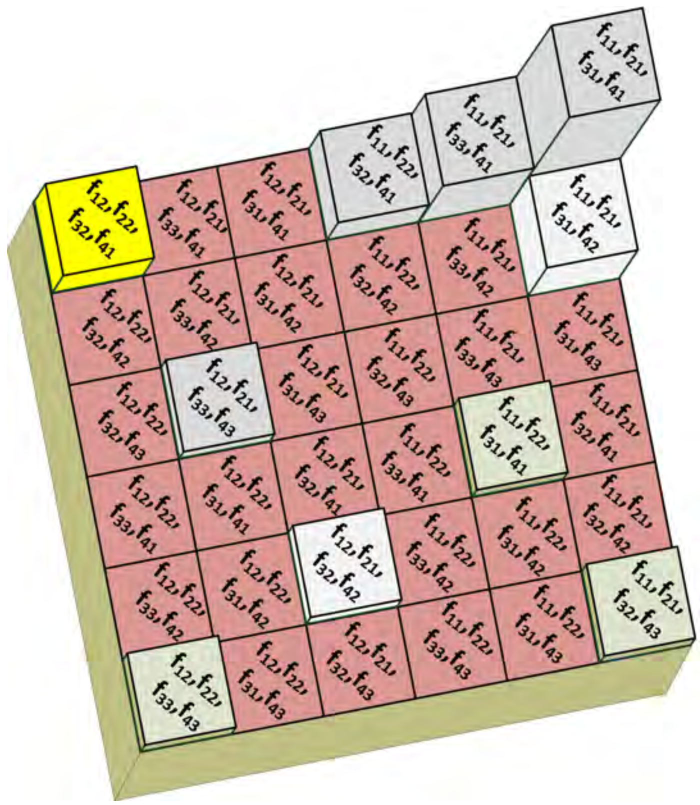

Figure 4.7: An Example of 3D Space Partitioning

(Brusilovsky and Millan, 2007). Furthermore for each of the features, it is required to define possible variations to which an adaptive system is supposed to address. For instance in case of the adaptivity based on background feature, medical adaptive systems able to distinguish two or more categories (as possible variations) of users according to their knowledge about terminologies in medical and adapt content presentation accordingly (Brusilovsky and Millan, 2007). Consequently, all the defined features and variations in each of the feature decide all possible combinations of preferences and hence number of partitions in a 3D space. The process of partitioning of a 3D space exploits a formula that calculates number of partitions by taking the product of number of variations in each of the features (see Figure 4.6).

According to the formula, for instance a 3D space need to present content to the user based on four features F1, F2, F3, and F4. Each of the features consists of a set of variations. For example, the features F1 and F2 each has two variations which are

F1(f11,f12) and F2(f21,f22) respectively, whereas features F3 and F4 each has three variations which are F3(f31,f32,f33) and F4(f41,f42,f43) respectively. Total number of partitions and possible combinations of preferences according to the discussed example are 36 and shown in Figure 4.7.

The partitioning technique is followed by a set of steps to exploit the partitions and ultimately to realize the adaptivity in 3D space for multi-user. In fact the partitioning process ensures adaptive content presentation whereas these steps assist in navigation to approach the partitions based on users' preferences. Both are realized through AWE3D architecture as shown in Figure 4.8. How these steps are carried out is shown in Figure 4.10.

When a user logins in the 3D space, the activity sensor module on client-side sense the presence of user using LSL functions touch_start() and llGetAgentInfo(), and send the collected information, and a request of reading profile of the user to present her content according to her preferences through llHTTPRequest() to the server-side. On this request, the personalization module on the server-side reads user profile using PHP scripts and forward recommendation for content presentation to the client-side. The content presenter module on the client-side using http_response() function receives the response of the personalization module, examine the sent recommendations and finds whether a partition in 3D space exists that fulfills these recommendations or not. If a partition that fulfills the user's preferences exists in the 3D space, then the avatar of a user is teleported to that partition, however if it does not exit then the content presenter module creates a new partition for the user according to her preferences with the help of 3D content repository and teleport the avatar of user to the newly created partition. In both cases contents are presented to the user and all activities of the user are tracked using activity sensor module and her profile is updated. If the user has completed a task in the 3D space (in a allocated partition), and yet other tasks are to be completed, in this case the activity sensor module again requests the server-side personalization module and receives the recommendations. The content presenter examines whether a partition according to the new recommendation is available or not, if it is available then the system teleport the user to the available partition, however if it is not available, it creates new partition according to the recommendations and teleport the user to the newly created partition. The users are free to navigate anywhere in the partition and allowed to leave the session anytime. The adaptive system for multi-user tracks their all activities. In such an environment a 3D space is able to offer customized content presentation and navigation to the users according to their preferences, where a group of users share the same preferences is served through the single partition whereas the users with different preferences are served through different partitions in a 3D space.

4.4.1 Enhanced Adaptive Web 3D (AWEB3D) Architecture

The proposed architecture for adaptivity in a 3D space for multi-user is based on the Adaptive Web 3D (AWE3D) (Chittaro and Ranon, 2002). To realize the adaptive support for multi-user in 3D space, the AWE3D is customized accordingly. The original AWE3D comprises of six major modules. One of these modules named Usage Data Sensing module resides on the client-side; whereas rest of five modules named Usage Data Recorder, User Model Database, VRML Content Database, VRML Content Creator and Personalization module are part of the server-side application. On the other hand, in the proposed customized architecture, there are eight modules. Out of these eight modules three are client-side modules where as rest of five are part of the server-side application as shown in 4.8. All these modules of the enhanced customized AWE3D are previously described in section 4.1, except a server-side module called buffer. The purpose of buffer in the architecture is to reduce the number of accesses to relational database. It temporarily stores all the data sent by the activity sensor module into a text file. When the stored data exceeds the set limit of data in the buffer, it transfers it to the learner model.

Exploiting the proposed adaptive approach and customized AWE3D architecture adaptive content presentation and navigation is implemented. For adaptive content presentation an approach similar to the page-variant is used where texture for the prim in the 3D space are selected according to the learner's preferences. The adaptive navigation is realized through teleporting the avatar of the learners to the relevant learning content and this approach also addresses the issue of being lost in 3D space especially in case of novice learners.

4.4.2 Limitations of the Proposed Approach

There are certain limitations in the proposed adaptive approach. For instance, the adaptive system teleports a learner to the learning-zone that is not newly created rather it was already available in a 3D space. In such situation when a learner arrives there she may find that some learning content units are already passed or learned by the learner who was learning there previously. This problem is not yet addressed; however a technique may address such a situation, where an adaptive system needs to set a threshold regarding number of learning content units already passed or learned? If these contents are lesser than the set threshold, only then a learner can join that learning-zone otherwise not. In case the set threshold is not satisfied, then a mega-region can be exploited. In the mega-region, multiple copies of the same learning-zone can be provided and learners are teleported there. In case of more than one copies of a learning-zone, more learners can be entertained.

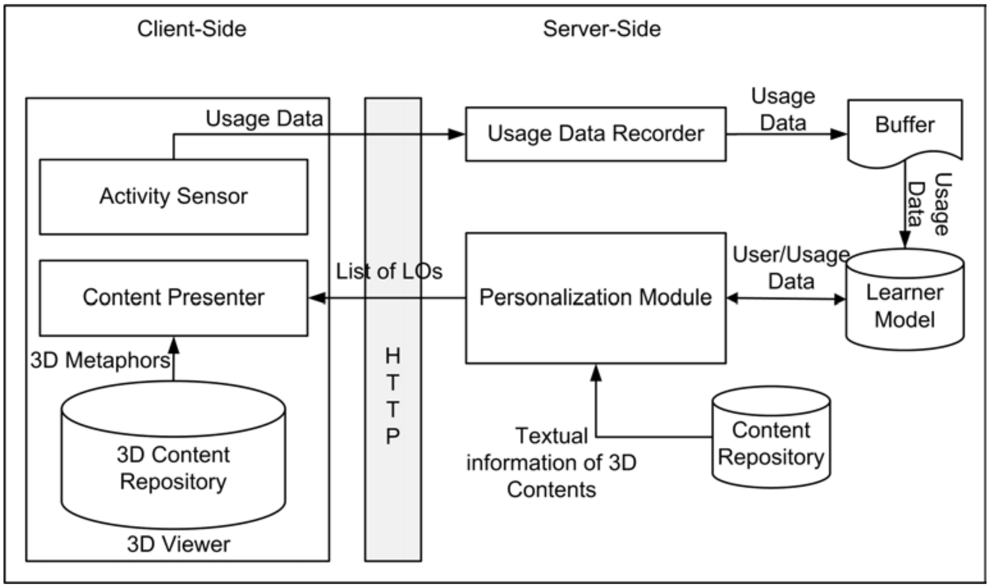

Figure 4.8: Customized AWE3D Architecture for multi-user

Using the proposed approach, the provided content presentation and navigational support are dynamic in nature; however partitioning of a 3D space is kept static for two reasons; 1) because of ease in presentation where a 3D space partitioning is decided in advance and names are assigned to each of the learning-zones. When a learner login to the system, learner is guided to the relevant learning-zone according to her profile, 2) On the other hand, system is able to assign names at run time to the different partitions (learning-zones) and able to select relevant learning-zone according to user profile, however in order to achieve the dynamism in 3D space partioning, all 3D metaphors for all learning-zones are required to be populated in the content repository of each learning-zone and this factor may lag in performance.

4.5 Application of Multi-user Adaptive Support

Application of multi-user adaptive support in a 3D space is explained in this section through a working scenario for ABE. Only the multi-user adaptivity in content presentation and navigation is described here, rest of the features of the learning scenario in 3D space are same as discussed in the section 4.2. The scenario serves for learning and evaluation simultaneously where learners of ABE may learn alphabet letters and commonly used words in a 3D space. The realized scenario provides adaptivity in content presentation on the basis of four features, which are language, domain, phase, and difficulty-level. The feature of domain comes under broader feature of background, where as features phase and difficulty-level come under the feature of knowledge. Each of the features has two defined variations. The scenario offers contents in two languages English and Urdu (two variations of the features of language); these contents are designed for two groups of learners which are house-wives and labor-workers because participants in the study (conducted in Pakistan, see Chapter 5 for details) belong to the said two trades (again defines two variations of the feature of domain); the contents offers alphabet letters learning and words learning (two variations of the feature of phase) with two levels of difficulty (defines two variations of the feature of difficulty-level) for both languages. As discussed previously in section 4.4, these features and there variations set the basis for the partitioning of the 3D space. Thus to realize the partitioning in 3D space for the presented scenario, product of numbers of variations of each features is calculated exploiting the formula (see Figure 4.6). The total recommended partitions for the presented scenario are 24. Each partition serves a group of learners having common preferences. For instance the 3D space is a circular in shape (as normally offered by OpenSim in very raw form), Figure 4.9 shows the realized partitioning strategy. The vertical line divides the space into left and right halves, one half (the left-half) offers contents in English language, and other half (the right-half) offers contents in Urdu language. The horizontal line cuts the space into upper-half (offers contents customized for house-wives domain) and lower-half (offers contents customized for labor-worker domain). Two lines in diagonal, from the upper-left quadrate of the space to the lower-right quadrate, and from the upper-right quadrate to the lower-left quadrate divide the space into partitions for alphabet-learning and words-learning. Finally a small centric circle divides the space for different difficulty levels (beginners and moderate). Each partition in 3D space is called learning-zone and identified by the name labeled inside each partition as shown in Figure 4.9. As different partitions offer different sets of preferences in content presentation, hence able to server multi-user in a same 3D space.

The partitioning technique is followed by a set of steps to exploit the partitions and ultimately to realize the adaptivity in 3D space for multi-user. These steps describe how a learner is able to approach the partitions. For instance, a learner logins into the 3D learning space for the first time, the 3D space exploiting the activity sensor module sends the learner's particular to the server-side. The personalization module on the server-side reads learner's profile and forward recommendations for content presentation to the client-side. The content presenter module on the client-side receives the response of the personalization module, examine the sent recommendations and finds whether a learning-zone in 3D space already exists that fulfills these recommendations or not. If a learning-zone that fulfills the learner's preferences exists in the 3D space, then the avatar of a learner is teleported to that learning-zone, however if it does not exit then the content presenter module creates a new learning-zone for the learner according to her preferences with the help of 3D content repository and teleport the avatar of learner

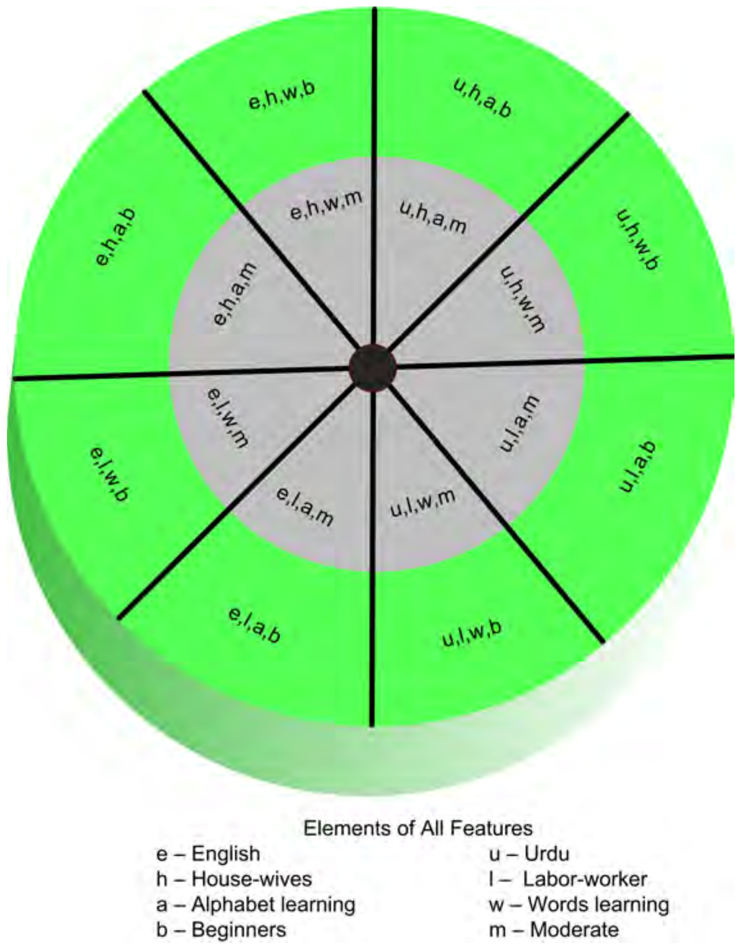

Figure 4.9: 3D space Partitioning for the Learning Scenario

to the newly created learning-zone.

In both cases contents are presented to the learners and all activities of the learners are tracked using activity sensor module and her profile is updated. Whenever a new learner logins into the 3D learning space, same steps are followed by the system hence multi-user are able to join the same 3D space for learning. If the learner has successfully completed all contents in the 3D space (in a allocated learning-zone), and yet other contents are to be completed, in this case the activity sensor module again requests the server-side personalization module and receives the recommendations. The content presenter examines whether a learning-zone according to the new recommendation is available or not, if it is available then the system teleport the learner to the next learning-zone in a 3D space, however if it is not available, it creates a new learning-zone according to the recommendations and teleport the learner to the newly created learning-zone. The learners are free to navigate anywhere in the learning-zone and allowed to leave the session anytime. The adaptive system for multi-user tracks their all activities. In such an environment a 3D space is able to offer customized content

1. User login
2. Read user profile
3. If a partition available (matching with user's preferences)
3a. In case of Yes, teleport the user to the available partition
3b. In case of No, create new partition, and teleport the user to the newly created partition
4. Present contents or task
5. Sense user's activities and update user model
6. If logout request
6a. In case of Yes, update user profile and logout
6b. In case of No, continue
7. If all contents and tasks are finished in allocated partition
7a. In case of Yes, goto step-2
7b. In case of No, goto step-4

Figure 4.10: A Set of Steps for Adaptive Support in multi-user 3D Space

presentation and navigation to more than one learner according to their preferences, where a group of learners share the same preferences are served through the same single learning-zone whereas the learners with different preferences are served through different learning-zones in a 3D space.

5

Experimental Design

In the last two chapters, selection of the features from learning theories, their mapping to the multiple intelligences, their realization through two dimensional (2D) and three dimensional (3D) learning environments, architecture of 3D learning environment and customization of AWE3D architecture for adaptivity are discussed. As, it is hypothesized that the 2D and 3D learning environments based on features adopted from the theories, especially from the theory of multiple intelligences, have potential to enhance multiple intelligences of learners, thus the next objective of this research is to investigate the impact of these 2D and 3D learning environments on the intelligences of adult learners, comparison of their learning gain in two different environments, and evaluation of their satisfaction and behavioral intention towards future use of these environments. For the said investigations, this chapter explains the research methodology, experimental design, validity of different instruments used in this research, a procedure adopted and a case study.

5.1 Research Methodology

The research method adopted in this research is focused towards collecting data about the impact of technology enhanced learning on the multiple intelligences of the adult learners, their learning gain and satisfaction, and it may assist us to answer the research questions established for this research and may open up avenues for further research. More specifically, for this research experimental and descriptive research approaches are adopted. The following subsections explain these two approaches and describe the reasons for their selection in this research.

5.2 The Experimental Approach

In order to find the impact of two different learning environments on the multiple intelligences of the learners, and on their learning gain, a comparison of two treatments (2D and 3D learning environments) sets the basis for the experimental approach in the research. Following the essence of the experimental approach, two groups are designed in this research, the control group and the experimental group (Bell, 2005). Selection of both control and experimental groups is random without any discrimination on multiple intelligences and knowledge of the learners which ensure participants selection validity (Ross and Morrison, 2004). Furthermore, in both learning environments same contents are presented and each environment offers same features which supports the validity of condition (Ross and Morrison, 2004) in this research. These two considerations classify the experimental approach as "true experimental" approach where internal validity of experiment is ensured.

The measurement of multiple intelligences for the control and experimental groups are carried out through a questionnaire at three points; before adult basic education (ABE), after the first phase (alphabet letters learning), and finally after the second phase (commonly used words learning). To determine the learning gain, both manual and computer supported techniques are used for each group, where learners are asked to recognize and pronounce the presented contents after each phase. As the participants were adult illiterates, interviews were conducted against each questionnaire. Results are compared and statistical analysis is performed for significant improvement in different multiple intelligences and assessment score.

5.3 The Descriptive Approach

Besides the experimental approach, the research also uses descriptive research approach. Exploiting the descriptive approach, two groups of learners are sampled, the first who used 2D learning environment and secondly those who used 3D learning environment for their basic education. Their satisfaction and behavioral intention towards future use of the 2D and 3D learning environments exploited in this research, is determined. Both quantitative and qualitative tools are used for descriptive approach. As questionnaire and interviews are used to determine satisfaction and behavioral intentions of the learners, it delineates the approach solely as quantitative approach. However, throughout in the research a close contact is kept with the participants, it develops the trust between research team and participants and ensures the qualitative aspect of the approach being used (Bogdan and Biklen, 2002). Also, other demographic analyses on the feelings of learners about different technologies being used for their education are also carried out at the end of this research to cover the qualitative aspects in this research.

5.4 Participants

Non-literates or pure illiterates are the intended participants of this research study. Initially 40 participants were selected, however this strength reduced to 32 after scrutinizing process. During scrutinizing process their age is determined and their skills to pronounce and recognize alphabet letters of Urdu language (the language being taught during the program) are examined. Only the adults with age greater than 15 with zero skills to pronounce and recognize alphabet letters were selected.

This study was conducted in a small town of Pakistan. Major reasons for the selection of Pakistan as study point were to best investigate the impact of technology in ABE programs in developing countries and to examine the applicability of technology in developing countries. Pakistan is located in South Asia where around 46% of the population is illiterate and majority of them (around 58.25%) are women (Choudhry, 2006). In rural areas it appears to be more critical where illiterate population is 56.16% and again majority of them are women (around 70%) (Choudhry, 2006). Furthermore, selection of a small town (Hassan Abdal) that is one of the rural areas of Pakistan is based on the inspiration to provide basic education platforms to most deprive community with no opportunities.

All of the participants in the study were female. Most of them (around 93%) were married and were either house wives or working at others' homes as maid. Only two of them were working as runner in a middle level school of girls in the town. Ten of them were in the age bracket of 45-60 year, eleven of them were in age bracket of 35-44, and rests of them were youngest with age bracket 25-34. None of them had formal schooling except two participants, and they also had to leave school within one year after the start. Only one of the participants had computer at home for her daughter, but she never used due to fear factor. However everyone was known to computer and they had seen it already and well motivated to get education through computers. Parents of all the participants were also uneducated except two of them, however at least one member from their families (either daughter or son or younger brother or sister) has basic education.

5.5 Instructional Material

As the essence of the research is to investigate the impact of different learning environments on the multiple intelligences of learners, their learning achievement score and their satisfaction, the two pre-requisites; contents design and use of technology as learning environments to present these contents without any discrimination, appears to be a critical task. Mielke explain this fact as, all the aspects of treatment such as contents, method of instruction must be same, only the media being compared can be different (Mielke, 1968). The following subsections describe about learning contents selected for learning environments, composition and major features of two learning environments, and how they exploit the selected content for the basic education of adults.

