

DESIGN AND DEVELOPMENT OF E-LEARNING ENVIRONMENT FOR
DEAF STUDENTS IN LEARNING NUCLEAR ENERGY

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To My Beloved Family

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ABSTRACT

This research aims to develop an e-learning environment for deaf students in learning Nuclear Energy. The performance level of deaf students, as well as learning patterns that have emerged from their activities within the developed e-learning environment were examined. This research utilizes a quantitative research design by using questionnaires and performance tests, as well as additional qualitative data from interviews. Data was attained from two different sets of questionnaires, the log data files from the e-learning, performance tests, and the interview sessions. Questionnaires were initially distributed to 52 deaf students from a school in Johor Bahru to examine their e-learning readiness. Next, an e-learning environment for the deaf students was developed with the implementation of sign language videos as the main feature. The same 52 deaf students were given another questionnaire to examine the usability and motivation to learn using the developed e-learning environment. After that, 20 Form four deaf students were involved in using the developed e-learning environment in order to examine their performance and learning patterns that emerged from their activities within the e-learning environment. Data were analyzed through descriptive analysis (mean and standard deviation), inferential analysis (paired-samples t-test, effect size, and power analysis) and data mining (decision tree). Data mining analysis using the decision tree technique was used to examine the learning patterns by the deaf students when using the developed e-learning environment based on their performance level. The results from descriptive analysis show that the deaf students have a moderate level of e-learning readiness, as well as the usability and motivation to learn using the developed e-learning environment. The results from the paired-samples t-test show that there is a statistically significant difference between the pre-test and the post-test scores ($p < 0.05$). The meta-analysis of the t-test shows that the treatment has a large effect size on the deaf students' performance, while the results from the power analysis show that if this treatment is repeated, similar results will be acquired. Eleven learning patterns were emerged based on three increment categories of the deaf students' performance. This research found that the learning patterns of deaf students who achieved the best increment category of performance accessed the sign language videos more frequently compared to other deaf students.

ABSTRAK

Kajian ini bertujuan untuk membangunkan persekitaran e-pembelajaran bagi pelajar yang mempunyai masalah pendengaran dalam mempelajari Tenaga Nuklear. Tahap prestasi pelajar dan corak pembelajaran yang terhasil daripada aktiviti pelajar masalah pendengaran di dalam persekitaran e-pembelajaran ini juga telah dikaji. Kajian ini menggunakan reka bentuk kajian kuantitatif dengan menggunakan soal selidik dan ujian prestasi, serta data kualitatif daripada temubual. Data telah diperolehi menerusi dua set soal selidik, fail data log daripada persekitaran e-pembelajaran, ujian prestasi dan sesi temubual. Pada mulanya, soal selidik telah diedarkan kepada 52 orang pelajar masalah pendengaran dari sebuah sekolah di Johor Bahru untuk mengkaji kesediaan pelajar terhadap e-pembelajaran. Seterusnya, satu persekitaran e-pembelajaran untuk pelajar masalah pendengaran telah dibangunkan dengan mengimplementasikan penggunaan video bahasa isyarat sebagai ciri utama. 52 orang pelajar masalah pendengaran yang sama telah diberikan satu lagi soal selidik untuk mengkaji kebolehgunaan dan motivasi untuk belajar menggunakan persekitaran e-pembelajaran yang dibangunkan. Seterusnya, 20 orang pelajar masalah pendengaran Tingkatan empat terlibat dalam menggunakan persekitaran e-pembelajaran yang dibangunkan bagi mengkaji tahap prestasi mereka serta corak pembelajaran yang terhasil daripada aktiviti mereka dalam persekitaran e-pembelajaran. Data dianalisis menggunakan analisis deskriptif (min dan sisihan piawai), analisis inferensi (ujian-t sampel berpasangan, saiz kesan dan analisis kuasa) serta perlombongan data (decision tree). Analisis perlombongan data (decision tree) digunakan untuk mengkaji corak pembelajaran pelajar masalah pendengaran berdasarkan tahap prestasi dalam menggunakan persekitaran e-pembelajaran yang dibangunkan. Keputusan daripada analisis deskriptif menunjukkan pelajar masalah pendengaran mempunyai tahap sederhana dalam kesediaan, kebolehgunaan dan motivasi untuk belajar menggunakan persekitaran e-pembelajaran yang dibangunkan. Keputusan ujian-t sampel berpasangan menunjukkan terdapat perbezaan yang signifikan di antara markah ujian pra dan ujian pasca ($p < 0.05$). Analisis meta ujian-t menunjukkan rawatan mempunyai saiz kesan yang besar terhadap prestasi pelajar masalah pendengaran sementara keputusan daripada analisis kuasa menunjukkan jika rawatan diulangi, keputusan yang sama akan diperolehi. Sebelas corak pembelajaran telah terhasil berdasarkan tiga kategori peningkatan prestasi oleh pelajar masalah pendengaran. Kajian mendapati corak pembelajaran pelajar masalah pendengaran yang memperoleh tahap peningkatan prestasi yang terbaik terdiri daripada mereka yang mengakses video bahasa isyarat paling kerap di antara pelajar masalah pendengaran yang lain.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xiii
	LIST OF FIGURES	xvii
	LIST OF ABBREVIATIONS	xix
	LIST OF APPENDICES	xx
1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Background of Problem	4
	1.3 Problem Statement	10
	1.4 Research Objectives	12
	1.5 Research Questions	12
	1.6 Theoretical Framework	13
	1.6.1 Cognitive Theory of Multimedia Learning	16
	1.6.2 Constructivism	16
	1.6.3 Problem Solving	18
	1.6.4 Information Processing Theory	19
	1.6.5 Linguistic Interdependence	20