5.5.1 Learning Content

In order to eradicate illiteracy and to provide primary education to all, Directed General of UNESCO launched an Asian-Pacific Program of Education for All (APPEAL) (UNESCO, 1989) in year 1987. The APPEAL Training Martial for Literacy Personnel (ALTP) presents principles of curriculum design for literacy training. These principles describe three levels of literacy skills. The Level-I focuses on Basic literacy skill, and the Levels II and III cover Middle standard and Self-Learning literacy skills. The level-I target the group of adult learners; 1) who have never been to school or dropped out of the school before acquiring literacy skills, and 2) who are unable to read simple words, paragraph or other written material. The Basic Level literacy skills include reading (headlines and sub-headings of newspaper, posters, and numbers from 1-1000 etc), writing (own name, simple letters, and numbers from 1-1000), numeracy (counting and recognizing letter 1-1000, 3-digit addition, and subtraction etc), and other skills such as communication and use of literacy skills in daily life. As this research targets the learners of the Level-I defined by APPEAL, so the learning contents included in this research and realized in the 2D and 3D learning environments focus on Basic literacy skills and solely embrace the reading skills. However, a curriculum design can be exemplary but could not be standardized, it may vary region to region is a matter of fact need to be considered (UNESCO, 1989). In Pakistan, according to census of 1998, adult literacy is defined as, "One who can read a newspaper and write a simple letter, in any language" referred as literate (Choudhry, 2006). Thus to address regional needs for designing content, previously designed courses for adult literacy in Pakistan are reviewed and considered. This section describes in detail about the selected content for this research.

Urdu a national language of Pakistan is realized to design the content. In Urdu language there are 51 alphabet letters in total. Literate Pakistan Foundation (LPF) developed a course for illiterates titled "JUGNOO SABAQ", and it included only 28 out of 51 alphabet letters (LPF, 2011; Starfish-Karachi, 2011). According to the research carried out by the LPF, these 28 alphabet letters (see Figure 5.1) use in the formation of 80% words whereas as rest of 23 alphabet letters (see Figure 5.2) only make 20% words. In order to give more exposure to the learners, the 28 alphabet letters which makes 80% of the words are included in the proposed content for the first phase of learning referred

چ	ج	ٹ	ت	پ	ب	ا
س	ز	ر	ڈ	د	خ	ح
گ	ک	ق	ف	غ	ع	ش
ے	ی	ہ	و	ن	م	ل

Figure 5.1: Selected 28 Alphabet Letters of Urdu Language

as alphabet learning phase. In the second phase, most commonly used words from the daily life of target community are included. Words three-tier philosophy of Beck and her colleagues is used while choosing the right words to teach (Beck et al., 2002). The tier one includes basic and frequently used words (like girl, store etc), the tier two has more abstract words (like consequence, complex etc), and the tier three consist of domain specific low frequency words (like trajectory, photosynthesis). Following the concept of three-tiers of words presented by Beck, most commonly used words from the daily life or the most known brand names that everyone may see around them are included. Furthermore, only those words are considered that are formed by the selected 28 alphabet letters (Starfish-Karachi, 2011). All included contents are further scrutinized and verified through other research studies, and curriculum classified for adult literacy in Pakistan (Ahmad, 1995; EEF, 2007; Nabi, 2006).

5.5.2 3D Learning Environment

One of the technology-based medium for instructions delivery is 3D virtual environment. OpenSim (OpenSim, 2011), an open source 3D virtual environment is selected for implementation, criteria of the selection is described in the chapter 3. For the learners of ABE, a learning environment using OpenSim is developed, it offers different learning scenarios; alphabet letters learning (Phase I), commonly used words learning (Phase II) as shown in Figure 5.3.

ص	ژ	ڑ	ذ	ث
پھ	بھ	ظ	ط	ض
دھ	چھ	جھ	ٹھ	تھ
گھ	کھ	ڑھ	رھ	ڈھ
		نھ	مھ	لھ

Figure 5.2: Remaining 23 Alphabet Letters of Urdu Language

Figure 5.3: Alphabet/Words Learning in 3D Learning Environment (A snapshot)

The major features of the 3D learning environment are; 1) multi-user environment support, 2) written alphabet letters and words in phase I and phase II respectively, 3) 3D metaphors for each alphabet letter/word, 4) audio support, 5) voice-chat channels, 6) avatar as learners' representative. These features have potential to exploit different intelligences of the learners. Table 3.3 shows each feature of the provided 3D learning environment along with the possible intelligences they can influence.

An assessment scenario follows each of the learning scenarios to evaluate the learners' learning gain. Assessment scenarios offer multiple choice questions in pictorial form. During assessment, a picture is presented to a learner, and he/she is required to select (by clicking through mouse) correct alphabet letter or word that defines the presented picture in assessment test (see Figure 5.4).

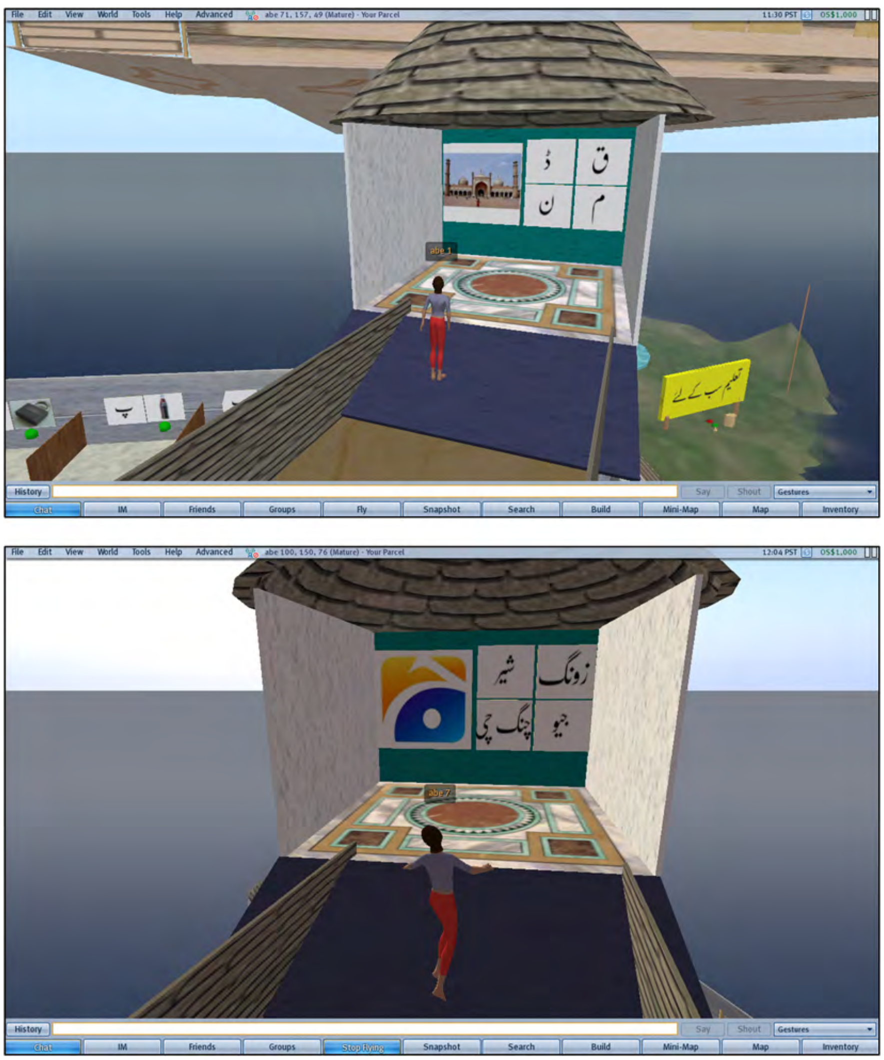

Figure 5.4: Alphabet/Words Assessment in 3D Learning Environment (A snapshot)

5.5.3 2D Learning Environment

The other technology-based medium selected for instruction delivery is a web-based 2D application. A learning environment for the adult learners of basic education is developed using web-based client-server environment, it also offers two learning scenarios for two different phases. The first phase offers alphabet letters learning and the second phase offers commonly used words learning as shown in Figure 5.5.

Figure 5.5: Alphabet/Words Learning in 2D Learning Environment (A snapshot)

The 2D web-based learning environment offers features such as; 1) written alphabet letters and words in phase I and phase II respectively, 2) 2D metaphors for each alphabet letter/word, 3) audio support, 4) voice-chat channels. In contrast to 3D learning environment, it does not offer multi-users environment and avatars for the learners. The intelligences of learners it influence are described in Table 3.4 along with the major features it offers.

Similarly, an assessment scenario follows each of the learning scenarios to evaluate the learners' learning gain. Assessment scenarios offer multiple choice questions in pictorial form. During assessment, a picture is presented to a learner, and he/she is required to select (by clicking through mouse) correct alphabet letter or word that defines the presented picture in 2D web-based environment (see Figure 5.6).

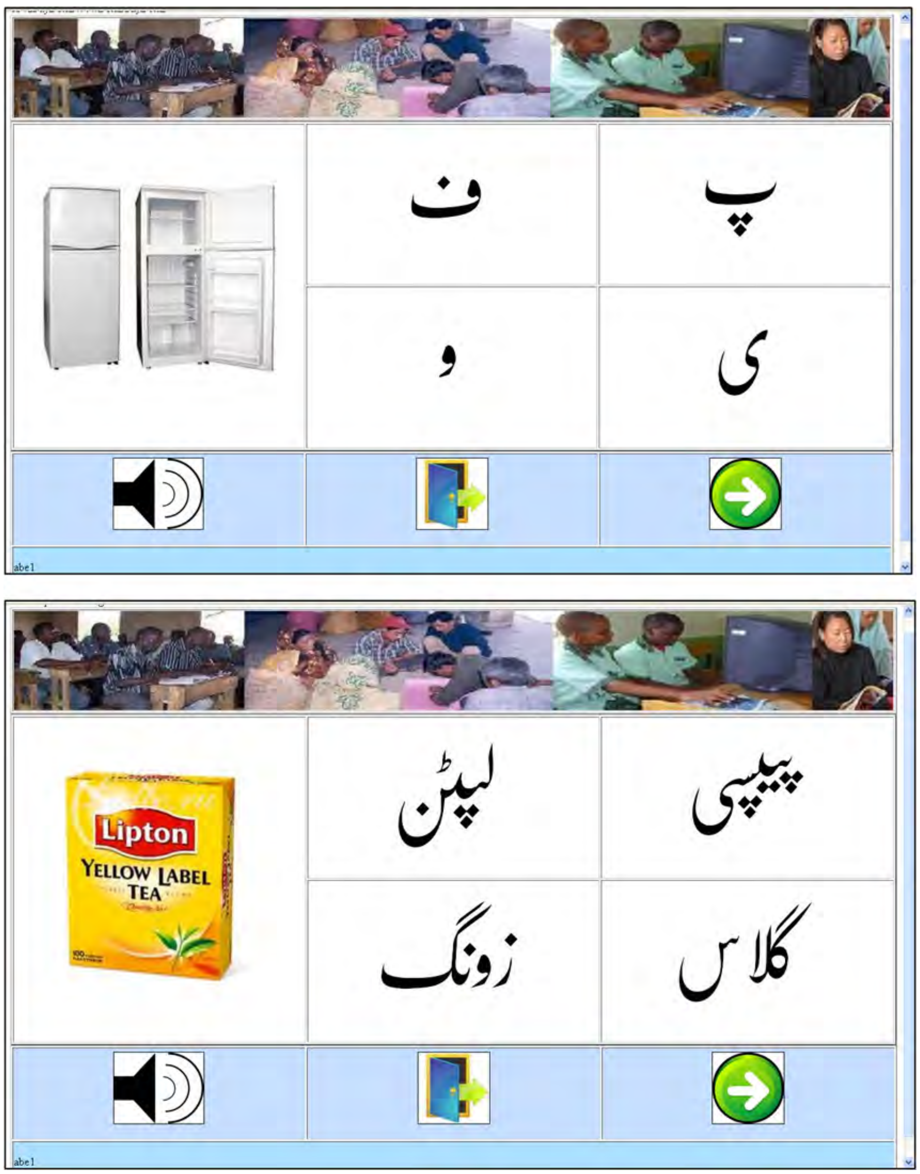

Figure 5.6: Alphabet/Words Assessment in 2D Learning Environment (A snapshot)

5.6 Assessment Instruments

Four instruments are used for the assessment of learners. A multiple intelligences (MI) inventory survey to determine the intelligences of the learners. A questionnaire to measure user satisfaction, behavioral intention and effectiveness of provided learning environments. Two other assessment instruments are designed and used to determine academic achievement before and after using the provided learning environments. The following subsections describe these instruments in detail.

5.6.1 Multiple Intelligences Inventory Survey

Like the learning style inventories, various MI inventories are developed to measure different intelligences of a person. Some are classified for children (Mckenzie, 2005), and many other are used for adolescent or older persons (Businessballs, 2011; LiteracyWorks, 2011b; Shearer, 1999). One of the earlier MI inventories that also endorsed by Gardner (Gardner, 1996) is a Multiple Intelligences Development Assessment (MIDAS) (Shearer, 1999). The MIDAS has been exploited by numerous studies and proved to be consistent and reliable (Kelly, 2005; Shearer, 1999). It consists of 119 questions rated on a 5-point Likert scale (Shearer, 1999). Similarly, other MI inventories consist of a set of questions to measure each of the intelligence, and answer against each question is rated on 5-point Likert scale. Thus the essence of all the inventories is same; however questions are rephrased according to suitability of the target audience. For the investigation of learners' intelligences, in this research English version of MI inventory used by Kim (Kim, 2009) is exploited. It was originally developed in Korean, and modified from the existing MI inventories (Armstrong, 1999; Christison, 1998). The reason for the selection is based on cultural aspects. Gardner extends it and says, "It is the culture that defines the stages and fixes the limits of individual achievement" (Gardner, 1983). As the selected MI inventory has already been used in studies in Asia, the research team preferred to use it (as it appears to be more close in cultural aspects). In the selected MI inventory, questionnaire consists of ten sections, and each section has eight questions. It is modified to exclude Naturalist intelligence because it is not included in the study. The questionnaire we finally used, consist of ten sections and each section has seven questions (one question for each intelligence). The learners are expected to answer each question on 5-point Likert scale; 1 (Strongly Disagree), 2 (Disagree), 3 (Undecided), 4 (Agree), 5 (Strongly Agree). For complete questionnaire of MI inventory see Appendix B.

In order to calculate the strength of a particular intelligence of a learner, for instance linguistic intelligences, Likert scale responses from 1-5 against each question of linguistic intelligence from all ten sections are selected and median of all ten responses is calculated. A learner with median higher than other learners in a particular intelligence is considered stronger in that intelligence. Moreover to calculate the combined strength in all seven intelligences for a particular learner, median of medians of all the seven intelligences is calculated that represents her combined strength in all intelligences.

5.6.2 Learning Gain Assessment Test

To find the improvement difference between post-test and pre-test score, a learning gain assessment is designed. The first learning gain assessment test intended to be conducted after alphabet learning phase. It consists of 28 questions (one question for each alphabet letter). The second learning gain assessment test planned to be conducted after words learning phase. It contains 27 questions (one question for each word). In each test, each question carries one score, thus on each correct response learner is awarded one score. At the end of each phase, complete score (sum of all scores against correct answers) of each learner is calculated. Each learning gain assessment test, first exhibited through learning environments (computer assisted), and secondly through traditional or manual approach by the principle investigator of the study.

The computer-assisted assessment test offers four alphabet letters (for alphabet letters assessment, after the first phase) or words (for words assessment, after the second phase) along with a metaphor. The learners are expected to select one correct answer (alphabet in case of the first phase, and word in case of the second phase) that best describes the metaphor presented in the question. Both 2D and 3D learning environments exhibit same tests, only the style of presentation varies in both environments (see Figures 5.6 and 5.4). Both learning environments, on each correct answer award a score to the learner and keep track of total score of each learner.

The manual part of the assessment test is designed to avoid the rapid-guessing. It consists of recognition and pronunciation of alphabet letter (after the first phase), and words (after the second phase). In the recognition part, an alphabet letter or a word is pronounced before the learners and a list of all alphabet letters or words is showed, and they are expected to choose the pronounced alphabet letter or word. In the pronunciation part, an alphabet letter (after first phase) or word (after second phase) is showed to the learner and they are expected to pronounce it. The pronunciation part avoids the probability of rapid-guessing. Same scoring approach is used in manual assessment test as well.

5.6.3 Questionnaire to Investigate Learners' Satisfaction, Behavioral Intention, and Effectiveness of Learning Environment

In order to investigate the learners' satisfaction, behavioral intention and effectiveness of 2D and 3D learning environments, a questionnaire designed by Liaw (Liaw, 2008) is used. This questionnaire was originally designed to determine the learner's satisfaction, behavioral intention and effectiveness of e-learning. It covers eight different dimension such as, 1) Perceived self-efficacy, 2) Perceived satisfaction, 3) Perceived usefulness, 4) Behavioral intention, 5) e-learning system quality, 6) Interactive learning activities, 7) e-learning effectiveness, and 8) Multimedia instructions. There are different numbers of questions regarding each dimension, and this questionnaire includes 26 questions in total. In order to exclude the learners' opinion about the internet, one question from the dimension of "e-learning system quality" is excluded because the focus of the research is not to consider the internet as quality parameter of the provided learning environment. Thus, 25 questions are considered in this research and each question is rephrased such that the term "e-learning" is replaced with "2D learning environment" in the questionnaire designed for the learners who worked in 2D learning environment and with "3D learning environment" in the other questionnaire designed for the learners who worked in 3D learning environment. See Appendix C for both questionnaires.

The learners are expected to response against each question on 5-point Likert scale; 1 (Strongly Disagree), 2 (Disagree), 3 (Undecided), 4 (Agree), 5 (Strongly Agree). In order to calculate a learner's response regarding a particular dimension, median of all the responses against all questions regarding that dimension is calculated. For instance, a learner with median greater than other learners in a particular dimension such as behavioral intention shows that the learner is more inclined to use the learning environment in future than other learners.

5.6.4 Grapheme Test

Participant screening is performed through Grapheme test. It ensures that whether the person is really an illiterate or not. Grapheme test includes two parts, recognition and pronunciation of alphabet letters of Urdu. During recognition process the moderator of study pronounces an alphabet letter and the learner is asked to recognize that alphabet letter from the list of 28 alphabet letters. In pronunciation phase, a learner is asked to pronounce all alphabet letters sequentially. A threshold of three alphabet letters was set; those who recognized or pronounced only three or less alphabet letter were considered as illiterate and included in the study. See Grapheme test in Appendix E.

5.7 Reliability and Validity of Assessment Instruments

Reliability of a test is concerned with its consistency that leads toward the precision where as validity of test describes accuracy of a test. When a test is perfectly valid, it is assumed reliable as well, however reverse is not true (Sanam, 2009). Two major assessment instruments, MI inventory and questionnaire to investigate learners' satisfaction, behavioral intention and effectiveness of 2D and 3D learning environments are adopted and used. Their validity is well established from research studies (Kim, 2009; Liaw, 2008). For the internal consistency to ensure reliability, Cronbach's alpha is most widely used approach, adopted in this research. The Cronbach's alpha measures internal consistency based on the average inter-item correlation (Malhotra, 2007; Malhotra and Peterson, 2008). The Coefficient alpha varies between 0 and 1, and value of 0.6 or less normally indicates poor internal consistency.

The Cronbach's alpha of the overall MI inventory was 0.84. For each intelligence, the value of Cronbach's alpha was greater than 0.6: linguistic-verbal (0.75), logical-mathematical (0.73), visual-spatial (0.94), musical (0.91), bodily-kinesthetic (0.79), interpersonal (0.88), and the intrapersonal (0.83). The Cronbach's alpha of the original questionnaire used to investigate the learners' satisfaction, behavioral intention and effectiveness of e-learning was reported 0.97 in (Liaw 2008). For this research it was calculated again and overall value for the Cronbach's alpha was 0.82. For all eight dimensions the Cronbach's alpha was not less than 0.6: Perceived self-efficacy (0.88), Perceived satisfaction (0.82), Perceived usefulness (0.73), Behavioral intention (0.79), learning environments quality (0.77), Interactive learning activities (0.69), learning environments effectiveness (0.92), and Multimedia instructions (0.96).

Both academia based evaluation instruments, the Grapheme test and the Learning Gain assessment test are well scrutinized by the classified curriculum for ABE in Pakistan and have strong accordance with the examination style exhibited in Pakistan (Ahmad, 1995; EEF, 2007; Nabi, 2006; Starfish-Karachi, 2011).

5.8 Procedure

Conducting this research study appeared to be more critical. The research team had to face various issues such as decision of location, mobilizing the people, technical resources, staff for assistance and many others. Keeping in view the fact of digital divide and majority of illiterates in developing countries that is 98% of illiterates worldwide (Wagner and Kozma, 2003). Moreover, as 51% of all illiterates are in South and West

Asia and majority of them are females that become 64% of this illiterate community (Wagner and Kozma, 2003), consequently these figures motivated the research team to target most deprive region of South and West Asia. As principal investigator (author of the thesis) of the research team belongs to Pakistan, one of the countries from South Asia. Thus a small town (Hassan Abdal) of Pakistan is selected to carry out the research study and females are decided to be intended participants of the study.

The next big challenge was to mobilize the illiterate persons to join the research study. The principal investigator contacted different schools in the selected town and got response from an Elementary level school to assist in this concern. After the meeting with the head of school, a plan to mobilize the illiterate persons was decided. Following the plan, an invitation letter (written in the national language Urdu) was designed and forwarded through the female teachers of the school to all houses of the community where the school was located. Although the written invitation was not worthy for this campaign because illiterates cannot read it at all, so the teachers motivated the women in face to face meeting to join this computer-assisted ABE program or at least appear in orientation ceremony of this program. However written invitation appeared to be effective to communicate the message to the literate persons in their families. On orientation day, around seventy illiterate women came in the school. It proved that mobilizing campaign was quite promising, although the research team could spend only two weeks on it. Every woman was either the mother or aunt/ grandmother/elder sister of the students who were already studying in this school. The head of school first described the purpose of the study and later on introduced the principal investigator of the research study and let him explain all the details. After describing the purpose, invitees were asked (those who are interested) to register themselves within next two days to join the study. On the last day of registration at closing time, the final strength of registered participants was 40 (see Appendix G for virtual tour of the study).

The next step was to establish classrooms for the study. The head of the school allowed the research team to use two rooms. In one room eight computers were set with full multimedia and local area network support. The other room was reserved to conduct the interviews and a blackboard was placed to at least explain some concept through traditional approach.

One day before the commencement of first session, all the 40 participants were invited and their Grapheme test was conducted. The principal investigator done this step by himself, to ensure the absolute illiterates in the study and finally 32 participants were selected. Due to limitation of resources (only two classrooms and eight computers) four sessions were designed, each consists of eight students. Different time slots were allocated to each session considering their feasibility and schedule of the day. Thus everyday every session had to come in one slot of ninety minutes. As this program was consist of 15 days, each participant got 22.5 hours of computer-assisted education. To provide assistance to the principal investigator, two female teachers in each slot were nominated by the head of school.

All the previously described data collection instruments such as, MI inventory survey, questionnaire to investigate the learners' satisfaction, behavioral intention and effectiveness of provided learning environments, and personal information are completed through interviews because the selected participant were absolute illiterate. In order to seek the correct information from the participant and to ensure original qualitative approach, the principal investigator preferred to be in close contact with the participants, and performed all the observations and conducted all the interviews by himself.

The following subsections explain how different steps are carried out and how instructional material, technology and assessment instruments are exploited in the research (For a quick overview see Figure 5.7).

5.8.1 Preliminary Phase

During the preliminary phase, first of all screening of all forty registered participants was performed through Urdu Grapheme test and finally 32 participants were selected. Later on, personal information about each participant was collected using a set of questionnaire. This step is preceded by MI inventory survey through which the stronger and weaker intelligence of all the participants are calculated.

5.8.2 First Phase

The selected 32 participants were divided into two groups, each consist of 16 participants (see Figure 5.7). However while developing the groups; a special care was taken to randomly select the participants irrespective of their stronger and weaker intelligences to overcome the issue of biasness. As the people who are stronger in a particular intelligence feels more comfortable to learn when material is presented in some specific way and vice versa. For instance, people with stronger visual-spatial intelligence are more capable to learn when material presented in pictorial form and people with musical intelligence feels more comfortable when the material presented in melodies and rhythms. Consequently, explicit selection of a participant (with some specific intelligence either stronger or weaker) for a specific learning environment is avoided to overcome the said biasness. One of these groups was named Pure3D that is an experimental group and other was named Pure2D that was a control group. Above mentioned first two sessions made up the Pure2D group who were planned to be taught through 2D learning environment, whereas second two sessions made up the Pure3D group those who were planned to be taught through 3D learning environment.

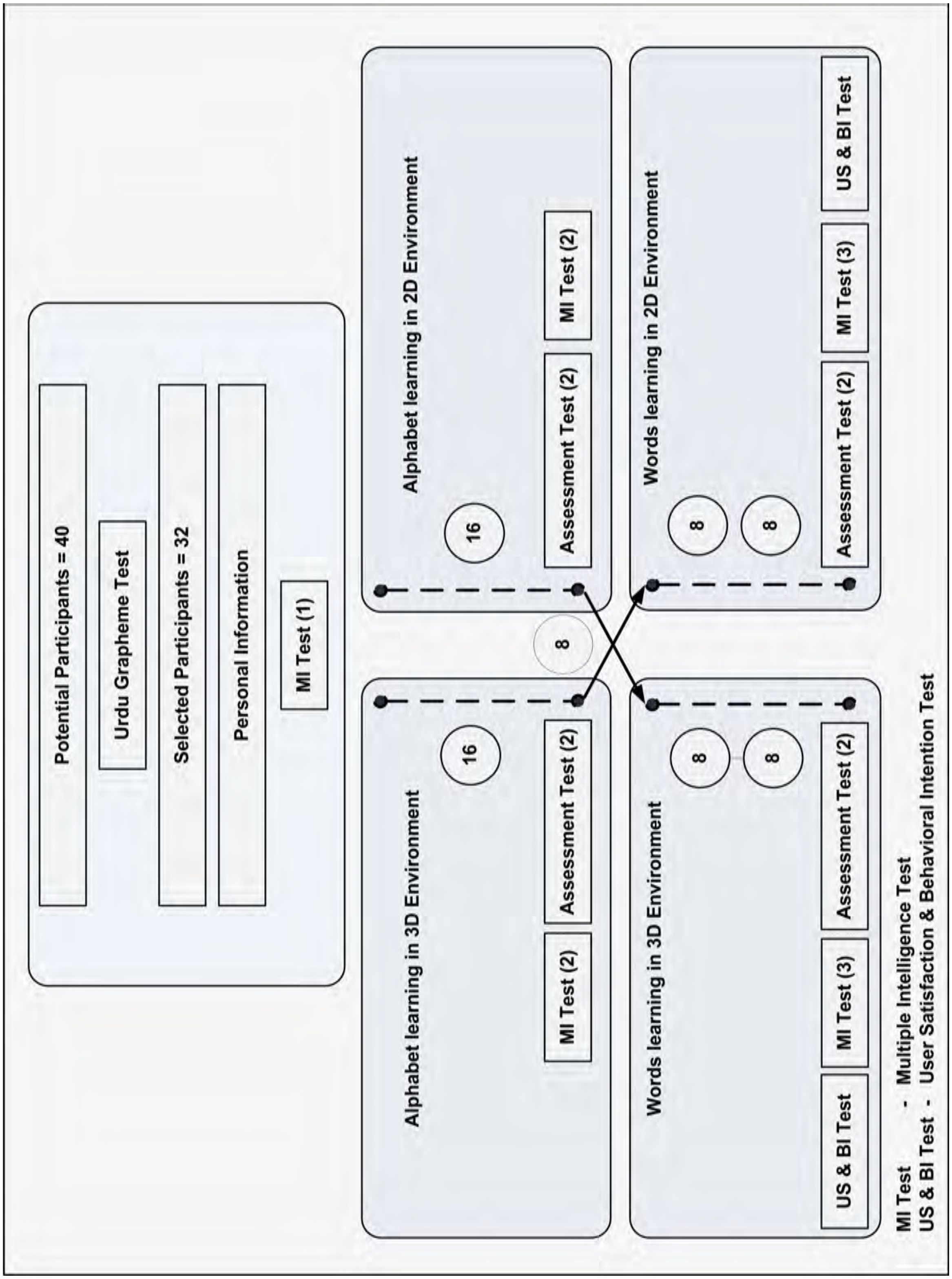

Figure 5.7: A Pictorial Representation of Adopted Procedure and All Steps

During the first phase, Urdu alphabet letters were taught to the learners (or participants, later on will be used interchangeably). Two different computer-assisted alphabet learning environments were used. The Pure3D group was taught through 3D learning environment and Pure2D group was taught through 2D learning environment. Before starting the session, only 15 minutes demonstration was given to each group about the use of each environment, because the main purpose was to experience computer-assisted self-directed learning instead of traditional approach. However principal investigator and the school staff for their assistance were present in each session to help them in case of problems such as, turning-on computers, running 2D and 3D learning environments, navigation through environment or other unforeseen technical issues. Two shortcuts of each environment were placed on the computers' desktop; the learners were directed to double click on the shortcuts to run the desired environment. All the learners in both environments were allowed to repeatedly use the learning environments, as many times as they want. Once both groups completed the learning contents in the first phase, a computer-assisted assessment test was conducted. However they were not explicitly informed that, it is a kind of examination, they were informed that computer will asked you what you have learned so far, and you need to response each question. At the end of assessment, both environments let the learner know what were their mistakes through signs of tick, and cross against each correct and incorrect answer respectively. There was provision of repetition for assessment as well. Each environment tracked their all correct and incorrect answers and the time spent on each question. Five days were spent in the first phase.

At the end of first phase, manual learning gain assessment test was conducted and responses of both Pure3D and Pure2D groups were noted and scored. Also the MI inventory survey for both Pure3D and Pure2D groups was conducted to determine the change in their intelligences through different learning environments.

5.8.3 Second Phase

In the second phase, commonly used Urdu words and nouns were taught to the learners. Two different computer-assisted learning environments were also used in this phase. In order to investigate real effects of both learning environments on the multiple intelligences and learning gain of the learners, few changes were introduced in Pure3D and Pure2D groups. Half of the participants (8 participants) from Pure3D group were randomly selected and in second phase they were planned to be taught through 2D learning environment. This group was named Hybrid3D2D (hybrid because they were taught alphabet letters through 3D learning environment and words through 2D learning environment). The rest of eight participants in Pure3D group were taught words, again through 3D learning environment and this group is called Pure3D. Similarly, half of the participants (8 participants) from Pure2D group were randomly selected and in second phase they were planned to be taught through 3D learning environment. This group was named Hybrid2D3D (hybrid because they were taught alphabet letters through 2D learning environment and words through 3D learning environment). The remaining eight participants in Pure2D were taught words, again through 2D learning environment and this group is named Pure2D. Thus two groups Pure3D and Hybrid2D3D (eight participants in each group and sixteen in total) were taught words through 3D learning environment; whereas other two groups Pure2D and Hybrid3D2D (eight participants in each group and sixteen in total) were taught words through 2D learning environment.

Before starting the session, again 15 minutes demonstration was given to each group about the use of each environment. Two shortcuts of each environment were placed on the computers' desktop; the learners were directed to double click on the shortcuts to run the desired environment. However principal investigator and the school staff for their assistance were present in each session to assist them. All the learners in both environments were allowed to repeatedly use the learning environments, as many times as they want. Once both groups completed the learning contents in the second phase, a computer-assisted assessment test was conducted. However they were not explicitly informed that, it is a kind of examination, they were informed that computer will asked you what you have learned so far, and you need to response each question. At the end of assessment, both environments let the learner know what were their mistakes through signs of tick, and cross against each correct and incorrect answer respectively. There was provision of repetition for assessment as well. Each environment tracked their all correct and incorrect answers and the time spent on each question. The words learning phase took ten day to complete.

At the end of second phase, manual learning gain assessment test was conducted and responses of participants of four groups, Pure3D, Hybrid2D3D, Pure2D and Hybrid3D2D were noted and scored. Also the MI inventory survey of all four groups was conducted to determine the change in their intelligences through different learning environments.

Finally, to investigate the learners' satisfaction, behavioral intention and effectiveness of each 2D learning environment and 3D learning environment, data was collected using questionnaires. The learners of Pure2D group who were only taught through 2D learning environment were interviewed against a questionnaire designed for 2D environment only. Similarly, the learners of Pure3D group who were only taught through 3D learning environment were interviewed against another questionnaire designed for 3D environment. However the learners who were taught through both 2D and 3D learning environments (Hybrid3D2D and Hybrid2D3D groups) were interviewed against both questionnaires designed for 2D and 3D environments.

5.9 Data Analysis: Parametric and Nonparametric Techniques

During the research study four types of data sets were collected. The first data-set includes multiple intelligences information that was collected using the MI inventory survey. The second data-set consists of information about learner's satisfaction, behavioral intention and effectiveness of exploited learning environments. The third data-set contains assessment score of the learners. Finally the fourth data-set comprises of demographic information regarding learners participated in the study. The first two data sets are ordinal in nature as collected on 5-point Likert scale. The third data-set includes assessment score that is purely an interval data. The last data-set however comprises of nominal data as it includes demographic information.

The decision of considering Likert scale data as interval or ordinal is a critical, and opens up a great debate. It is the nature of data (interval or ordinal) that decides the analysis techniques, whether it should be parametric (in case of interval data) or nonparametric (in case of ordinal data). Thus, the first concern is about the decision of nature of Likert scale data and the second concern is regarding the justification of statistical analysis technique.

In these concerns William and his colleagues clearly describe that the ordinal data expressed using integer never justify the use of parametric analysis (William et al., 1996). Moreover, operations such as sum and differences are inappropriate on rating scale data (Svensson, 2001). It shows that the data on 5-point Likert scale although expressed in integer format but it is not meant to be treated as an interval data, because on Likert scale average of "fair" and "good" is not possible to be expressed as "fair-and-half", and this is even true when "fair" and "good" are expressed through integers (Jamieson, 2004). Also the behavior of Likert data often shows skewed or polarized distribution (Jamieson, 2004), and when data exhibit such a behavior and sample size is small ($N<50$) it is recommended to be considered as ordinal data and analyzed through nonparametric technique (Kaptein et al., 2010; William et al., 1996). On the other hand, when the sample size is enough and the data exhibits normal distribution, it qualifies for interval data and consequently for parametric tests (William et al., 1996). These studies well establish the nature of Likert scale data as ordinal data.

Furthermore, Kaptein and his colleagues performed a survey on proceeding of CHI 2009 (Kaptein et al., 2010). They describe that 45% of all the published papers used

Likert scale in their researches. Out of these articles 80.6% used parametric approach for analysis where as only 8.3% used nonparametric approach. However, one of the seven deadly sins of the statistical analysis described by William and his colleagues is to use parametric analysis approach for the ordinal data (William et al., 1996). Kaptein and his colleagues also recommended nonparametric approach for the Likert scale analysis, especially when the sample size is small (N<50).

Thus for the statistical analysis on the first two data sets (in which data is collected through Likert scale) the nonparametric approach is qualified, due to small sample size, non-normal distribution of data and ordinal nature of Likert scale data recommended by the studies discussed above. For the third data-set, as it consists of interval data the parametric analysis technique is used. All of the nonparametric and parametric tests are performed using SPSS 19. Friedman Test (an alternative of one-way ANOVA) is performed to determine the differences between groups of first data set. The Mann-Whitney U test is used to compare difference between two groups in the second data set. Finally, as the data set three includes interval data, independent-sample t-test and paired-sample t-test are applied to compare the means of two independent and dependent groups respectively.

6

Research Findings

This chapter presents the results of analyzed data sets associated with each of the research questions. Also few important parameters from the demographic profile of the learners are selected and their influence on learners' learning gain and satisfaction regarding two provided learning environments is analyzed. The following sections describe the results of assessment score of the learners in two dimensional (2D) and three dimensional (3D) learning environments, effects of 2D and 3D learning environments on the learners' intelligences, correlation between assessment score and quotients of different multiple intelligences, and comparison of the learners' satisfaction, behavioral intention and effectiveness of 2D and 3D learning environments.

6.1 Comparison of Assessment Score

The results were analyzed to compare the effect of two different learning environments (2D and 3D) on the assessment scores of the learners. The assessment scores after alphabet-learning and words-learning of four different groups (Pure2D, Pure3D, Hybrid2D3D, and Hybrid3D2D) designed in the study, were analyzed to investigate whether the learners' assessment scores were higher in 2D learning environment or in 3D learning environment. During this analysis the data-set three was exploited.

6.1.1 Pure3D Group Vs Pure2D Group after Alphabet Learning

The assessment scores of Pure2D and Pure3D groups were analyzed after the alphabet learning, to investigate the difference in learning gain between 2D and 3D learning environments. It was expected that the learners in Pure3D group would score higher than the learners in Pure2D group as 3D learning environment offers immersive learning environment.

An independent t-test was conducted to compare the means of assessment scores of both Pure3D and Pure2D groups after the alphabet-learning. The results showed that the mean score of Pure3D group (M=21.093, SD=8.59) was greater than the

Table 6.1: Mean of Alphabet Assessment Scores - Pure3D Group Vs Pure2D Group

Alphabet Learning	**Groups**	**N**	**Mean**	**Equality of Variances**		**t-test for Equality of Means**	
	Pure3D	16	21.093	F	p-value	t	p-value (2-tailed)
	Pure2D	16	14.750	7.306	0.011	2.441	.022

Table 6.2: Mean of Words Assessment Scores - Pure3D Group Vs Pure2D Group

Words Learning	**Groups**	**N**	**Mean**	**Equality of Variances**		**t-test for Equality of Means**	
	Pure3D	8	22.187	F	p-value	t	p-value (2-tailed)
	Pure2D	8	13.375	-8.81	0.022	-2.2	0.045

mean score of Pure2D group (M=14.75, SD=5.84). The analysis revealed statistical significant difference (at the $p<0.05$) between the assessment scores of Pure2D and Pure3D groups as shown in Table 6.1. The results suggest that the learners achieve higher learning performance when presented with 3D learning environment.

6.1.2 Pure3D Group Vs Pure2D Group after Words Learning

Similarly, to investigate the difference between the assessment scores of Pure2D and Pure3D groups after the words-learning, the assessment scores of Pure2D and Pure3D groups were analyzed. Expectations were same as in the alphabet assessment analysis that the Pure3D group who were taught through 3D learning environment would show better performance than the Pure2D group. An independent t-test was conducted to compare the means of assessment scores of both Pure3D and Pure2D groups after the words-learning. The analysis showed significant difference between Pure3D and Pure2D groups. The t-test indicated that the mean score of Pure3D group (M=22.18, SD=9.41) was greater than the mean score of Pure2D group (M=13.37, SD=6.34). The assessment scores of both groups, after the words-learning are shown in Table 6.2.

On evaluating the assessment scores of Pure3D and Pure2D groups, the results from alphabet assessment score and words assessment score exhibit the same pattern where the learners who were taught through 3D learning environment (the Pure3D Group) showed better performance than those who were taught through 2D learning environment (the Pure2D Group).

Table 6.3: Learner's Interest in All Groups towards 2D and 3D Learning Environments

Learners' interest in Learning Environments (in Percentage)		
Groups	**3D**	**2D**
Pure3D	75.00	25.00
Pure2D	68.75	31.25
Hybrid2D3D	75.00	25.00
Hybrid3D2D	62.50	37.50

Table 6.4: Mean of Words Assessment Scores - Pure3D Group Vs Hybrid2D3D Group

Words Learning	**Groups**	**N**	**Mean**	**Equality of Variances**		**t-test for Equality of Means**	
	Pure3D	8	22.18	F	p-value	t	p-value (2-tailed)
	Hybrid2D3D	8	24.12	9.48	0.008	-0.560	0.591

6.1.3 Pure3D Group Vs Hybrid2D3D Group after Words Learning

In order to further scrutinize the trend of greater assessment score of Pure3D group than Pure2D group in the case of both alphabet and words learning, an analysis on the assessment scores of Pure3D and Hybrid2D3D groups after the words-learning was performed. As the Pure3D group was taught alphabet and words both through 3D learning environment, and the Hybrid2D3D group was taught alphabet through 2D learning environment and words through 3D learning environment, it was expected that the results of assessment scores of both Pure3D and Hybrid2D3D groups should have no difference.

An independent t-test was conducted to compare the means of assessment scores of both Pure3D and Hybrid2D3D groups after the words-learning. As expected, there was no significant difference (at the $p<0.05$) found in the assessment scores of both Pure3D and Hybrid2D3D groups as shown in Table 6.4. The t-test showed that, the mean of assessment score of Pure3D group was ($M=22.18$, $SD=9.41$), and of Hybrid2D3D group was ($M=24.12$, $SD=2.66$).

To further drill down the results and to find the reasons of this no significant difference, qualitative information is exploited along with the quantitative data. After the study, it was determined from Hybrid2D3D group through interviews which environment they like most. The qualitative information showed that 75% of the learners from Hybrid2D3D group wanted to be taught through 3D learning environment and only 25% were satisfied with 2D learning environment. Coincidently, in Pure3D group,

Table 6.5: Paired Samples Statistics within Hybrid2D3D Group

Division of Hybrid2D3D Groups	Mean	N	Std. Deviation	Std. Error Mean
Alphabet Learning in 2D	16.500	8	6.419	2.260
Words Learning in 3D	24.125	8	2.669	0.940

Table 6.6: Mean of Assessment Scores of Hybrid2D3D Group- Alphabet-learning in 2D Vs Words-learning in 3D

Hybrid2D3D	Paired Differences					t	df	p-value (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Alphabet Learning(2D)- Words Learning (3D)	-7.625	7.543	2.667	-13.931	-1.318	-2.859	7	0.024

same percentage of the learners (75%) was interested in 3D learning environment, and only 25% learners voted 2D learning environment as shown in Table 6.3. These figures from qualitative data well establish the reasons for no significant difference between Pure3D and Hybrid2D3D groups.