1.7	Rationales of the Study	21
1.8	Importance of the Study	21
1.8.1	Deaf Students	22
1.8.2	Teachers	22
1.8.3	E-Learning Environment Researchers and Developers	22
1.9	Scope and Limitation of the Study	23
1.10	Operational Definition	23
1.10.1	E-Learning Environment	24
1.10.2	Deaf	24
1.10.3	Sign Language	25
1.10.4	Nuclear Energy	25
1.10.5	Usability	26
1.10.6	Performance	26
1.11	Summary	27
2	LITERATURE REVIEW	28
2.1	Deafness	28
2.1.1	Deaf and Hard of Hearing (HoH)	31
2.1.2	Deafness Models	31
2.1.3	Deafness Communication	34
2.2	Deafness in Malaysia	35
2.2.1	Malaysian Sign Language	37
2.3	Deafness Education	38
2.3.1	Deaf Students in Education and Science	41
2.3.2	Problem Solving for Deaf Students	44
2.3.3	Problem Solving Strategies for Deaf Students	46
2.4	Technology in Education	48
2.4.1	Cognitive Theory of Multimedia Learning	50

2.5	Technology for Deaf in Education	53
2.6	E-Learning Environment	55
2.6.1	E-Learning Classification	56
2.6.1.1	Technologies	57
2.6.1.2	Type of Communication	57
2.6.1.3	Class Structure	60
2.6.1.4	Schedule	61
2.7	E-Learning Readiness	61
2.8	E-Learning Environment for Deaf	69
2.9	E-Learning Usability Assessment	75
2.10	Instructional System Design	79
2.11	Summary	83
3	RESEARCH METHODOLOGY	84
3.1	Research Design	84
3.2	Research Procedures	88
3.2.1	Phase 1: Developing Research Instruments and Conducting A Pilot Study	90
3.2.2	Phase 2: Designing an E- Learning Environment	91
3.2.3	Phase 3: Giving Pre Test and Post Test	91
3.2.4	Phase 4: Implementing Developed E-Learning Environment	91
3.2.5	Phase 5: Analyzing Data	92
3.3	Samples	92
3.4	Instrumentations	93
3.4.1	E-Learning Readiness Questionnaire	94
3.4.2	Treatment	95
3.4.2.1	E-Learning Environment	95

3.4.2.2	Sign Language Video	96
3.4.2.3	Learning Activity	98
3.4.3	Performance Test (Pre and Post Test)	99
3.4.4	Log Data on Deaf Students' Activities in E-Learning	100
3.4.5	Questionnaire on the Deaf Students' E-Learning Usability and Motivation to Learn	101
3.5	Preliminary Investigation	102
3.6	Pilot Study	105
3.7	Findings from the Pilot Study	105
3.7.1	Validity and Reliability of Questionnaires	106
3.7.2	Validity and Reliability of Performance Test	108
3.8	Data Analysis	108
3.8.1	Analysis on Deaf Students' E-Learning Readiness	109
3.8.2	Analysis on Deaf Students' Performance	110
3.8.3	Analysis on Deaf Students' E-Learning Usability and Motivation to Learn	112
3.8.4	Formulation of the Learning Patterns in Using the E-Learning	113
3.9	Interview Sessions	115
3.10	Expected Outcome	115
3.11	Summary	116
4	DESIGN AND DEVELOPMENT OF E-LEARNING ENVIRONMENT FOR DEAF STUDENTS	117