Moreover, if the learners in Hybrid2D3D group were more interested in 3D learning environment, then it can be inferred that the assessment score of these learners when they were taught alphabet in 2D learning environment must be poor than their score of words-learning in 3D learning environment. In order to investigate this aspect, a paired t-test was conducted to compare the means of assessment scores after the alphabet-learning when they were taught through 2D learning environment and words-learning when they were taught through 3D learning environment for the learners of same Hybrid2D3D group. The results showed that there was a significant difference in the mean values of assessment scores at the $p<0.05$ as shown in Table 6.5 and Table 6.6. The mean of assessment score after the words-learning in 3D learning environment ($M=24.12$, $SD=2.66$) was greater than the mean of assessment score after the alphabet-learning in 2D learning environment ($M=16.5$, $SD=6.41$). These results support the previously calculated results that the learners achieve higher learning performance when presented with 3D learning environment.

Table 6.7: Mean of Words Assessment Scores - Pure2D Group Vs Hybrid3D2D Group

	Groups	**N**	**Mean**	**Equality of Variances**		**t-test for Equality of Means**	
Words Learning	Pure2D	8	13.375	F	p-value	t	p-value (2-tailed)
	Hybrid3D2D	8	13.375	0.125	0.484	0.04	0.968

Table 6.8: Paired Samples Statistics within Hybrid3D2D Group

Division of Hybrid3D2D Groups	**Mean**	**N**	**Std. Deviation**	**Std. Error Mean**
Alphabet Learning in 3D	17.937	8	9.473	3.349
Words Learning in 2D	13.375	8	6.306	2.229

6.1.4 Pure2D Group Vs Hybrid3D2D Group after Words Learning

To investigate the trend that the assessment score of Pure3D group always appear greater than the assessment score of Pure2D group in the case of both alphabet and words learning, an analysis on the assessment scores of Pure2D and Hybrid3D2D groups after the words-learning was performed. As the Pure2D group was taught alphabet and words both through 2D learning environment, and the Hybrid3D2D group was taught alphabet through 3D learning environment and words through 2D learning environment, it was expected that the results of assessment scores of both Pure2D and Hybrid3D2D groups should have no difference.

An independent t-test was conducted to compare the means of assessment scores of both Pure2D and Hybrid3D2D groups after the words-learning. As expected, there was no significant difference (at the $p<0.05$) found in the assessment scores of both Pure2D and Hybrid3D2D groups as shown in Table 6.7. The t-test showed that, the mean of assessment score of Pure2D was (M=13.37, SD=6.48), and for Hybrid3D2D was (M=13.37, SD=6.30).

To find out the reasons of this no significant difference qualitative information is exploited along with the quantitative data. After the study, it was determined from Hybrid3D2D group through interviews which environment they like most. The qualitative information showed that 62.5% of the learners from Hybrid3D2D group wanted to be taught through 3D learning environment and only 37.25% were satisfied with 2D learning environment. In Pure2D group 68.75% of the learners were interested in 3D learning environment, and only 31.25% learners voted 2D learning environment as shown in Table 6.3. These figures from qualitative data well establish the reasons for no significant difference between Pure2D and Hybrid3D2D groups.

However, if the learners in Hybrid3D2D group were more interested in 3D learning

Table 6.9: Mean of Assessment Scores of Hybrid3D2D Group - Alphabet-learning in 3D Vs Words-learning in 2D

Hybrid3D2D	Paired Differences					t	df	p-value (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Alphabet Learning(3D)-Words Learning (2D)	4.562	9.021	3.189	-2.979	12.104	1.430	7	0.196

environment, then it can be inferred that the assessment score of these learners when they were taught alphabet in 3D learning environment must be better than their score of words-learning in 2D learning environment. In order to investigate this aspect, a paired t-test was conducted to compare the means of assessment scores after the alphabet-learning when they were taught through 3D learning environment and words-learning when they were taught through 2D learning environment for the learners of same Hybrid3D2D group. Although the mean of assessment score after the alphabet-learning in 3D learning environment (M=17.93, SD=9.47) was greater than the mean of assessment score after the words-learning in 2D learning environment (M=13.37, SD=6.30) but the result were not significant at the $p<0.05$ as shown in Table 6.8 and Table 6.9. As the mean of assessment score after the alphabet-learning in 3D learning environment is greater than the mean of assessment score after the words-learning in 2D learning environment, it can be inferred from the results that the significant difference can be achieved with larger sample size because there exists the same trend where the learners achieve higher learning performance when presented with 3D learning environment.

6.1.5 Age-wise Comparison of Assessment Score between 3D and 2D Learning Environments

When assessment scores in two different environments were evaluated on the continuum of age of learners very interesting findings revealed. In the case of assessment score after the alphabet-learning, the learner from age group (25-34) scored higher in 3D learning environment than 2D learning environment. Also the score of learners from age group (35-44) was observed higher in 3D learning environment as compared to 2D learning environment. However the learners from age group 45 and above have higher score in 2D learning environment than 3D learning environment as shown in Figure 6.1. In

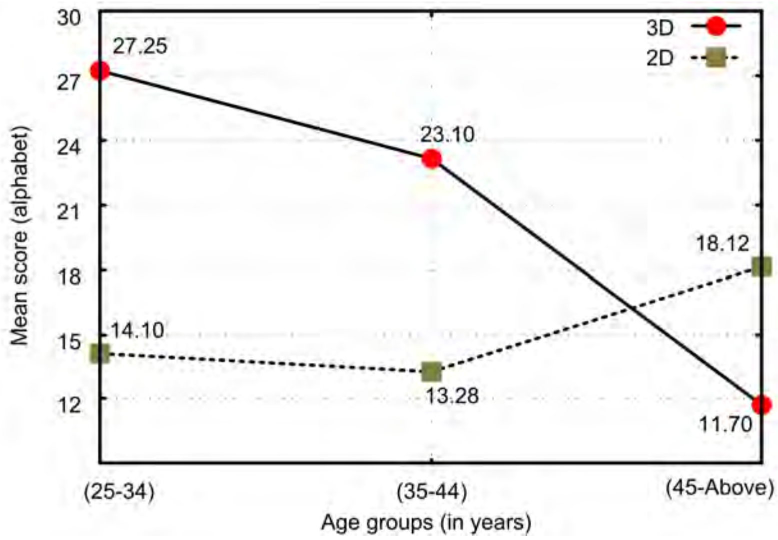

Figure 6.1: Age-wise Comparison of Alphabet Assessment Score between two Learning Environments

the case of score after the words-learning, same pattern was observed that the learners from age groups (25-34) and (35-44) have higher score in 3D learning environment than 2D learning environment, whereas the learners from age group 45 and above scored higher in 2D learning environment as compared to 3D learning environment as shown in Figure 6.2.

6.2 Final Observations about Assessment Score

The results from analysis on the assessment scores of the learners showed that the learners who were taught through 3D learning environment have greater score than the learners who were taught through 2D learning environment. As the same learning content are presented in both learning environments, only the medium of presentation was different thus it is concluded that 3D learning environment is more helping for adult learners in their adult basic education (ABE) programs than 2D learning environment. The results also revealed that learners from age group (25-44) performed better in 3D learning environment as compared to 2D learning environment, whereas learners from age group 45 and above showed better performance in 2D learning environment. These findings answer the second research question, and foster to investigate that why the learners who were taught through 3D environment performed better, is there some relationship of multiple intelligences with likeliness of 3D environment and good performance. These investigations are carried out in the next section.

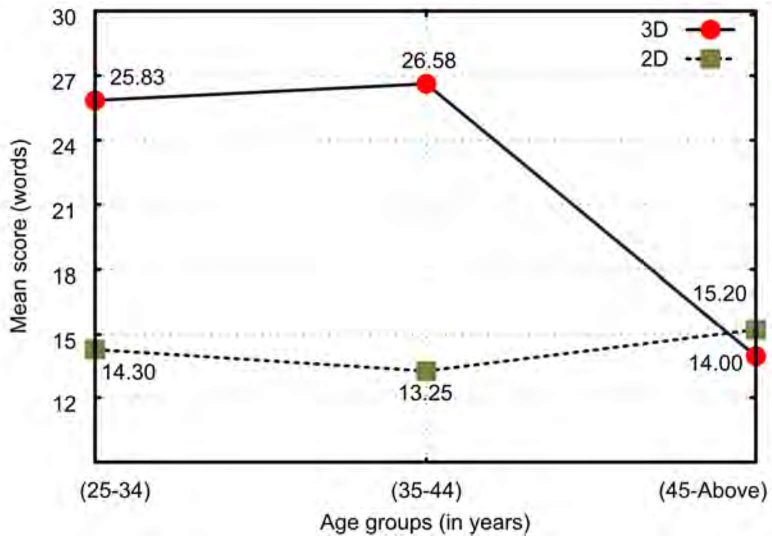

Figure 6.2: Age-wise Comparison of Words Assessment Score between two Learning Environments

Table 6.10: Holistic View of Quotients of Combined Intelligences

All Learners (N=32)	Type of Intelligences	Mean Rank (Friedman Test)			p-value
		Before ALI	After ALI (Phase I)	After ALI (Phase II)	
	MI-Combined	1.52	2.02	2.47	<0.00

6.3 Holistic View of Multiple Intelligences Trends

To investigate the impact of provided 2D and 3D learning environments on the intelligences of adult learners, the first data-set collected through Multiple Intelligences (MI) inventory at three different points, before Adult Literacy Instructions (ALI), after the first phase, and finally after the second phase is exploited. This section describes holistic view of the multiple intelligences of the learners at above mentioned three time points irrespective of their grouping.

Table 6.11: Seven Intelligences with abbreviations

Sr. No.	Intelligences	Abbreviations
1	Linguistic-Verbal	LV
2	Visual-Spatial	VS
3	Musical	MU
4	Logical-Mathematical	LM
5	Bodily-Kinesthetic	BK
6	Interpersonal	IRP
7	Intrapersonal	IAP

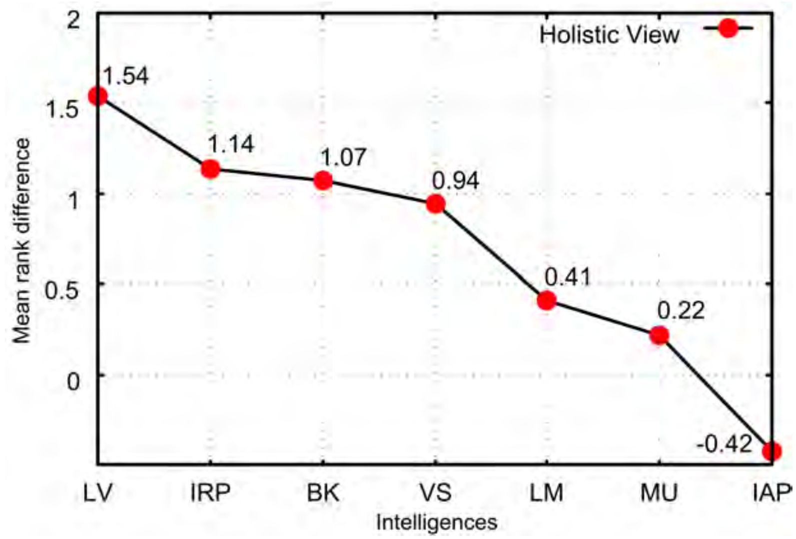

Figure 6.3: Order of Intelligences based on Mean Rank Difference (Holistic View)

A Friedman test was conducted to compare the measures of multiple intelligences of all the learners on three different occasions. It was expected that the education through 2D and 3D learning environments will influence the learners' intelligences. The results from the test showed that there was a statistically significant difference between the mean ranks of the measures of combined intelligences at three points as shown in Table 6.10. In order to find the influence of 2D and 3D learning environments on each of the intelligences (see Table 6.11 for all Intelligences along with their abbreviations used in the rest of thesis) of the learners, the Friedman tests were conducted again. There was a significant difference (at the $p<0.05$) in each of the multiple intelligences at three different time points as shown in Table 6.12. The mean rank differences before ALI and after the second phase of ALI exhibit the order of intelligences from most influenced to least influenced intelligences as: linguistic-verbal, interpersonal, bodily-kinesthetic, visual-spatial, logical-mathematical, musical and intrapersonal as shown in Figure 6.3. The change in each of the intelligences irrespective of the consideration of two different environments also shows that technology enhanced learning environments have potential to influence the intelligences of adult learners.

In the holistic view, however few surprising results appeared as shown in Table 6.12, the logical-mathematical intelligence also increased albeit there was no treatment of this intelligence in both of the learning environments. Also the increase in the musical intelligence appeared to be significant in the holist view, although a partial treatment was available for the musical intelligences in provided environments.

Table 6.12: Holistic View of Quotients of All Intelligences

N=32 Sr. No	Types of Intelligences	Mean Rank (Friedman Test)			p-value
		Before ALI	After ALI (Phase I)	After ALI (Phase II)	
1	Linguistic-Verbal	1.27	1.92	2.81	<0.000
2	Visual-Spatial	1.53	2.00	2.47	<0.000
3	Musical	1.83	2.13	2.05	<0.021
4	Logical-Mathematical	1.75	2.09	2.16	<0.001
5	Bodily-Kinesthetic	1.45	2.03	2.52	<0.000
6	Interpersonal	1.34	2.17	2.48	<0.000
7	Intrapersonal	2.22	1.98	1.80	<0.002

6.4 Comparison of MI Trends

To find out the reasons of the uncertain observations discussed in the holistic view and to investigate the role of each 2D and 3D environments in this increasing trend of MI quotients, MI trends in each of the groups (Pure2D, Pure3D, Hybrid2D3D and Hybrid3D2D) after 2D and 3D education are further evaluated in this section.

6.4.1 Pure2D and Pure3D Groups

After the holistic view of MI trends, further analysis of each of the learning groups appeared to be crucial. In this section impact of 2D learning environment and 3D learning environment on the quotients of intelligences of each learner in Pure2D and Pure3D groups is evaluated. Before starting adult literacy instructions the quotients of multiple intelligences of both groups are shown in Figure 6.4.

A series of Friedman tests was conducted to find the differences in the quotients of multiple intelligences of the learners in the Pure2D group at three different time points in 2D learning environment. There were significant differences in the quotients of linguistic-verbal, visual-spatial, bodily-kinesthetic and interpersonal intelligences, however no differences were found in the quotients of musical, logical-mathematical and intrapersonal intelligences at three different time points as shown in Table 6.13.

The uncertain findings such as increase in quotients of logical-mathematical and musical intelligences revealed in the holistic view did not appear to be significant in Pure2D group in these results as were expected. However increase in quotient of bodily-kinesthetic is associated with the interactive activities (such as using interface, mouse) being performed by the learners during the learning at alphabet-learning and words-learning in 2D learning environment, and this change is also noticed and discussed by McKenzie in his study (Mckenzie, 2005). Although there was no explicit treatment

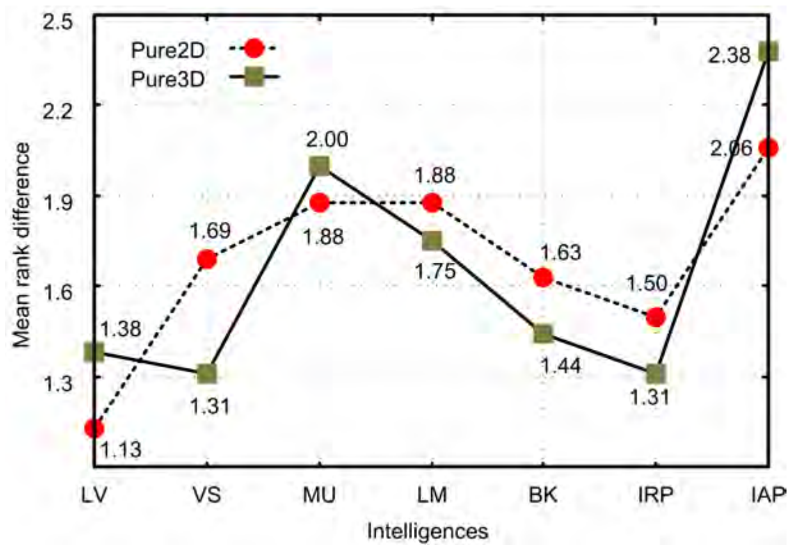

Figure 6.4: Comparison of Quotients of All Intelligences between Pure2D and Pure3D Groups Before ALI (based on Mean Rank Differencce)

Table 6.13: Quotients of All Intelligences in Pure2D Group

N=8 Sr. No	Types of Intelligences	Mean Rank (Friedman Test) Before ALI	After ALI (Phase I)	After ALI (Phase II)	p-value
1	Linguistic-Verbal	1.13	2.00	2.88	<0.001
2	Visual-Spatial	1.69	1.69	2.63	<0.007
3	Musical	1.88	2.06	2.06	<0.368
4	Logical-Mathematical	1.88	2.00	2.13	<0.368
5	Bodily-Kinesthetic	1.63	1.75	2.63	<0.009
6	Interpersonal	1.50	2.00	2.50	<0.018
7	Intrapersonal	2.06	2.06	1.88	<0.607
8	Combined	1.50	2.00	2.50	<0.018

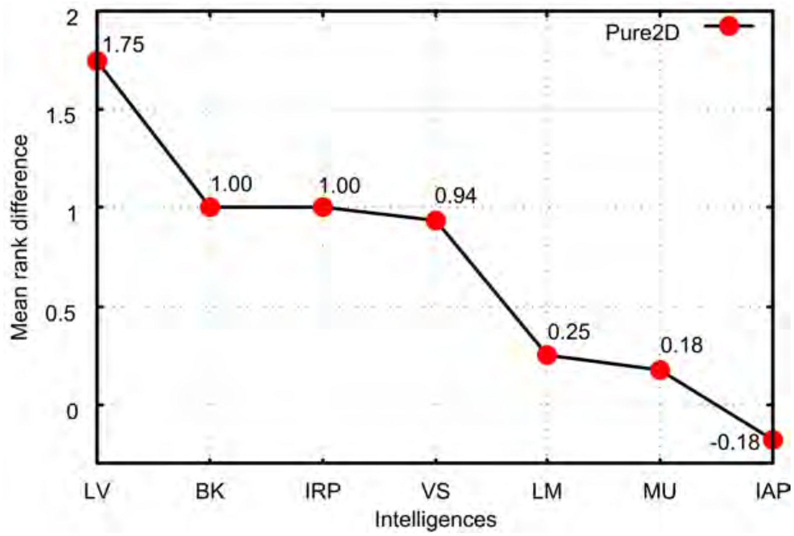

Figure 6.5: Order of Intelligences in Pure2D Group (based on Mean Rank Difference)

Table 6.14: Quotients of All Intelligences in Pure3D Group

N=8	Types of Intelligences	Mean Rank (Friedman Test)			p-value
Sr. No		Before ALI	After ALI (Phase I)	After ALI (Phase II)	
1	Linguistic-Verbal	1.38	1.75	2.88	<0.002
2	Visual-Spatial	1.31	2.25	2.44	<0.006
3	Musical	2.00	2.00	2.00	<1.00
4	Logical-Mathematical	1.75	2.13	2.13	<0.135
5	Bodily-Kinesthetic	1.44	2.06	2.50	<0.014
6	Interpersonal	1.31	2.00	2.69	<0.004
7	Intrapersonal	2.38	2.00	1.63	<0.050
8	Combined	1.56	2.06	2.38	<0.037

for intrapersonal intelligence in the 2D learning environment, but it should has been increased after having lesson in computer-assisted 2D learning environment because of the fact of self-directed learning. However the decrease in the quotient of intrapersonal may be because of collaborative sessions in the study among learners. On the basis of mean rank difference, order of most influenced to least influenced intelligences after having lessons in 2D learning environment is shown Figure 6.5.

Similarly, a series of Friedman tests was conducted to find the differences in the quotients of multiple intelligences of the learners in the Pure3D group at three different time points in 3D learning environment. Significant differences found in the quotients of linguistic-verbal, visual-spatial, bodily-kinesthetic and interpersonal intelligences, however no differences were appeared in the quotients of musical, logical-mathematical and intrapersonal intelligences at three different time points as shown in Table 6.14.

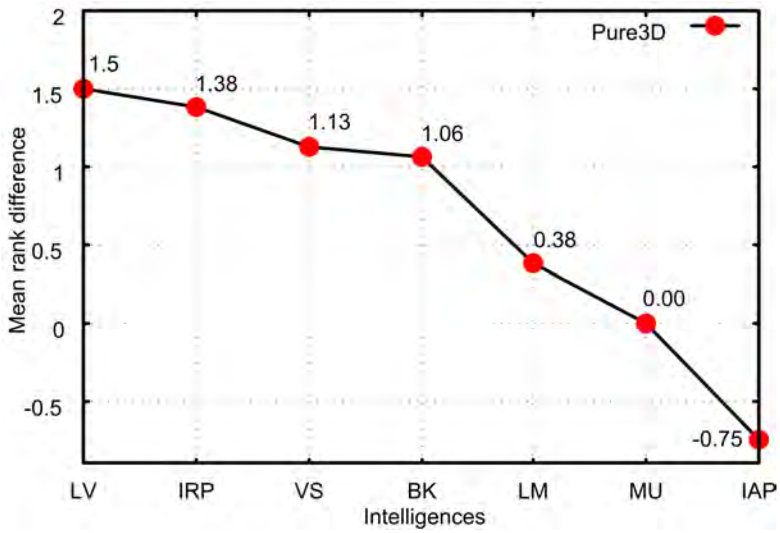

Figure 6.6: Order of Intelligences in Pure3D Group (based on Mean Rank Difference)

Moreover, the uncertain findings such as increase in quotients of logical-mathematical and musical intelligences revealed in the holistic view did not appear to be significant also in Pure3D group in these results, as were expected. Although there was no explicit treatment for intrapersonal intelligence in the 3D learning environment, but it should has been increased after having lesson in computer-assisted 3D learning environment because of the fact of self-directed learning. However the decrease in the quotient of intrapersonal may be because of collaborative sessions in the study among learners. On the basis of mean rank difference, order of most influenced to least influenced intelligences after having lessons in 3D learning environment is shown in Figure 6.6.

The results after the tests revealed that, in 2D learning environment the order of influenced intelligences (from most to the least) is different from the order of influenced intelligences in 3D learning environment. The 2D learning environment influenced the intelligences of the learners in Pure2D group (from most to the least improvement) as: linguistic-verbal, bodily-kinesthetic, interpersonal, visual-spatial, logical-mathematical, musical and intrapersonal. On the other hand, the 3D learning environments influenced the intelligences of the learners in Pure3D group in following order: linguistic-verbal, interpersonal, visual-spatial, bodily-kinesthetic, logical-mathematical, musical and intrapersonal.

Further analysis on the mean ranks from Pure2D and Pure3D groups revealed the following facts (see Figure 6.7): 1) significant improvement appeared in four types of intelligences of the learners in both 2D and 3D learning environments - linguistic-verbal, visual-spatial, bodily-kinesthetic and interpersonal, 2) the 2D learning environment influenced only liguistic-verbal intelligence more than 3D learning environment because the improvement in liguistic-verbal in 2D learning environment was greater than 3D

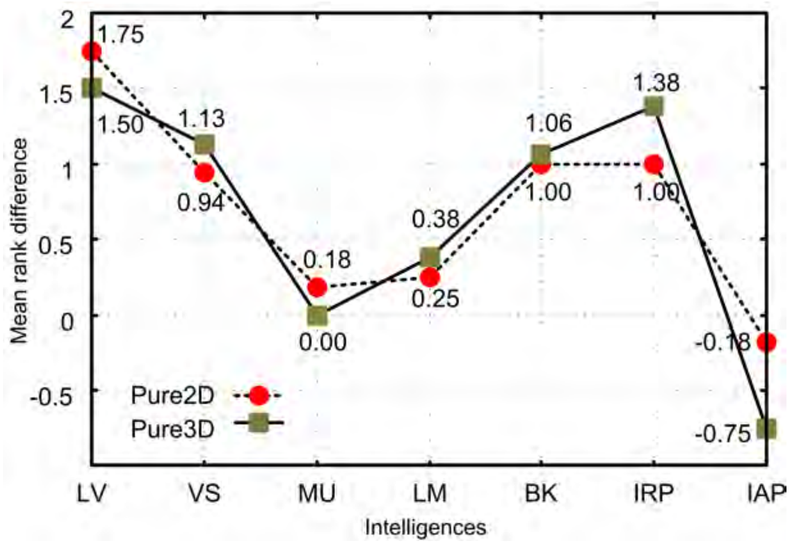

Figure 6.7: Comparison of Quotients of All Intelligences between Pure2D and Pure3D Groups After ALI (based on Mean Rank Difference)

learning environment, 3) the 3D learning environment influenced visual-spatial, bodily-kinesthetic and interpersonal intelligences more than the 2D learning environment because mean ranks of these intelligences were greater in 3D learning environment as compared to 2D learning environment.

6.4.2 Hybrid2D3D and Hybrid3D2D Groups

As discussed in the last section Pure2D group was taught both alphabet letters and words in 2D learning environment and Pure3D group was taught both alphabet letters and words in 3D learning environment. Accordingly the impact of these learning environments was examined on the multiple intelligences of the learners in each group respectively. In order to scrutinize previously evaluated results, impact of both 2D and 3D learning environments on the multiple intelligences of the learners in Hybrid2D3D and Hybrid3D2D groups was further examined. The Hybrid2D3D group was taught alphabet in 2D learning environment and words in 3D learning environment whereas Hybrid3D2D was taught alphabet in 3D learning environment and words in 2D learning environment. Before starting adult literacy instructions the quotients of multiple intelligences of both groups are shown in Figure 6.8.

A series of Friedman tests was conducted to find the differences in the quotients of multiple intelligences of the learners in the Hybrid2D3D group at three different time points (before adult literacy instructions, after the alphabet-learning in 2D learning environment and after the words-learning in 3D learning environment). There were significant differences (at the $p<0.05$) in quotients of linguistic-verbal, visual-spatial, and

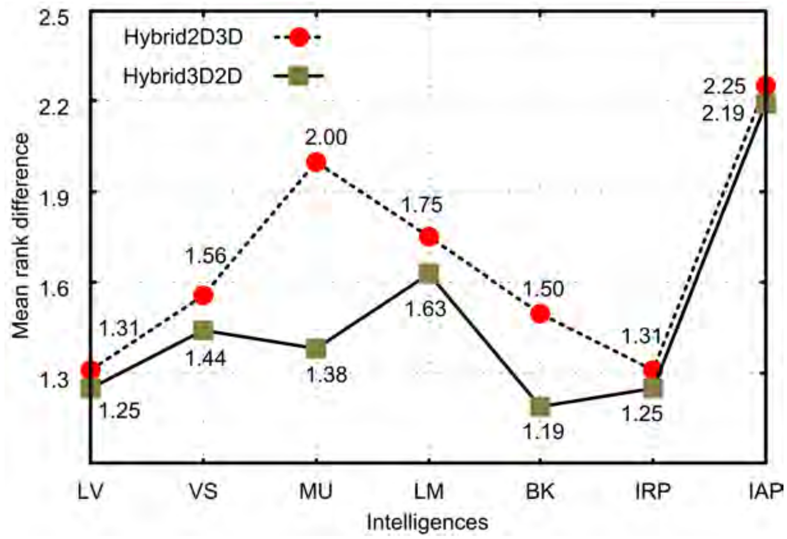

Figure 6.8: Comparison of Quotients of All Intelligences between Hybrid2D3D and Hybrid3D2D Groups Before ALI (based on Mean Rank Differencce)

Table 6.15: Quotients of All Intelligences in Hybrid2D3D Group

N=8 Sr. No	Types of Intelligences	Mean Rank (Friedman Test) Before ALI	After ALI (2D) (Phase I)	After ALI (3D) (Phase II)	p-value
1	Linguistic-Verbal	1.31	2.13	2.56	<0.006
2	Visual-Spatial	1.56	1.56	2.88	<0.018
3	Musical	2.00	2.00	2.00	<1.000
4	Logical-Mathematical	1.75	2.13	2.13	<0.135
5	Bodily-Kinesthetic	1.50	1.69	2.81	<0.223
6	Interpersonal	1.31	2.00	2.69	<0.004
7	Intrapersonal	2.25	1.88	1.88	<0.135
8	Combined	1.56	1.75	2.69	<0.025

interpersonal intelligences, however no differences were found in the quotients of musical, logical-mathematical, bodily-kinesthetic and intrapersonal intelligences as shown in Table 6.15.

Although in 2D learning environment there was treatment for linguistic-verbal, visual-spatial, and interpersonal whereas in 3D learning environment there was an extra treatment for bodily-kinesthetic, but these two environments could influence linguistic-verbal, visual-spatial, and interpersonal intelligences of the learner in Hybrid2D3D group at the significant level p<0.0.5. Also the unexpected significant difference in logical-mathematical and musical intelligences appeared in holistic trends of multiple intelligences was suppressed here because there was no treatment for logical-mathematical intelligence in the both learning environments. Although there was a

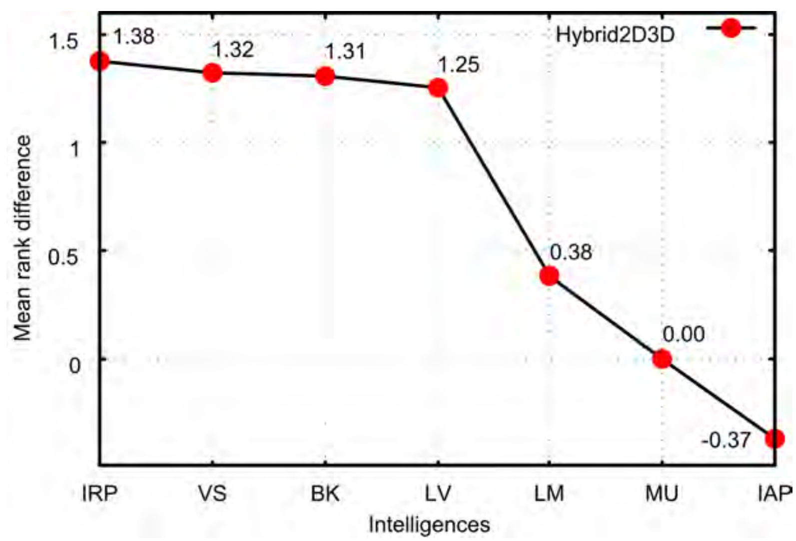

Figure 6.9: Order of Intelligences in Hybrid2D3D Group (based on Mean Rank Difference)

little support for musical intelligence but could not show significant difference. On the basis of mean rank difference, order of most influenced to least influenced intelligences of the learners after having lessons in 2D and 3D learning environments is shown Figure 6.9.

As the Hybrid2D3D group was taught in two different learning environments such that alphabet-learning in 2D learning environment and words-learning in 3D learning environment. It was important to analyze the differences in intelligences after the alphabet-learning in 2D environment and after the words-learning in 3D learning environment. In order to achieve it, pair-wise comparisons were performed using the Wilcoxon signed rank test for each of the intelligences. Results from the test showed that, 1) statistically significant difference was found in linguistic-verbal intelligence after the alphabet-learning in 2D learning environment with p= 0.038, however difference was not significant after the words-learning in 3D learning environment with p= 0.109, 2), also significant difference was found in visual-spatial intelligence after the words-learning in 3D learning environment with p= 0.014, however difference was not significant after the alphabet-learning in 2D learning environment with p= 1.0 ,3) significant difference was found in bodily-kinesthetic intelligence after the words-learning in 3D learning environment with p= 0.027, however difference was not significant after the alphabet-learning in 2D learning environment with p= 0.317, 4) also significant difference was found in case of interpersonal intelligence after the alphabet-learning in 2D learning environment with p=0.038 and after the words-learning in 3D learning environment with p=0.038. However statistically no significant difference was found in case of other intelligences both after the alphabet-learning in 2D learning environment and words-learning in 3D learning environment. For the descriptive statistics and results

Table 6.16: Descriptive Statistics of Hybrid2D3D Group

Intelligences	N	Median
Linguistic-Verbal (Before ALI)	8	3.25
Linguistic-Verbal (After ALI-2D)	8	4.00
Linguistic-Verbal (Before ALI-3D)	8	4.00
Visual-Spatial (Before ALI)	8	4.00
Visual-Spatial (Before ALI-2D)	8	4.00
Visual-Spatial (Before ALI-3D)	8	4.00
Musical (Before ALI)	8	3.00
Musical (Before ALI-2D)	8	2.50
Musical (Before ALI-3D)	8	2.50
Logical-Mathematical (Before ALI)	8	2.00
Logical-Mathematical (Before ALI-2D)	8	2.00
Logical-Mathematical (Before ALI-3D)	8	2.00
Bodily-Kinesthetic (Before ALI)	8	2.75
Bodily-Kinesthetic (Before ALI-2D)	8	2.75
Bodily-Kinesthetic (Before ALI-3D)	8	4.50
Interpersonal (Before ALI)	8	3.00
Interpersonal (Before ALI-2D)	8	3.00
Interpersonal (Before ALI-3D)	8	3.50
Intrapersonal (Before ALI)	8	3.00
Intrapersonal (Before ALI-2D)	8	2.50
Intrapersonal (Before ALI-3D)	8	2.50

from the Wilcoxon test see Table 6.16 and Table 6.17 respectively.

It shows that 2D learning environment could influence four types of intelligences which are linguistic-verbal, visual-spatial, bodily-kinesthetic, and interpersonal in Pure2D group (discussed in last section) whereas 2D learning environment for alphabet-learning in hybrid group could improve only two intelligences which are linguistic-verbal and interpersonal in Hybrid2D3D group as shown in Table 6.21 (when Wilcoxon test applied).

Further investigation was performed to find the impact of 2D and 3D learning environment on the multiple intelligences of the learners in Hybrid3D2D. The Friedman tests were conducted to find the differences in the quotients of multiple intelligences of the learners in the Hybrid3D2D group at three different time points (before adult literacy instructions, after the alphabet-learning in 3D learning environment and after the words-learning in 2D learning environment). The results showed that the significant differences (at the $p<0.05$) were found in linguistic-verbal, visual-spatial, musical, bodily-kinesthetic, and interpersonal intelligences. However no differences were found in the rest of two intelligences. For detailed results from the Friedman tests see Table 6.18.

Table 6.17: Pair-wise Difference in Hbyrid2D3D Group

Intelligences (Pair-wise)	**z-test**	**p-value**
Linguistic-Verbal (Before ALI)-Linguistic-Verbal (After ALI-2D)	-2.070	0.038
Linguistic-Verbal (After ALI-2D)-Linguistic-Verbal (After-ALI-3D)	-1.604	0.109
Visual-Spatial (Before ALI)-Visual-Spatial (After ALI-2D)	0.000	1.000
Visual-Spatial (After ALI-2D)-Visual-Spatial (After-ALI-3D)	-2.460	0.014
Musical (Before ALI)-Musical (After ALI-2D)	-0.447	0.655
Musical (After ALI-2D)-Musical (After-ALI-3D)	0.000	1.000
Logical-Mathematical (Before ALI)-Logical-Mathematical (After ALI-2D)	-1.414	0.157
Logical-Mathematical (After ALI-2D)-Logical-Mathematical (After-ALI-3D)	0.000	1.000
Bodily-Kinesthetic (Before ALI)-Bodily-Kinesthetic (After ALI-2D)	-1.000	0.317
Bodily-Kinesthetic (After ALI-2D)-Bodily-Kinesthetic (After-ALI-3D)	-2.214	0.027
Interpersonal(Before ALI)- Interpersonal (After ALI-2D)	-2.070	0.038
Interpersonal (After ALI-2D)- Interpersonal (After-ALI-3D)	-2.070	0.038
Intrapersonal(Before ALI)- Intrapersonal (After ALI-2D)	-1.342	0.180
Intrapersonal (After ALI-2D)- Intrapersonal (After-ALI-3D)	0.000	1.000

Table 6.18: Quotients of All Intelligences in Hybrid3D2D Group

N=8	**Types of**	**Mean Rank (Friedman Test)**			**p-value**
Sr. No	**Intelligences**	**Before ALI**	**After ALI (3D) (Phase I)**	**After ALI (2D) (Phase II)**	
1	Linguistic-Verbal	1.25	1.81	2.94	<0.001
2	Visual-Spatial	1.44	2.56	2.00	<0.011
3	Musical	1.38	2.56	2.06	<0.008
4	Logical-Mathematical	1.63	2.13	2.25	<0.061
5	Bodily-Kinesthetic	1.19	2.56	2.25	<0.002
6	Interpersonal	1.25	2.44	2.31	<0.007
7	Intrapersonal	2.19	2.00	1.81	<0.223
8	Combined	1.38	2.25	2.38	<0.015

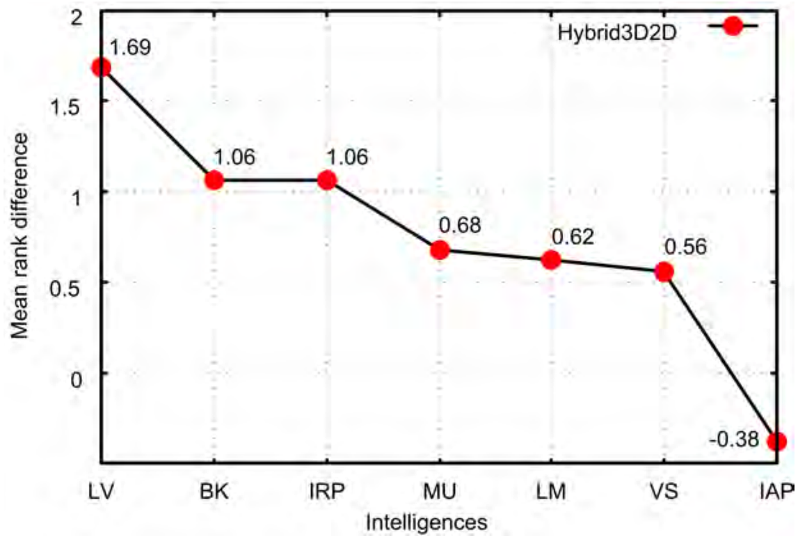

Figure 6.10: Order of Intelligences in Hybrid3D2D Group (based on Mean Rank Difference)

Thus these two environments influenced linguistic-verbal, visual-spatial, musical, bodily-kinesthetic and interpersonal intelligences of the learner in Hybrid3D2D group at the significant level p<0.0.5. A significant difference appeared in musical intelligence might be because of the partial treatment of musical intelligence, however this time no difference was found in logical-mathematical intelligence. On the basis of mean rank difference, order of most influenced to least influenced intelligences of the learners of Hybrid3D2D group after having lessons in 3D and 2D learning environments is shown Figure 6.10.

The Hybrid3D2D group was taught in two different learning environments such that alphabet-learning in 3D learning environment and words-learning in 2D learning environment. It was important to analyze the difference after the alphabet-learning in 3D environment and after the words-learning in 2D learning environment. In order to achieve it, pair-wise comparisons were performed using the Wilcoxon signed rank test for each of the intelligences. The results revealed that, 1) statistically significant difference was found in linguistic-verbal intelligence after the words-learning in 2D learning environment with p=0.017, however no difference was appeared in this intelligences after the alphabet-learning in 3D learning environment, 2) after the alphabet-learning in 3D learning environment the visual-spatial intelligence also showed significant difference with p=0.020, however there was no difference after the words-learning in 2D learning environment, 3) Similarly there was a significant difference in musical intelligence after the alphabet-learning in 3D learning environment with p=0.026, however no difference appeared after the words-learning in 2D learning environment, 4) after the alphabet-learning in 3D learning environment the bodily-kinesthetic intelligence also showed significant difference with p=0.011, however there was no difference af-

Table 6.19: Descriptive Statistics of Hybrid3D2D Group

Intelligences	**N**	**Median**
Linguistic-Verbal (Before ALI)	8	2.25
Linguistic-Verbal (After ALI-2D)	8	3.00
Linguistic-Verbal (Before ALI-3D)	8	4.00
Visual-Spatial (Before ALI)	8	4.00
Visual-Spatial (Before ALI-2D)	8	4.50
Visual-Spatial (Before ALI-3D)	8	4.00
Musical (Before ALI)	8	3.00
Musical (Before ALI-2D)	8	3.75
Musical (Before ALI-3D)	8	3.50
Logical-Mathematical (Before ALI)	8	1.00
Logical-Mathematical (Before ALI-2D)	8	1.25
Logical-Mathematical (Before ALI-3D)	8	1.25
Bodily-Kinesthetic (Before ALI)	8	3.00
Bodily-Kinesthetic (Before ALI-2D)	8	3.25
Bodily-Kinesthetic (Before ALI-3D)	8	3.25
Interpersonal (Before ALI)	8	3.25
Interpersonal (Before ALI-2D)	8	4.00
Interpersonal (Before ALI-3D)	8	4.00
Intrapersonal (Before ALI)	8	2.25
Intrapersonal (Before ALI-2D)	8	2.25
Intrapersonal (Before ALI-3D)	8	2.25

ter the words-learning in 2D learning environment, 5) Interpersonal intelligence also showed significant difference after the alphabet-learning in 3D learning environment with $p=0.024$, however no significant difference appeared after the words-learning in 2D learning environment. For the descriptive statistic see Table 6.19 and for Wilcoxon results see Table 6.20.

The results from Pure3D group reveal that 3D learning environment influenced four intelligences which are linguistic-verbal, visual-spatial, bodily-kinesthetic, and interpersonal whereas in case of Hybrid3D2D group, the 3D learning environment during alphabet learning influenced same three intelligences (visual-spatial, bodily-kinesthetic and interpersonal), and it also influenced musical intelligence, however it could not influence the linguistic-verbal intelligence (see Table 6.22).