4.1	Introduction	117
4.2	Instructional Design	117
4.3	ADDIE Model	118
4.3.1	Analysis Phase	119
4.3.1.1	Analysis of Content	119
4.3.1.2	Analysis of User	120
4.3.2	Design Phase	121
4.3.3	Development Phase	124
4.3.3.1	Software and Hardware	125
4.3.3.2	Sign Language Videos and E-Learning	127
4.3.3.3	Alpha Testing	135
4.3.4	Implementation Phase	135
4.3.5	Evaluation Phase	136
4.4	The Developed E-Learning Environment	136
4.4.1	Logging In	137
4.4.2	Main Page	138
4.4.3	Sub Topic	139
4.4.3.1	Notes	140
4.4.3.2	Forum	141
4.4.3.3	Quizzes	142
4.4.3.4	Chat Rooms	143
4.4.3.5	Glossaries	145
4.5	Summary	146
5	RESEARCH FINDINGS	147
5.1	Introduction	147
5.2	Background of Respondents	148
5.3	E-Learning Readiness of the Deaf Students	148
5.4	E-Learning Usability and Motivation to Learn of the Deaf Students	155

5.5	Performance Level of the Deaf Students in Learning Science	161
5.6	Learning Patterns of Using the E- Learning by the Deaf Students	169
5.7	Interview Session	175
5.8	Summary	176
6	DISCUSSIONS AND CONCLUSION	178
6.1	Introduction	178
6.2	Overview of the Research	178
6.3	Discussion	179
6.3.1	E-Learning Readiness of the Deaf Students	179
6.3.2	Sign Language Video Implementation within the Developed E-Learning	184
6.3.3	E-Learning Usability and Motivation to Learn of the Deaf Students	186
6.3.4	Performance Level of the Deaf Students in Learning Science	191
6.3.5	Learning Patterns of Using the E- Learning by the Deaf Students	197
6.4	Conclusion	202
6.5	Implications of the Research	205
6.6	Contributions of the Research	206
6.7	Limitations of the Study	207
6.8	Recommendations of Future Studies	208
6.9	Summary	209
	REFERENCES	211
	Appendices A – I	224 - 265

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Countries Based on Sub-Regions and Their Distribution Percentage of Deaf Individuals	29
2.2	Differences between Medical and Social Model	33
2.3	Registered Disabled Individuals Based on Various Disabilities (2002 - 2007)	35
2.4	Difference between Bahasa Malaysia/English and BIM	38
2.5	E-Learning Readiness Assessment	63
2.6	E-learning Environment for Deaf Students	69
2.7	E-learning Usability Assessment	76
3.1	Types of Research Design Based on Research Questions	85
3.2	Sample Size Based on Population	93
3.3	Dimensions of E-Learning Readiness Questionnaire	94
3.4	Score Division of the Likert Scale E- Learning Readiness Questionnaire	95
3.5	Tools in Moodle	96
3.6	Sign Language Video Script	97
3.7	Learning Activities Based on Sub Topics	98
3.8	Learning Activities Based on Problem Solving Strategies	99
3.9	Examples of questions in Performing Test	100

3.10	Example of Questions in Forum	100
3.11	Dimensions of E-Learning Usability and Motivation to Learn Questionnaire	101
3.12	Score Division of the Likert Scale E-Learning Usability and Motivation to Learn Questionnaire	102
3.13	Instrumentations and Respective Respondents	102
3.14	Log Data of Preliminary Investigation	104
3.15	Cronbach's Alpha Coefficient Rules of Thumb	107
3.16	Cronbach's Alpha Value for E-Learning Readiness Questionnaire	107
3.17	Cronbach's Alpha Value for E-Learning Usability and Motivation to Learn Questionnaire	107
3.18	Interpretation of mean scores of variable	109
3.19	Deaf Students' E-Learning Readiness Level	110
3.20	Grading System for Pre-Test and Post-Test Score	110
3.21	Increment Category from Pre and Post-Test Score	111
3.22	Paired Samples Statistics	112
3.23	Paired Samples Correlations	112
3.24	Paired Samples Test	112
3.25	Deaf Students' E-Learning Usability and Motivation to Learn	113
3.26	Summary of Data Analysis	115
4.1	Number of Questions of Nuclear Energy in SPM Science Paper Year 2009-2013	120
4.2	Learning Activities and Problem Solving Strategies	123
4.3	Software and Hardware Used in the	

	Development	126
4.4	Description of Sign Language Video 1	127
4.5	Description of Sign Language Video 2	128
4.6	Description of Sign Language Video 3	129
4.7	Description of Sign Language Video 4	130
4.8	Description of Sign Language Video 5	131
4.9	Description of Sign Language Video 6	132
4.10	Components in E-Learning Environment	146
5.1	Total Number of Deaf Students Based on Gender	148
5.2	Total Number of Deaf Students Based on Age	148
5.3	Technology Access	150
5.4	Online Skills and Relationships	151
5.5	Online Video	152
5.6	Internet Discussions	153
5.7	Importance to Success	154
5.8	Deaf Students' E-learning Readiness	154
5.9	Content	156
5.10	Learning and Support	157
5.11	Visual Design	158
5.12	Navigation	158
5.13	Interactivity	159
5.14	Motivation to Learn	160
5.15	Deaf Students' E-learning Usability and Motivation to Learn	160
5.16	Deaf Students' Performance Level in Learning Science	162
5.17	Deaf Students' Minimum and Maximum Scores, Means, and Standard Deviation of Pre-Test and Post-Test	165
5.18	Normality Test for Pre-Test Score and Post-test Score	167