6.5 Final Observations about MI Trends

The findings showed that when impact of 2D learning environment on the intelligences of Pure2D group was examined, the environment exhibited potential to influence four

Table 6.20: Pair-wise Difference in Hbyrid3D2D Group

Intelligences (Pair-wise)	**z-test**	**p-value**
Linguistic-Verbal (Before ALI)-Linguistic-Verbal (After ALI-3D)	-1.826	0.068
Linguistic-Verbal (After ALI-3D)-Linguistic-Verbal (After-ALI-2D)	-2.388	0.017
Visual-Spatial (Before ALI)-Visual-Spatial (After ALI-3D)	-2.333	0.020
Visual-Spatial (After ALI-3D)-Visual-Spatial (After-ALI-2D)	-1.732	0.083
Musical (Before ALI)-Musical (After ALI-3D)	-2.232	0.026
Musical (After ALI-3D)-Musical (After-ALI-2D)	-1.633	0.102
Logical-Mathematical (Before ALI)-Logical-Mathematical (After ALI-3D)	-1.633	0.102
Logical-Mathematical (After ALI-3D)-Logical-Mathematical (After-ALI-2D)	-1.000	0.317
Bodily-Kinesthetic (Before ALI)-Bodily-Kinesthetic (After ALI-3D)	-2.530	0.011
Bodily-Kinesthetic (After ALI-3D)-Bodily-Kinesthetic (After-ALI-2D)	-1.414	0.157
Interpersonal(Before ALI)- Interpersonal (After ALI-3D)	-2.251	0.024
Interpersonal (After ALI-3D)- Interpersonal (After-ALI-2D)	-0.577	0.564
Intrapersonal(Before ALI)- Intrapersonal (After ALI-3D)	-1.000	0.317
Intrapersonal (After ALI-3D)- Intrapersonal (After-ALI-2D)	-1.000	0.317

intelligences which are linguistic-verbal, visual-spatial, bodily-kinesthetic, and interpersonal. For counter check, impact of 2D learning environment on the multiple intelligences of Hybrid2D3D and Hybrid3D2D groups was also determined. The results showed that 2D learning environment could only influence two intelligences (linguistic-verbal and interpersonal) in Hybrid2D3D group and in Hybrid3D2D group this number reduced to single intelligence that is linguistic-verbal intelligence as described in Table 6.21. Summarizing the results regarding impact of the 2D learning environment on the intelligences of learners in Pure2D, Hybrid2D3D and Hybrid3D2D groups, there is an indicator that 2D learning environment consistently influenced the linguistic-verbal intelligence of the learners in all three groups, interpersonal intelligence was influenced in Pure2D and Hybrid2D3D groups, whereas visual-spatial and bodily-kinesthetic intelligences are influenced by 2D learning environment only in the case of Pure2D group. In 2D learning environment, there was treatment of linguistic-verbal, interpersonal and visual-spatial intelligences. Thus the results are quite confirming because linguistic-verbal is influenced in all three groups and interpersonal in at least two groups. In spite of the treatment available for visual-spatial in 2D learning environment it could only be influenced in one group, albeit the trends are there. The reason for the bodily-kinesthetic even without its treatment in 2D learning environment is associated with the interactive activities (such as using interface, mouse handling) being performed by the learners during the learning, and this fact has conformance with McKenzie's study (Mckenzie, 2005).

In the case of 3D learning environment when its impact on Pure3D group was ex-

Table 6.21: Comparison of Intelligences Influenced in 2D Learning Environment

Intelligences/ Groups	**LV**	**VS**	**MU**	**LM**	**BK**	**IRP**	**IAP**
Pure2D	Yes	Yes	No	No	Yes	Yes	No
Hybrid2D3D (2D)	Yes	No	No	No	No	Yes	No
Hybrid3D2D (2D)	Yes	No	No	No	No	No	No

Table 6.22: Comparison of Intelligences Influenced in 3D Learning Environment

Intelligences/ Groups	**LV**	**VS**	**MU**	**LM**	**BK**	**IRP**	**IAP**
Pure3D	Yes	Yes	No	No	Yes	Yes	No
Hybrid2D3D (3D)	No	Yes	No	No	Yes	Yes	No
Hybrid3D2D (3D)	No	Yes	Yes	No	Yes	Yes	No

amined, the results showed that the environment has potential to influence four intelligences which are linguistic-verbal, visual-spatial, bodily-kinesthetic, and interpersonal. For further analysis, impact of 3D learning environment on the multiple intelligences of Hybrid2D3D and Hybrid3D2D groups was also determined. The results revealed that 3D learning environment influenced three intelligences (visual-spatial, bodily-kinesthetic, and interpersonal) of learners in Hybrid2D3D group and in Hybrid3D2D it influenced again four intelligences which are visual-spatial, musical, bodily-kinesthetic, and interpersonal as shown in Table 6.22. Summarizing the results regarding impact of 3D learning environment on the intelligences of learners in Pure3D, Hybrid2D3D and Hybrid3D2D groups, there is an indicator that the 3D learning environment consistently influenced three intelligences 1) visual-spatial, 2) bodily-kinesthetic, and 3) interpersonal in all three groups, linguistic-verbal intelligence was influenced only in Pure3D group, whereas musical intelligence was influence by 3D learning environment only in the case of Hybrid3D2D group only. In 3D learning environment, there was support available to influence four types of intelligences, visual-spatial, bodily-kinesthetic, interpersonal, and linguistic-verbal. Also partial treatment for musical intelligence was available in the environment. The result also revealed the same trend because three of the intelligences (visual-spatial, bodily-kinesthetic, interpersonal) were influenced in all three groups. Although there was support for the linguistic-verbal intelligence however 3D learning environment could only influence that intelligence in Pure3D group.

Table 6.23: Correlation between Assessment Score and MI Quoutients

Groups	Environment	Phase	LV	VS	MU	LM	BK	IRP	IAP
Pure2D	2D	Alphabet	0.675	-0.711*	-0.736*	0.736*	-0.036	-0.033	0.129
	2D	Words	0.346	-0.902**	-0.603	0.541	-0.380	-0.118	-0.102
Pure3D	3D	Alphabet	-0.643	0.839**	0.663	-0.792*	0.603	0.283	-0.141
	3D	Words	-0.715*	0.990**	0.638	-0.800*	0.513	0.130	-0.289
Hybrid2D3D	2D	Alphabet	0.340	-0.675	0.522	-0.126	0.438	0.694	-0.500
	3D	Words	-0.299	0.245	0.574	-0.468	0.120	0.437	-0.572
Hybrid3D2D	3D	Alphabet	0.039	0.562	0.490	-0.429	0.720*	0.845**	-0.745*
	2D	Words	0.606	-0.127	-0.321	0.026	-0.025	0.468	-0.062

Spearman's rho
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

6.6 Correlation between Assessment Score and MI Quotients

Apart from investigating the impact of learning environment on multiple intelligences of the learners and on their learning assessment score, correlation between assessment score and intelligences of the learners in different groups (Pure2D, Pure3D, Hybrid2D3D and Hybrid3D2D) after alphabet-learning and after words-learning was examined. The Spearman's rho tests were applied on the first and third data sets. Before performing this analysis the data-set three was converted from the interval to the ordinal type. The correlation results for each of the groups are shown in Table 6.23 and are explained in the following subsections.

6.6.1 Pure2D and Pure3D Groups

In the case of Pure2D group the results showed that there was a strong, positive correlation between assessment score after the alphabet-learning and logical-mathematical intelligences which was statistically significant (rs = 0.736, p = 0.037). It shows that the learners who have higher assessment score after the alphabet-learning, their logical–mathematical intelligences are stronger. However for the visual-spatial and musical intelligences this correlation was found negative, and the results were significant for both visual-spatial (rs = -0.711, p = .048), and musical (rs = 0.736, p = .037) intelligences. Also for linguistic-verbal intelligence the results showed the trend of positive correlation but it was not statistically significant (rs = 0.675, p = 0.066). It shows that, this association can be significant with larger sample size because trend was there in results. Later on correlation between assessment score after the words-learning and all of the intelligences of learners in Pure2D group were examined , and results showed that there was strong, negative correlation between visual-spatial intelligence and assessment score after words learning (rs = -0.902, p = 0.002).

For the Pure3D group results showed that there was strong, positive correlation between visual-spatial intelligence and scores after the alphabet-learning and words-learning. The correlation results of visual-spatial intelligence were statistically significant both for assessment scores after the alphabet-learning (rs = 0.839, p = 0.009) and assessment score after the words-learning (rs = 0.990, p = .000). It clearly indicates that those who were stronger in visual-spatial intelligence also scored higher in 3D learning environment. However there was negative correlation found between logical-mathematical intelligences and assessment score after the alphabet-learning (rs = -0.792, p = 0.019) and assessment score after the words-learning (rs = -0.800, p = 0.017). This trend was opposite to the Pure2D group. Also negative correlation was found between linguistic-verbal and assessment score after the words-learning and result were significant (rs = -0.715, p = .046). Similar trend appeared for linguistic-verbal intelligence and assessment score after the alphabet-learning but results were not significant, however with larger sample size this correlation can be statistically significant according to the results (rs = -0.643, p = .086).

6.6.2 Hybrid2D3D and Hybrid3D2D Groups

In Hybrid2D3D group, surprisingly no strong correlation between intelligences and assessment scores after the alphabet-learning and words-learning either positive or negative was found. However trend (rs = -0.675, P = 0.066) shows that if the sample increases, strong negative correlation may appear between visual-spatial intelligence and assessment score after the alphabet-learning (through 2D learning environment).

In case of the Hybrid3D2D group the results showed that there was positive correlation between bodily-kinesthetic and assessment score after the alphabet-learning (in 3D learning environment), and it was statistically significant (rs = 0.720, P = .044). Also strong positive correlation was found between interpersonal intelligence and assessment score after the alphabet-learning (in 3D learning environment), the result were quite promising (rs = 0.845, P = .008). However negative correlation was found between assessment score after the alphabet-learning (in 3D learning environment) and intrapersonal intelligence with (rs = -0.745, P = .034).

6.7 Final Observations about Correlation

These results indicate that learners with dominant logical-mathematical intelligence have good assessment score whereas learners with dominant visual-spatial and musical intelligences have lower score in Pure2D group. In Pure3D group, positive correlation between visual-spatial and assessment score (both after alphabet and words learning) and negative correlation between logical-mathematical and assessment score (both after alphabet and words learning) are supporting the previous results revealed in case of the Pure2D group. Also the negative correlation between linguistic-verbal and assessment score (after words learning) indicates that learner with dominant linguistic-verbal intelligence did not perform well in 3D learning environment. However those who performed well, have dominant visual-spatial intelligence. Also the tendency of negative correlation between visual-spatial intelligence and assessment score after the alphabet-learning (in 2D learning environment) in Hybrid2D3D group supports the results of Pure2D group (negative correlation between assessment score and visual-spatial intelligence) and Pure3D group (positive correlation between assessment score and visual-spatial intelligence). These facts show positive bonding between learners with dominant visual-spatial intelligence and 3D learning environments. In case of the Hybrid3D2D group, positive correlation between assessment score and bodily-kinesthetic intelligence is another indicator in the favor of 3D learning environment.

6.8 Comparison of Learners' Satisfaction, Behavioral Intentions and Effectiveness of Learning Environments

To answer the last research question, the third data-set was exploited, where learner's satisfaction, behavioral intentions, and the effectiveness of 2D and 3D learning environments is determined. The results are described in the following subsections.

6.8.1 2D Learning Environment and 3D Learning Environment

As a first step, the data-set three collected from Pure3D and Pure2D groups was analyzed. A Mann-Whitney test was conducted to analyze the difference between two groups, the one who never used 3D learning environment (Pure2D), and the other who never worked on 2D learning environment (Pure3D). The results showed that there was no difference between two groups as shown in Table 6.24. None of the both groups taught through other environment appeared to be the primary reason for these results.

Further analysis was carried out, and this time Mann-Whitney test was applied on data-set three collected from Hybrid groups, those who used both 2D and 3D learning environments, either during the first phase or second phase. The results showed that

Table 6.24: Comparison of Pure2D and Pure3D Groups regarding Learning Environments

Responses about 2D & 3D Environments	N	Mean Rank	p-value
Pure2D	8	7.31	0.328 (2-tailed)
Pure3D	8	9.69	0.164 (1-tailed)

Table 6.25: Comparison of Hybrid Groups regarding Learning Environments

Responses about 2D & 3D Environments	N	Mean Rank	p-value
Hybrid Groups (2D)	16	13.13	0.043 (2-tailed)
Hybrid Groups (3D)	16	19.88	0.021 (1-tailed)

the learners who used both environments, their responses were significantly different (at the $p<0.05$) as shown in Table 6.25. These findings reveal that learners who used both learning environments appeared to be better judge and results were significantly different. The learners were more satisfied from 3D learning environment (Mean Rank = 19.88, p = 0.043) as compared to 2D learning environment (Mean Rank = 13.13, p = 0.021).

6.8.2 Parametric Analysis of 2D and 3D Learning Environments

As discussed earlier that questionnaire used to investigate the learners' satisfaction, their behavioral intentions and effectiveness of 2D and 3D learning environments was consist of eight different parameters. These parameters are, Perceived Self-Efficacy, Perceived Satisfaction, Perceived Usefulness, Behavioral Intention, Environment Quality, Interactive Learning Activities, Environment Effectiveness and Multimedia Instructions. This section describes the differences of responses about 2D and 3D learning environments against each parameter. Mann-Whitney tests were applied to analyze the differences (at the $p<0.05$) as shown in Table 6.26.

The results shows that statistically significant differences appeared in four parameters: Perceived Satisfaction (2D=13.16, 3D=19.84, p=0.043), Environment Quality (2D=13.03, 3D=19.97, p=0.035), Interactive Learning Activities (2D=11.78, 3D= 21.22, p=0.003), and Multimedia Instructions (2D=12.53, 3D=20.47, p=0.003). However, in case of rest of four parameters positive trend exists for the 3D learning environments, and result might be significant with larger sample size as shown in Figure 6.11.

Table 6.26: Parametric Comparison of Hybrid Groups regarding Learning Environments

Sr. No.	Parameters	Hybrid Groups' Responses about Environments	N	Mean Rank	p-value
1	Perceived Self-Efficacy	2D	16	15.09	0.402 (2-tailed)
		3D	16	17.91	0.201 (1-tailed)
2	Perceived Satisfaction	2D	16	12.16	0.043 (2-tailed)
		3D	16	19.84	0.0215 (1-tailed)
3	Perceived Usefulness	2D	16	14.88	0.341 (2-tailed)
		3D	16	18.13	0.1705 (1-tailed)
4	Behavioral Intension	2D	16	14.53	0.239 (2-tailed)
		3D	16	18.47	0.1195 (1-tailed)
5	Environment Quality	2D	16	13.03	0.035 (2-tailed)
		3D	16	19.97	0.0175 (1-tailed)
6	Interactive Learning Activities	2D	16	11.78	0.003 (2-tailed)
		3D	16	21.22	0.0015 (1-tailed)
7	Environment Effectiveness	2D	16	14.56	0. 254 (2-tailed)
		3D	16	18.44	0.127 (1-tailed)
8	Multimedia Instructions	2D	16	12.53	0.003 (2-tailed)
		3D	16	20.47	0.0015 (1-tailed)

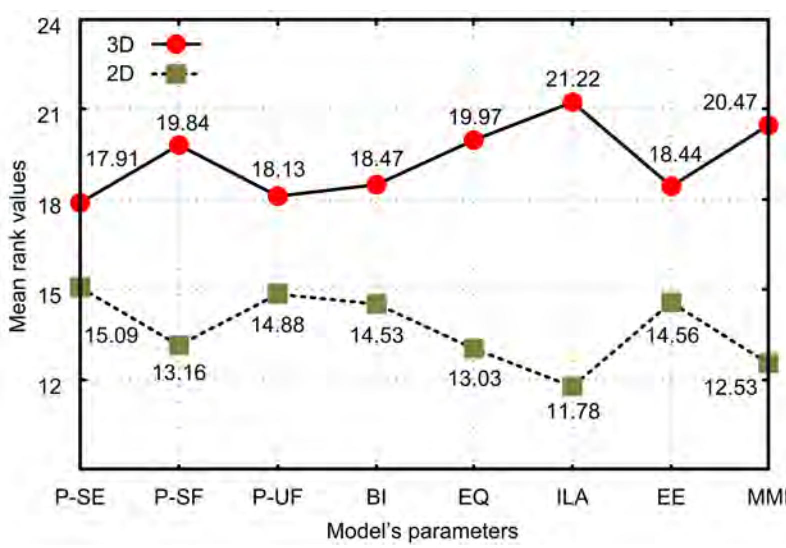

Figure 6.11: Parametric Analysis of 2D and 3D Learning Environments

6.9 Final Observations about Learners' Satisfaction, Behavioral Intention and Effective

The findings showed that learners were more interested to work in 3D learning environment than 2D learning environment because mean rank values of Perceived Satisfaction (2D=13.16, 3D=19.84, p=0.043), Environment Quality (2D=13.03, 3D=19.97, p=0.035), Interactive Learning Activities (2D=11.78, 3D=21.22, p=0.003), and Multimedia Instructions (2D=12.53, 3D=20.47, p=0.003) found greater for 3D learning environments. None of the parameters could show greater mean rank for 2D learning environment. Also the mean rank values for the rest of four parameters appeared greater for 3D learning environment than 2D learning environment, however they could not meet the significance at the $p<0.05$. The underlying reasons for the no significant difference in these four parameters were investigated through qualitative data. When learners who worked in both environment were asked, in which environment you found yourself comparatively weaker. Most of the learners replied that they can work in both environments and it appeared to be the primary reason for no difference in case of Perceived Self-Efficacy. When the learners were asked, which environment they found more useful and effective. Majority of them replied that both are useful and effective than traditional environment because this was their first experience to be taught through computer-supported education and it appeared to be the reason for no significant difference in Perceived Usefulness and Environment Effectiveness. Similarly, learners were asked, which environment they would prefer to use in their future. Many of the learners replied that both environments and it was reason for no statistically significant difference in case of Behavioral Intentions. Although results are not statistically significant however trends are there as mean rank values in case of 3D learning environment are still greater than 2D learning environment and there is an indication for significant difference with larger sample size.

6.10 Qualitative feedback

Qualitative feedback was also received from the learners to investigate their preferences about computer-assisted education, and different learning environments used in the study. This feedback was received at the end of both phases where following questions were asked from the participants of the study.

- Question No.1. Do you want education, if yes why, and if no, why? (from learners of all groups)

- Question No.2. Do you like computer-assisted education, if yes, why, and if no, why? (from learners of all groups)
- Question No.3. Which environment (either 2D or 3D) you liked most and why? (from those learners who were taught through both environments)
- Question No.4. Do you like face to face contact with instructor and why or why not? (from those learners who were taught through both environments)
- Question No.5. Do you like face to face contact with peers, and why or why not? (from those learners who were taught through both environments)
- Question No.6. Do you like unsupervised learning, and why or why not? (from those learners who were taught through both environments)
- Question No.7. Did you like contents and pictures used for teaching? (from those learners who were taught through both environments)
- Question No.8. What are your final remarks about this kind of learning? (from those learners who were taught through both environments)

While answering the first question, all learners responded that they want to learn, however different learners expressed different reasons for seeking the education. In case of the second question, everyone replied that they want education through computer-assisted environment and presented various reasons for computer-assisted education. Responses against the third question are summarized in Table 6.3. While answering the fourth and fifth question, only five learners were interested in face to face contact with the instructor, whereas 24 learners wanted face to face contact with peers. In case of the sixth question, 29 learners voted the unsupervised learning approach, and only one learner preferred supervised learning and rest of the two learners did not answer the question. A sample of the feedback received (translated from Urdu and local language Punjabi) is presented in Table 6.27 to give an indication of how different learners answered the "Why" part of the questions.

The feedback together suggests that, everyone do have thrust of education, they want education, and they preferred to be taught through computer-assisted learning approach rather traditional approach. Most of them were inclined towards 3D learning environment, however there were small in numbers who selected 2D learning environment. Those who performed well in 3D environment during the study, their age bracket was 25-44, whereas learners in age group of 45 and above showed good performance in 2D environment. It shows that performance of the learners and two different environments has some association with age that is further needed to be investigated.

Moreover, most of the learners preferred face to face contact with peers instead of instructor, and liked unsupervised way of learning through computer-assisted approach. Also the selection of contents in this study especially the metaphors used along with the alphabet letters and words were quite attractive for them. They said they already knew every picture but were unable to read, but now they can read them and even can try to write them. Majority of the learners enjoyed while learning through computer-assisted education, they were happy and they liked informal way of learning, self-directed learning, unsupervised learning. They wished to have schools like the study.

Table 6.27: Learners' responses to the "Why" part of Questions

Question No.1
1) I want to develop reading skills. 2) Because I want to read written material around me. 3) For reading and writing skills. 4) To speak with literate person. 5) For reading novel and stories. 6) To better look after my children. 7) To read files name, letters, address etc at my job. 8) For reading products' name while shopping. 9) For good manners and etiquettes.
Question No.2
1) Because computer is more helping than instructor. 2) It has good pictures, sounds. 3) I also learned computer, how to operate it. 4) It has pictures and sound, I can repeat the alphabet/words. 5) It was a new experience but I enjoyed learning through it. 6) I can repeat as many times as I want. 7) No need to ask instructor. 8) There was no fear of instructor. 9) Because there was a person talking to me.
Question No.3
1) Because it is more like game (in case of 3D). 2). You can see who is around you (in case of 3D). 3) I found this mode most helping (in case of 3D). 4) Because it is like school, but no teacher, and better than school (in case of 3D). 5) My friends were with me (in case of 3D). 6) You can see what is happening (in case of 3D). 7) I like games as my children play (in case of 3D). 8) This is (means 3D) more interesting than other (means 2D) (in case of 3D). 9) I like this (means 2D) because in other (means 3D) I often lost (in case of 2D). 10) Because I was alone there, I do not want others. (in case of 2D)
Question No.4
1) Because instructor would beat me on incorrect answer. 2) I am afraid of strict instructors. 3) I dont like teachers. 4) When I was in school she beat me. 5) She always asked me to memories many things. 6) I have bad memories of school and strict teachers.
Question No.5
1) I enjoyed learning with others. 2) They (calling the names of other learners) helped me. 3) We were together in computer (she meant that in 3D multi-user virtual environment).
Question No.6

1) No fear of teacher. 2) I want to learn independently. 3) I perform well when no one supervises me. 4) Independent is easy.
Question No.7
1) They were different from book, when I was in school. 2) I know every picture. 3) These are different from my child's book. 4) These are all those things that I normally used to see around me, now I can read also. 5) Education is such easy, I never thought. 6) I know every picture, and now I can read it also. 7) You cannot guess how they make things easier for me.
Question No.8
1) At first when I came here, I was afraid but it is really a fun. 2) I cannot believe seeking education is so easy. 3) Now, I can operate computer also, I am very happy, I will tell my daughters. 4) Yesterday you saw, now I can write little bit. 5) I wish our schools should be like this. 6) My daughter also wants to join, will you allow? 7) During this, the time passed so fast. 8) I am feeling that, I spent 15 years in the study rather 15 days. 9) Now, I planned to get education further. 10) I realized now, nothing is impossible.

7

Conclusion

This research proposed a novel platform for the adult basic education (ABE) based on the features selected from the learning theories. Impact of the proposed learning environment on the multiple intelligences and assessment score of the learners is investigated. Moreover, learners' satisfaction, behavioral intention towards future use, and effectiveness of the learning environment is examined. To further scrutinize the said investigations, qualitative information is also exploited. For comparative analysis, two dimensional (2D) web-based application offering same features was chosen.

In summary, an effort has been made to pop-up potential features important in designing adult learning environments, and to provide computer-based three dimensional (3D) learning environments to the absolute illiterate; which is a step forward from the current state of the art in computer-based learning environments for the intended community of learners. The following sections summarize the main research findings, and some directions for future research.

7.1 Summary of Research Findings

During the course of the research work, several research findings were discovered while addressing the following five research questions.

- Do emerging technologies such as 3D virtual worlds have more potential to offer additional features (important in learning) recommended by various theories than 2D web-based applications?

- How much does a 3D learning environment increases learning gain in comparison to 2D learning environment, in case of ABE?

- Do different learning environments (2D and 3D) effect multiple intelligences (MI) inventory score of learners? If yes which type of MI quotients will increase most in 2D and 3D learning environments?

- What is the relationship between quotients of multiple intelligences of the learners and their assessment score in two different learning environments?

- Do learners' satisfaction and behavioral intention increase when they learn in 3D learning environment as compared to 2D learning environment?

In order to answer the first research question literature is revisited, features are selected from the learning theories and mapped to the emerging technologies, whereas to investigate the rest of four research questions empirical studies are conducted. The following sections present the main conclusion to each of these research questions.

7.1.1 Selection of Technology

Although both 2D and 3D spaces have potential to offer most of the features discussed in section 3.2. However, some of the features are either best realized by 3D space than 2D space, or only achievable through 3D space. These features are situated learning, learning by doing, role based learning (facilitated learning), culture, context, best visual support such as immersive environment and motivational aspects. For the underpinned reason 3D space is selected as primary tool to implement the learning platform for the ABE.

7.1.2 Learning Gain

The assessment scores of two phases (alphabet-learning and words-learning) of four different groups (Pure2D, Pure3D, Hybrid2D3D, and Hybrid3D2D) were analyzed to investigate whether the learners' assessment scores were higher in 2D learning environment or in 3D learning environment. The following points summarize the main results:

- It was observed that both learning environments had different impact on assessment score of the learners. It was found that the learners who were taught through 3D learning environment had greater score than the learners who were taught through 2D learning environment. As the same learning content were presented in both learning environments, only the medium of presentation was different thus it is concluded that 3D learning environment is more helping for adult learners in their ABE programs than 2D learning environment.
- Further analysis of assessment score with respective to age of learners revealed that the learners from age group (25-44 years) performed well in 3D learning environment as compared to 2D learning environment, whereas learners from age group 45 years and above showed good performance in 2D learning environment.
- It shows that age is another indicator need to be considered while selecting different learning environments for ABE.

In summary, 3D virtual worlds as learning environments are more effective platforms than 2D web-based learning environments in case of the younger learners (with age bracket of 25-44) whereas in case of the learners with age greater than 45 years findings are complementary.

7.1.3 Multiple Intelligences

Empirical studies were conducted to investigate the impact of provided 2D and 3D learning environments on the intelligences of adult learners, and to find the reasons of higher assessment score in 3D learning environment. The following points summarize the findings:

- It was found that computer-assisted education irrespective of 2D and 3D learning environments, had impact on the intelligences of the learners. There was treatment of five intelligences in both environments and outcomes revealed that all these intelligences of the learner were improved after having computer-assisted education.

- In the case of impact of 2D learning environment on the intelligences of the learners in Pure2D, Hybrid2D3D and Hybrid3D2D groups, it was observed that the 2D learning environment consistently influenced the linguistic-verbal intelligence of the learners in all three groups. Apart from the linguistic-verbal intelligence, the 2D learning environment also influenced interpersonal intelligence in Pure2D and Hybrid2D3D groups and visual-spatial and bodily-kinesthetic in Pure2D group. The results were quit confirming as in 2D learning environment there was treatment of three intelligences; linguistic-verbal, interpersonal, and visual-spatial. Furthermore improvement in bodily-kinesthetic intelligence even without treatment was not surprising because it is related to interactive activities such as use of mouse, clicks on buttons of interface being performed by the learners and these findings have strong conformance with the result of studies conducted by McKenzie (Mckenzie, 2005).

- In the case of impact of 3D learning environment on the intelligences of the learners in Pure3D, Hybrid2D3D and Hybrid3D2D groups, it was revealed that the 3D learning environment consistently influenced three intelligences; 1) visual-spatial, 2) bodily-kinesthetic, and 3) interpersonal, in all three groups. In 3D learning environment, there was support to influence four types of intelligences, visual-spatial, bodily-kinesthetic, interpersonal, and linguistic-verbal. Also partial treatment for musical intelligence was available in the environment. The result also revealed the trends accordingly; however linguistic-verbal intelligence could be improved only in the Pure3D group although there was treatment available for this intelligence in the 3D learning environment.

In summary, the 3D learning environment has more potential to influence more multiple intelligences of the learners as compared to the 2D learning environment.

7.1.4 Assessment Score and Multiple Intelligences

Apart from investigating the impact of learning environments on multiple intelligences of the learners and on their learning assessment scores, correlation between assessment scores and intelligences of the learners in different groups (Pure2D, Pure3D, Hybrid2D3D and Hybrid3D2D) was also examined. The main results are concluded in following points:

- These results showed that learners with dominant logical-mathematical intelligence had good assessment score whereas learners with dominant visual-spatial and musical intelligences had lower score in Pure2D group.

- In Pure3D group, positive correlation between visual-spatial and assessment score (both after alphabet and words learning) and negative correlation between logical-mathematical and assessment score (both after alphabet and words learning) were also supporting the pervious results revealed in case of the Pure2D group.

- Also the negative correlation between linguistic-verbal and assessment score (after words learning) indicated that learners with dominant linguistic-verbal intelligence did not perform well in 3D learning environment. However those who performed well had dominant visual-spatial intelligence.

- The tendency of negative correlation between visual-spatial intelligence and assessment score after the alphabet-learning (in 2D learning environment) in Hybrid2D3D group supporting the results of Pure2D group (negative correlation between assessment score and visual-spatial intelligence) and Pure3D group (positive correlation between assessment score and visual-spatial intelligence).

- These facts revealed that positive bonding exists between learners with dominant visual-spatial intelligence and 3D learning environments.

- In case of the Hybrid3D2D group, positive correlation between assessment score and bodily-kinesthetic intelligence was another indicator in the favor of 3D learning environment.

In summary, positive relationship exist between 3D learning environment and learners with dominant visual-spatial intelligence. Also positive relationship was found between 2D learning environment and learners with dominant linguistic-verbal intelligence.

7.1.5 Effectiveness of 2D and 3D Learning Environments

In this study, learners' opinion regarding the both learning environments were also determined and empirically analyzed. The results concerning learners' satisfaction, behavioral intention towards future use of the learning environments, and effectiveness of the learning environments are summarized in the following points:

- For learners' satisfaction, behavioral intention towards future use of the learning environments and effectiveness of the learning environments was determined using eight parameters: perceived self-efficacy, perceived satisfaction, perceived usefulness, behavioral intention, environment quality, interactive learning activities, environment effectiveness, and multimedia instructions. The 3D learning environment had great impact on the learners because the learners were more satisfied from the 3D learning environment than 2D learning environment, and it was revealed through significant difference in mean rank values of four parameters; perceived satisfaction, environment quality, interactive learning activities, and multimedia instructions. Although, no significant difference was recorded in the rest of four parameters: perceived self-efficacy, perceived usefulness, behavioral intention, and environment effectiveness, but none of these parameter showed greater mean value in favor of 2D learning environment.

- The underlying reasons for the no significant difference in these four parameters were investigated through qualitative data. In this concern, learners who worked in both environments were asked some questions at the end of study. *In which environment you found yourself comparatively weaker?* Most of the learners replied that they can work in both environments and it appeared to be the primary reason for no difference in case of perceived self-efficacy. They found themselves capable to work in both learning environments. *Which environment you found more useful and effective?* Majority of them replied that both were useful and effective than traditional environment because this was their first experience to be taught through computer-supported education and it appeared to be the reason for no significant difference in perceived usefulness and environment effectiveness. They compared both of these learning environments to the traditional learning platforms and voted in the favor of both. *Which environment you would prefer to use in future?* Most of the learners replied that both environments and it was the reason for no statistically significant difference in case of behavioral intentions. As it was new experience for them to have computer-assisted education thus they showed their intention to use both learning environment in their future. Although results were not statistically significant (in the case of perceived self-efficacy, perceived usefulness, behavioral intention, and environment effectiveness) however trends was there as mean rank values in case of 3D learning environment were still greater than 2D learning environment and there was an indication for significant difference with larger sample size.

In Summary, the 3D learning environment appeared to be an effective learning environment for ABE because cumulatively all eight parameter revealed significant difference with greater mean values in the case of 3D learning environment.

7.1.6 Qualitative Observations

The qualitative feedback revealed that, everyone had thrust of education, wanted to get education, and preferred to be taught through computer-assisted learning approach rather traditional approach. Most of them were inclined towards 3D learning environment, however there were small in numbers who selected 2D learning environment. Those who performed well in 3D environment during the study, their age bracket were 25-44, whereas learners in age group of 45 and above showed good performance in 2D environment. It shows that performance of the learners and two different environments have some association with age that is further needed to be investigated.

Moreover, most of the learners preferred face to face contact with peers instead of instructor, and liked unsupervised way of learning through computer-assisted approach. Also the selection of contents in this study especially the metaphors used along with the alphabet letters and words were quite attractive for them. They said they already knew every picture but were unable to read, but now they can read them and even can try to write them. Majority of the learners enjoyed while learning through computer-assisted education, they were happy and they liked informal way of learning, self-directed learning, unsupervised learning. They wished to have schools like the study.

7.2 Directions for Future Work

The work presented in this thesis does not represent the definitive solution for developing learning environments for the ABE. Rather it is a stepping-stone from which further research can be undertaken. This section outlines a small list of suggestions for future work that could be carried out based on this research.

- As the duration of the study was not too long and each learner spent an average of 22.5 hours over both learning environments, thus to observe, 1) learner's performance, 2) impact of learning environments on the multiple intelligences, 3) learners' satisfaction, behavioral intention towards future use, and effectiveness of these learning environments, with greater accuracy, it would be necessary to extend the duration of the study and addition of more content.

- Also the sample population was small as only 32 learners participated in the study, thus to generalize the findings it would be necessary to conduct the study with larger sample size.

- Some inconsistencies were observed in the answers of MI inventory at Likert-scale. Although the principal investigator collected this data through interviews but he had to follow the same set of questionnaire to meet the standard. Some questions in the selected MI inventory showed inconsistencies may be because of social and religious differences. Thus some other MI inventories or some other approaches to determine the stronger and weaker intelligences of the learners need to be exploited.

- Currently content has been developed and 2D/3D learning environments were exploited to offer content for five intelligences only, content for other intelligences such as intrapersonal, logical-mathematical and naturalistic to be developed, and learning environments need to be improved accordingly.

- In current study adaptive support for content presentation is not fully exploited because the research team could seek the learners from the one trade/domain only. It would be of interest to conduct a study having learners from different trades and to compare adaptive learning with learner-controlled learning.

- The content were created for only one trade, there is also need to develop more content to wrap the larger trades. Furthermore, authoring tool for creating content would be very helpful for instructors.

- The approach for assessing learning gain was based on the use of pre-test and post-test consisting of multiple-choice questions in computer-assisted assessment specifically. It would be valuable to introduce other approaches instead of multiple-choice questioning.

- In the current study, linguistic scenarios are exploited, there is a need to exploit other scenarios such as numeracy and science learning.

- This research only considers the age parameter from the demographic profile for the comparison of learning in two different learning environments, there is a need to perform comparison with other parameters such as, gender, marital status etc.
- Only one model for learners' satisfaction, behavioral intention towards future use, and effectiveness of the learning environment is exploited in this research, it would be interesting to use other models and perform comparison of result in this concern.
- This research compares 3D learning environment with 2D learning environment, it would be interesting to compare 3D learning environment with traditional learning approach also.

A

Lesson Plans

Complete lesson plans for alphabet-learning and words-learning in both 2D and 3D environments are part of this appendix. Each lesson plan includes; description about the level and objectives of the lesson, material being used and international standards that are considered in the study, a complete procedure to present the material, expected outcomes, and assessment approaches. According to the procedure explained in Chapter 5, following four lesson plans are realized during the study.

Lesson Plan One:

Table A.1: A Detailed Lesson Plan for Alphabet-learning in 3D Environment

Level: Urdu Alphabet Letters Learning for Adult Absolute Illiterates		
Objectives: The learners will be able to recognize and pronounce alphabet letters of Urdu (National language of Pakistan)		
Material:		
Material	**Intelligences Involved**	**Technologies exlpoited**
3D immersive virtual environment that includes: Written alphabet letters 3D metaphors for each alphabet letter Avatar as learner's representative Audio support Voice chat channels	BK, IRP LV VS BK LV, MU* LV, IRP	Microcomputers with key board, mouse, display terminal, speakers and microphone, Local Area Network, 3D virtual world of OpenSim,
Standards:		

The study follows National Educational Technology Standards for Students (NETS) developed by the International Society for Technology in Education (ISTE); **1. Technology Productivity Tools** Student use technology tools to enhance learning, increase productivity, and promote creativity. **2. Technology Communication Tools** Student use telecommunications to collaborate, publish, and interact with peers, experts and other audience. Student use variety of media and formats to communicate information and ideas effectively to multiple audiences.
Orientation:
As the target audience in this study is illiterate and novice to computers and 3D environment, so an orientation will be given to work with the computer supported educational environment. This orientation will explain, How to start computer? How to use mouse and keyboard? How to use headphones? How to work inside world of OpenSim e.g., use of mouse for interaction and keyboard for navigation and data inputs if required?
Procedure:
The learners will perform following task in the 3D virtual environment for learning alphabet letters; 1. After login they will visit each and every Learning Object (LO) contains contents about an alphabet letter. 2. Learners will see the written alphabet letter. 3. Learners will see the 3D metaphors against each alphabet letter. 4. Learners will listen audio file for each LO. 5. Learner will interact with peers or instructor through voice chat for assistance and discussion. 6. Learners will navigate in 3D environment using arrow key. 7. Learner will click LO. 8. Learner will complete the LO in multiple session depending upon his learning pace. 9. Learner will change the camera position by mouse wheel to change the view.
Outcomes:
Learners will recognize alphabet letters and metaphors. Learners will pronounce the alphabet letters.
Assessment activities:

Alphabet letters learning phase will follow the assessment phase, but learner will not be informed that this is an assessment phase because the adult learners do not want to be evaluated explicitly. The assessment phase will comprise of two sessions, a) computer-assisted assessment, and b) interview-based assessment. In computer-assisted assessment, a metaphor along with four written alphabet letters will be presented on the LO and only one will be the correct and learner will be asked to click on the right alphabet letter. The interview-based assessment will cover recognition and pronunciation of alphabet letters. In recognition, a learner will be asked to find an alphabet letter from the list of alphabet, whereas in pronunciation, a learner has to pronounce all the alphabet letters from the presented list.
Qualitative outcomes:
Score will be given against each correct recognition and pronunciation of alphabet letter.

*** - shows partial support**

Lesson Plan Two:

Table A.2: A Detailed Lesson Plan for Words-learning in 2D Environment

Level: Commonly used words (of Urdu) learning for those who have already learned Urdu alphabet letters in the 3D learning Environment		
Objectives: The learners will be able to recognize and pronounce few most commonly used words from daily life (in National language of Pakistan, Urdu)		
Material:		
Material	**Intelligences Involved**	**Technologies exlpoited**
2D learning environment includes: Written words 2D pictures for each word Audio support Voice chat channels	LV LV VS LV, MU* LV, IRP	Microcomputers with key board, mouse, display terminal, speakers and microphone, Local Area Network, 2D web-based setting
Standards:		

The study follows National Educational Technology Standards for Students (NETS) developed by the International Society for Technology in Education (ISTE); **1. Technology Productivity Tools** Student use technology tools to enhance learning, increase productivity, and promote creativity. **2. Technology Communication Tools** Student use telecommunications to collaborate, publish, and interact with peers, experts and other audience. Student use variety of media and formats to communicate information and ideas effectively to multiple audiences.
Orientation:
As the target audience in this study is illiterate and novice to computers and 2D environment, so an orientation will be given to work with the computer supported educational environment. This orientation will explain, How to start computer? How to use mouse and keyboard? How to use headphones? How to work inside 2D settings e.g., use of mouse and keyboard for interaction and navigation and data inputs if required?
Procedure:
The learners will perform following task in the 2D learning environment for learning commonly used words; 1. After login they will visit each and every Learning Object (LO) contains contents about a word. 2. Learners will see the written word. 3. Learners will see the 2D pictures against each word. 4. Learners will listen audio file for each LO. 5. Learner will interact with peers or instructor through voice chat for assistance and discussion. 6. Learners will navigate among LO using hyperlinks. 7. Learner will click LO. 8. Student will complete the LO in multiple sessions depending upon his learning pace.
Outcomes:
Learners will recognize words and metaphors. Learners will pronounce the alphabet letters.
Assessment activities:

Words learning phase will follow the assessment phase, but learner will not be informed that this is an assessment phase because the adult learners do not want to be evaluated explicitly. The assessment phase will comprise of two sessions, a) computer-assisted assessment, and b) interview-based assessment. In computer-assisted assessment, a metaphor along with four written words will be presented on the LO and only one will be the correct and learner will be asked to click on the right word.. The interview-based assessment will cover recognition and pronunciation of words. In recognition, a learner will be asked to find a word from the list of words, whereas in pronunciation, a learner has to pronounce all the words from the presented list. Final learning score of a learner will be decided after considering the both parts of assessment.
Qualitative outcomes:
Score will be given against each correct recognition and pronunciation of alphabet letter.

*** - shows partial support**

Lesson Plan Three:

Table A.3: A Detailed Lesson Plan for Alphabet-learning in 2D Environment

Level: Urdu alphabet letters learning for adult absolute illiterates		
Objectives: The learners will be able to recognize and pronounce alphabet letters of Urdu (National language of Pakistan)		
Material:		
Material	**Intelligences Involved**	**Technologies exlpoited**
2D learning environment includes: Written words 2D pictures for each word Audio support Voice chat channels	LV LV VS LV, MU* LV, IRP	Microcomputers with key board, mouse, display terminal, speakers and microphone, Local Area Network, 2D web-based setting
Standards:		

The study follows National Educational Technology Standards for Students (NETS) developed by the International Society for Technology in Education (ISTE); **1. Technology Productivity Tools** Student use technology tools to enhance learning, increase productivity, and promote creativity. **2. Technology Communication Tools** Student use telecommunications to collaborate, publish, and interact with peers, experts and other audience. Student use variety of media and formats to communicate information and ideas effectively to multiple audiences.
Orientation:
As the target audience in this study is illiterate and novice to computers and 2D environment, so an orientation will be given to work with the computer supported educational environment. This orientation will explain, How to start computer? How to use mouse and keyboard? How to use headphones? How to work inside 2D settings e.g., use of mouse and keyboard for interaction and navigation and data inputs if required?
Procedure:
The learners will perform following task in the 2D environment for learning alphabet letters; 1. After login they will visit sequentially each and every Learning Object (LO) contains contents about an alphabet letter. 2. Learners will see the written alphabet letter. 3. Learners will see the 2D pictures against each alphabet letter. 4. Learners will listen audio file for each LO. 5. Learner will interact with peers or instructor through voice chat for assistance and discussion. 6. Learners will navigate among LO using hyperlinks. 7. Learner will click LO. 8. Learner will complete the LO in multiple sessions depending upon his learning pace.
Outcomes:
Learners will recognize alphabet letters and 2D pictures. Learners will pronounce the alphabet letters.
Assessment activities:

Alphabet letters learning phase will follow the assessment phase, but learner will not be informed that this is an assessment phase because the adult learners do not want to be evaluated explicitly. The assessment phase will comprise of two sessions, a) computer-assisted assessment, and b) interview-based assessment. In computer-assisted assessment, a metaphor along with four alphabet letters will be presented on the LO and only one will be the correct and learner will be asked to click on the right alphabet letter. The interview-based assessment will cover recognition and pronunciation of alphabet letters. In recognition, a learner will be asked to find an alphabet letter from the list of alphabet, whereas in pronunciation, a learner has to pronounce all the alphabet letters from the presented list. Final learning score of a learner will be decided after considering the both parts of assessment.
Qualitative outcomes:
Score will be given against each correct recognition and pronunciation of alphabet letter.

*** - shows partial support**

Lesson Plan Four:

Table A.4: A Detailed Lesson Plan for Words-learning in 3D Environment

Level: Urdu Commonly used Words Learning for those who have already learned Urdu Alphabet Letters in 2D learning Environment.		
Objectives: The learners will be able to recognize and pronounce few most commonly used words from daily life (in National language of Pakistan, Urdu)		
Material:		
Material	**Intelligences Involved**	**Technologies exlpoited**
3D immersive virtual environment that includes: Written alphabet letters 3D metaphors for each alphabet letter Avatar as learner’s representative Audio support Voice chat channels	BK, IRP LV VS BK LV, MU* LV, IRP	Microcomputers with key board, mouse, display terminal, speakers and microphone, Local Area Network, Internet, 3D virtual world of OpenSim,
Standards:		

The study follows National Educational Technology Standards for Students (NETS) developed by the International Society for Technology in Education (ISTE); **1. Technology Productivity Tools** Student use technology tools to enhance learning, increase productivity, and promote creativity. **2. Technology Communication Tools** Student use telecommunications to collaborate, publish, and interact with peers, experts and other audience. Student use variety of media and formats to communicate information and ideas effectively to multiple audiences.
Orientation:
As the target audience in this study is illiterate and novice to computers and 3D environment, so an orientation will be given to work with the computer supported educational environment. This orientation will explain, How to start computer? How to use mouse and keyboard? How to use headphones? How to work inside world of OpenSim e.g., use of mouse for interaction and keyboard for navigation and data inputs if required?
Procedure:
The learners will perform following task in the 3D virtual environment for learning words; 1. After login they will visit each and every Learning Object (LO) contains contents about a word. 2. Learners will see the written word. 3. Learners will see the 3D metaphors against each word. 4. Learners will listen audio file for each LO. 5. Learner will interact with peers or instructor through voice chat for assistance and discussion. 6. Learners will navigate in 3D environment using arrow key. 7. Learner will click LO. 8. Learner will complete the LO in multiple sessions depending upon his learning pace. 9. Learner will change the camera position by mouse wheel to change the view.
Outcomes:
Learners will recognize words and metaphors. Learners will pronounce the words.
Assessment activities:

The words learning phase will follow the assessment phase, but the learner will not be informed that this is an assessment phase because the adult learners do not want to be evaluated explicitly. The assessment phase will comprise of two sessions, a) computer-assisted assessment, and b) interview-based assessment. In computer-assisted assessment, a metaphor along with four written words will be presented on the LO and only one will be the correct and learner will be asked to click on the right word. The interview-based assessment will cover recognition and pronunciation of words. In recognition, a learner will be asked to find a word from the list of alphabet, whereas in pronunciation, a learner has to pronounce all the words from the presented list.
Qualitative outcomes:
Score will be given against each correct recognition and pronunciation of a word.

*** - shows partial support**

B

Multiple Intelligences Inventory Test

For the investigation of learners' intelligences, in this research English version of Multiple intelligences (MI) inventory used by Kim (Kim, 2009) is exploited. It was originally developed in Korean, and modified from the existing MI inventories (Armstrong, 1999; Christison, 1998). It is further modified to exclude the naturalist intelligence because it is not included in the study. The questionnaire finally used, consists of ten sections and each section has seven questions (one question for each of the intelligence. The learners are expected to answer each question on 5-point Likert scale; 1 (Strongly Disagree), 2 (Disagree), 3 (Undecided), 4 (Agree), 5 (Strongly Agree).

Section 1:

- I like to read books. (LV)
- I try to sort out complex things in a logical way. (LM)
- I like to draw a picture or sketch when I think. (VS)
- I like to sing when I am alone. (MU)
- I like to repair or make things for myself. (BK)
- I am good at making friends in school. (IRP)
- I like to spend time on thinking of things that are important to me. (IAP)

Section 2:

- I try to use words that I learned newly in my talking and writing. (LV)
- I prefer to do math social studies or English. (LM)
- I know how to tell subtle differences in colors, lines, and shapes. (VS)

- I often like to listen to music. (MU)
- I am good at balancing. (BK)
- I enjoy attending meetings or parties at the social clubs. (IRP)
- I think highly of my independence. (IAP)

Section 3:

- I am good at making points or explaining things. (LV)
- I am good at finding patterns or errors in a certain situation. (LM)
- I like to visualize certain ideas well. (VS)
- I often tap rhythmically on the table or deck. (MU)
- I learn new dances and sports very easily. (BK)
- I make it a rule to go to the party for fun. (IRP)
- I often talk to myself looking at a mirror. (IAP)

Section 4:

- I am good at talking figuratively, using languages full of expressions. (LV)
- I work well with numbers and data. (LM)
- I can read maps easily. (VS)
- I play musical instruments well. (MU)
- I often talk, making gestures with hands. (BK)
- People like to make friendships with me. (IRP)
- I often think of my self-worth and my responsibility. (IAP)

Section 5:

- I make a good use of vocabulary in describing objects. (LV)
- I always look for patterns, regularities, and logical connections from my work. (LM)
- I visualize the story in my head when I read. (VS)
- I can tell when music sounds off-key. (MU)
- I engage in physical activities even though they are physically demanding. (BK)
- I look for opportunities through which I can make new friendships. (IRP)
- I like to think hard before I take certain actions. (IAP)

Section 6:

- I am good at persuading people to do things. (LV)
- I feel comfortable with abstract ideas. (LM)
- I concentrate on what I watch more than on what I listen to. (VS)
- I know many songs as if I had a good library of song titles in my head. (MU)
- I am easily bored when I sit quietly. (BK)
- I tend to ask other people when I need to make an important decision. (IRP)
- I like to spend time alone. (IAP)

Section 7:

- I am highly interested in the meanings of words. (LV)
- I am able to understand charts and diagrams easily. (LM)
- I am good at decorating things with colors. (VS)
- I like to make up a new melody and sing a song. (MU)
- I like to figure out how things operate by manipulating them with my hands. (BK)

- I try to avoid conflicting situations and make efforts to get along, when they occur. (IRP)
- I like to set up a certain goal for myself. (IAP)

Section 8:

- I like to write. (LV)
- The topics and discussions on sciences interest me. (LM)
- I can visualize the other angle without looking at it. (VS)
- I am good at tapping out musical beats. (MU)
- I am good at hand-crafting such as making wood crafts, making models, and needling. (BK)
- I am born to make people around me feel comfortable. (IRP)
- I tend to rely on my own decision, not paying attention to other people's advice. (IAP)

Section 9:

- I like to go to the bookstore or library to look for a new idea. (LV)
- I believe that there is a logical rule governing phenomena in the world. (LM)
- I remember people's face rather than their names. (VS)
- I know the clear difference between the songs I like and those that I don't like. (MU)
- I prefer to engage myself in sports rather than watching them on TV. (BK)
- I often help my friends. (IRP)
- I like to own a small business rather than work at the company. (IAP)

Section 10:

- I am good at doing crossword puzzles and word games. (LV)
- I enjoy doing games that require strategies and skills. (LM)
- I am good at finding pictures in a picture dictionary and finding ways in a labyrinth. (VS)
- I enjoy listening to the top 20 music hits. (MU)
- I am good at mimicking the physical actions of other people. (BK)
- I like to work well with other people through cooperation. (IRP)
- I like to play games such as computer games that I can do by myself. (IAP)

C

Questionnaire of Model of Learners' Satisfaction

In order to investigate the learners' satisfaction, behavioral intention and effectiveness of 2D and 3D learning environments, a questionnaire designed by Liaw (Liaw, 2008) is modified and used. This questionnaire was originally designed to determine the learner's satisfaction, behavioral intention and effectiveness of e-learning. The learners are expected to answer each question on 5-point Likert scale; 1 (Strongly Disagree), 2 (Disagree), 3 (Undecided), 4 (Agree), 5 (Strongly Agree). It covers eight different dimensions.

For 3D Learning Environment

Perceived self-efficacy:

- I feel confident using the 3D learning environment (the OpenSim 3D MUVE).
- I feel confident operating 3D learning environment functions.
- I feel confident using 3D learning contents.

Perceived satisfaction:

- I am satisfied with using 3D learning environment as a learning assisted tool.
- I am satisfied with using 3D learning environment functions.
- I am satisfied with 3D learning contents.
- I am satisfied with 3D multimedia instruction .

Perceived usefulness:

- I believe 3D learning contents are informative.
- I believe 3D learning environment is a useful learning tool.
- I believe 3D learning contents are useful.

Behavioral intention:

- I intend to use 3D learning environment to assist my learning.
- I intend to use 3D learning content to assist my learning.
- I intend to use 3D learning environment as an autonomous learning tool.

3D learning environment quality:

- I am satisfied with 3D learning environment functions.
- I am satisfied with 3D learning content.
- I am satisfied with 3D learning environment interaction.

Interactive learning activities:

- I would like to share my 3D learning environment experience.
- I believe 3D learning environment can assist teacher-learner interaction.
- I believe 3D learning environment can assist learner-learner interaction.

3D learning environment effectiveness:

- I believe 3D learning environment can assist learning efficiency.
- I believe 3D learning environment can assist learning performance.
- I believe 3D learning environment can assist learning motivation.

Multimedia instruction:

- I like to use voice media instruction in 3D learning environment.
- I like to use video media instruction in 3D learning environment.
- I like to use multimedia instruction in 3D learning environment.

For 2D Learning Environment

Perceived self-efficacy:

- I feel confident using the 2D learning environment (the web-based 2D environment).
- I feel confident operating 2D learning environment functions.
- I feel confident using 2D learning contents.

Perceived satisfaction:

- I am satisfied with using 2D learning environment as a learning assisted tool.
- I am satisfied with using 2D learning environment functions.
- I am satisfied with 2D learning contents.
- I am satisfied with 2D multimedia instruction .

Perceived usefulness:

- I believe 2D learning contents are informative.
- I believe 2D learning environment is a useful learning tool.
- I believe 2D learning contents are useful.

Behavioral intention:

- I intend to use 2D learning environment to assist my learning.
- I intend to use 2D learning content to assist my learning.
- I intend to use 2D learning environment as an autonomous learning tool.

3D learning environment quality:

- I am satisfied with 2D learning environment functions.
- I am satisfied with 2D learning content.
- I am satisfied with 2D learning environment interaction.

Interactive learning activities:

- I would like to share my 2D learning environment experience.
- I believe 2D learning environment can assist teacher-learner interaction.
- I believe 2D learning environment can assist learner-learner interaction.

3D learning environment effectiveness:

- I believe 2D learning environment can assist learning efficiency.
- I believe 2D learning environment can assist learning performance.
- I believe 2D learning environment can assist learning motivation.

Multimedia instruction:

- I like to use voice media instruction in 2 learning environment.
- I like to use video media instruction in 2D learning environment.
- I like to use multimedia instruction in 2D learning environment.

D

Questionnaire for Learners' Personal Information

Personal information about the participants collected two times during the study, once during the preliminary phase and secondly after the study. Following questionnaire is used to collect the intended information.

Table D.1: Questionnaire for learners' personal information

Before the Study	
Name:	
Age:	Gender: (M / FM)
Marital Status: (Single / Married / Divorced)	Address:
Are you working? (Yes / No)	If Yes, what is the nature of work? :
Have you ever been in school?	If Yes, how long?, If No, why? :
Are your Parents Educated?	If Yes, what is level? :
Have you ever used Computer?	If Yes, to what extent? :
Do you want to get education?	If Yes, why? :
Do you like school?	If No, why? :
Do you like informal education?	If Yes, why? :
Do you like computer-supported education?	If Yes, why? :
After the Study	
Do you like face to face contact with teacher? (Yes / No)	
Do you like face to face contact with peers? (Yes / No)	
Do you like supervised learning? (Yes / No)	
Do you like unsupervised learning? (Yes / No)	
Do you like learning by doing in immersive setting? (Yes / No)	

E

Urdu Grapheme Test

Grapheme test includes two parts, recognition and pronunciation of alphabet letters of Urdu. During recognition process the moderator of study pronounces an alphabet letter and the learner is asked to recognize that alphabet letter from the list of 28 alphabet letters. In pronunciation phase, learner is asked to pronounce all alphabet letters sequentially. Grapheme test consists of 28 alphabet letters of Urdu language.

چ	ج	ٹ	ت	پ	ب	ا
س	ز	ر	ڈ	د	خ	ح
گ	ک	ق	ف	غ	ع	ش
ے	ی	ہ	و	ن	م	ل

Figure E.1: Grampheme test consists of 32 alphabet letters

F

Learning Contents

The learning contents include alphabet letters, commonly used word of Urdu language and metaphors most relevant to the learners' needs. In Figure F.1 and Figure F.4 both alphabet letters and commonly used words are listed respectively, whereas Figure F.2 and Figure F.3 show some of the metaphors used in learning contents.

چ	ج	ٹ	ت	پ	ب	ا
س	ز	ر	ڈ	د	خ	ح
گ	ک	ق	ف	غ	ع	ش
ے	ی	ہ	و	ن	م	ل

Figure F.1: Selected Alphabet Letters

جیو	ٹیلی فون	تالہ	پیپسی	باٹا	اخبار
روٹی	ڈاکٹر	دیگ	خرگوش	حکا	چنگ چی
فریج	غبارہ	عینک	شیر	سیون اپ	زونگ
نوکیا	مسجد	لپٹن	گلاس	کوٹ	قلفی
			یوفون	ہاکی	وارد

Figure F.4: Selected Commonly used Words

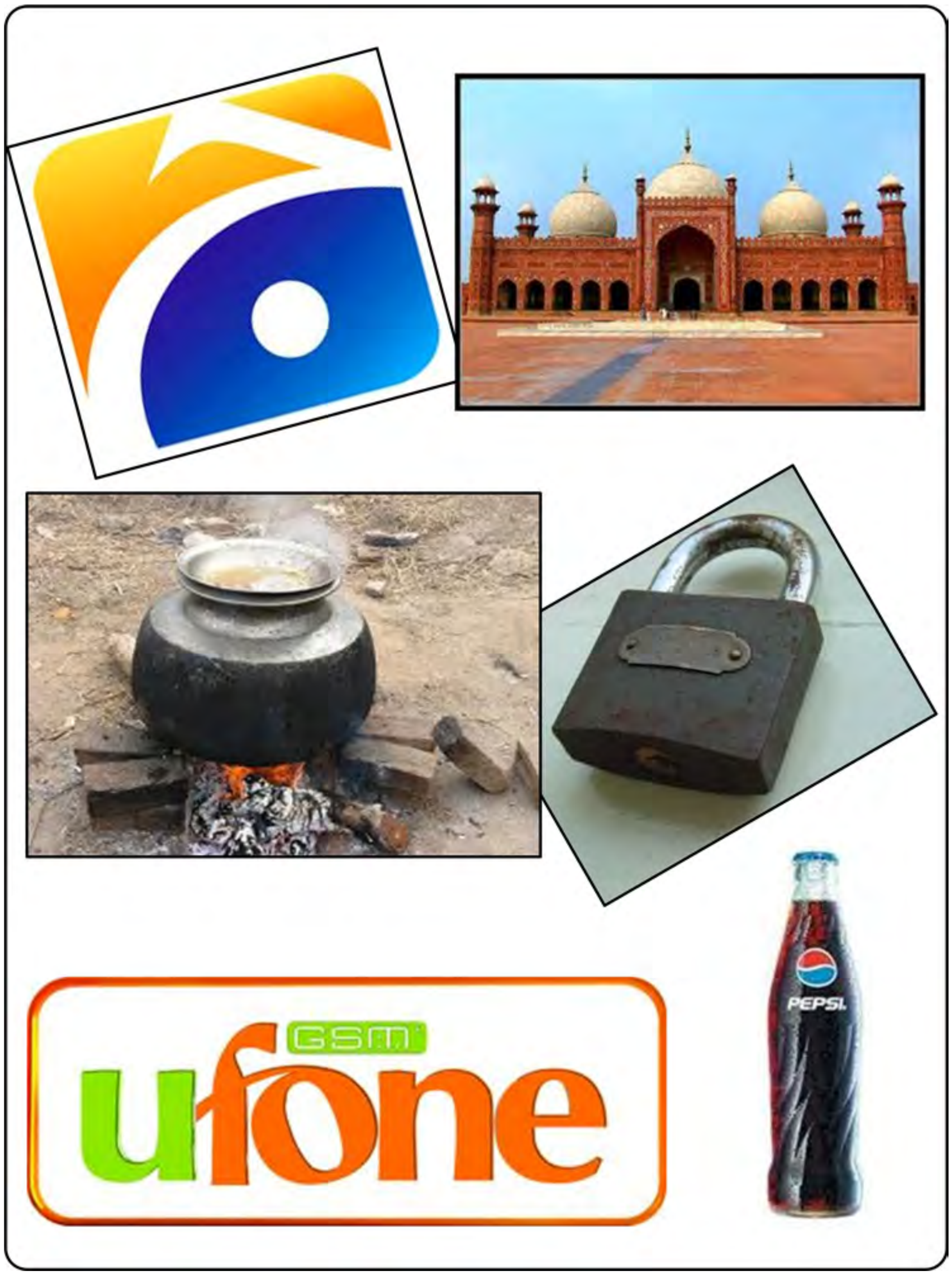

Figure F.2: Few Selected Metaphors

Figure F.3: Few Selected Metaphors

G

Virtual Tour of the Study

The virtual study tour includes some of the snapshots during orientation, learning sessions, and certificate award ceremony. These snapshots are added with the consents of the head of school, staff, and participants.

Figure G.1: Principal Investigator of the study, and head of school in Orientaion Ceremony

Figure G.2: Participants in Orientaion Ceremony

Figure G.3: Participants in Orientaion Ceremony

Figure G.4: Participants in a Learning Session

Figure G.5: Participants in a Learning Session

Figure G.6: Participants in a Learning Session

Figure G.7: Participants in a Learning Session

Figure G.8: Certificate Awarding Ceremony at the end of Study

Figure G.9: Certificate Awarding Ceremony at the end of Study

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Curriculum Vitae

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Areas of interest	• Emerging e-Learning Technologies • Adaptive System for academics • Learning Styles, Multiple Intelligences • 3D Virtual Worlds
Key Skills	• Designing and development in 3D Virtual Environments like OpenSim, Second Life, Relational Database designing and development, Web development. • Linden Scripting Language (LSL) for 3D Virtual Environments, Visual Basic 6.0, PHP scripting language for Web, SQL Server 2000, MySQL, C++.
Work experience	
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Name and address of employer	Department of Computer Science, COMSATS Institute of Information Technology, Lahore, Pakistan
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Name and address of employer	Computer Science Division, Govt. Degree College, Hazro, Pakistan
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Trainings

- Participated in 1-Day Faculty Development Workshop held in CIIT Islamabad on May 20, 2006.
- Participated in 1-Day Faculty Development Workshop held in CIIT Islamabad on March 25, 2006.
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Personal skills and competences

Mother tongue(s)	Punjabi (Fluent),
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Awards/ Distinctions

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Academic Achievements and Positions:

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Publications

- Iqbal, T., Hammermüller, K., and Tjoa, A. M. (2011). Realization of 3D virtual world platform for the basic education of adult illiterates. Journal of Mobile Multimedia, 7(3):194–215.
- Iqbal, T., Hammermüller, K., and Tjoa, A. M. (2011). Adaptivity in 3D virtual environments for multi-users and its application in adult basic education. In Proceedings of the 3rd International Conference on Computer Supported Education, pages 213–218, Noordwijkerhout, Netherlands. SciTePress.
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- Hammermüller, K., Kelle, S., **Iqbal, T.**, (2009). Aspect of Social Games in 3D Spaces Considering Usability and Accessibility", ECGBL 09, Austria.
- **Iqbal**, T., Daudpota, N., (2006). XML based Framework for ETL Processes For Relational Databases, WSEAS Transactions on Information Science and Applications. Vol. 3, no. 7, pp. 1402-1406.
- Bilal, K., **Iqbal, T.**, Ali Safi, A., Daudpota. N, (2005). Dynamic Load Balancing In PVM Using Intelligent Application", 3rd World Enformatika Conference (WEC'05), Turkey.