5.19	Paired-Sample t-Test for Pre-Test and Post-Test Scores	168
5.20	Effect Size and Post Hoc Power Analysis	169
5.21	Attributes for the Decision Tree Structure	170
5.22	Learning Patterns Based on Increment Category	172
5.23	Learning Patterns of P4 Increment Category	173
5.24	Summary of P4 Increment Category Learning Patterns	173
5.25	Learning Patterns of P3 Increment Category	174
5.26	Summary of P3 Increment Category Learning Patterns	174
5.27	Learning Patterns of P2 Increment Category	174
5.28	Summary of P2 Increment Category Learning Patterns	175
5.29	Sample of the Findings from the Interview Session	175

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Theoretical Framework	14
1.2	Conceptual Framework	15
2.1	Technology for the Deaf	53
2.2	Access Technology for the Deaf in Education	54
2.3	Type of Communications in E-Learning	58
2.4	Kinneavy's (1971) Communication Triangle	76
3.1	One-group Pre Test and Post Test Research Design	86
3.2	Research Procedure	89
3.3	E-Learning Environment	103
3.4	Sign Language Video	104
3.5	Example of Decision Tree	114
4.1	ADDIE Model	119
4.2	Template of the Interface of the Sign Language Video	122
4.3	Interface of Sign Language Videos	123
4.4	Screenshot of Sign Language Video 1	128
4.5	Screenshot of Sign Language Video 2	129
4.6	Screenshot of Sign Language Video 3	130
4.7	Screenshot of Sign Language Video 4	131
4.8	Screenshot of Sign Language Video 5	132
4.9	Screenshot of Sign Language Video 6	133

4.10	Development Process of Sign Language	
	Video	134
4.11	Editing Process of Raw Videos	134
4.12	HTML Editor	135
4.13	Logging in Window	137
4.14	User Editing Profile Window	138
4.15	Main Page Window of the E-Learning	
	Environment	139
4.16	Example of the Sub Topic Layout	140
4.17	Example of Notes	141
4.18	Example of the Forum Section	142
4.19	Example of Quiz	143
4.20	Chat Rooms for Students	144
4.21	Chat Rooms for Students and	
	Instructor/Administrator	144
4.22	Example of the Glossary	145
5.1	Percentage Score of Pre-Test based on	
	Objective and Subjective Questions	163
5.2	Percentage Score of Post-Test based on	
	Objective and Subjective Questions	163
5.3	Classification of Pre-Test and Post-Test	
	Scores Category	164
5.4	Classification of Pre-Test and Post-Test	
	Increment Category	165
5.5	Differences of Pre-Test and Post-Test	
	Scores	166
5.6	Decision Tree Structure	171

LIST OF ABBREVIATIONS

UPSR	-	Ujian Penilaian Sekolah Rendah
ICT	-	Information and Communication Technology
RFID	-	Radio Frequency Identification
HECE	-	Heuristic Evaluation for Child E-Learning
HCI	-	Human Computer Interaction

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	E-Learning Readiness Questionnaire	224
B	Learning Activities	228
C	Pre and Post Test Assessment	232
D	E-Learning Usability and Motivation to Learn Questionnaire	240
E	Interview Questions	244
F	Validation of E-Learning Readiness Questionnaire	245
G	Validation of E-Learning Usability and Motivation to Learn Questionnaire	251
H	Validation of Pre and Post Test Assessment	257
I	Validation of E-Learning Environment	259
J	Sign Language Videos Script (Bahasa Malaysia version)	265

CHAPTER 1

INTRODUCTION

1.1 Introduction

There are many disabled people who have the right to get the best education as possible, just like the other normal individuals. Deaf individuals are among that group of people. Deaf individuals, particularly deaf students, have the same mental capabilities as the other normal students in terms of academic achievement (Wolff *et al.*, 1989). The term '*deaf & dumb*' is not appropriate for describing deaf students since they typically only suffer from a hearing disability, not a lacking of intelligence (Sisqo and Anderson, 1978). Therefore, the term '*deaf*', '*hard of hearing*' or '*hearing impaired*' seem more appropriate to be used in this today culture. In this particular research, the term '*deaf*' is used based on contexts of this particular research which focusing on the students who are completely deaf and the term is commonly used in the Malaysian context. Consequently, they can be taught the same subjects in school as those taught to their hearing peers.

Science is one of the core subjects taught in school. Deaf students are required to learn the same science topics as their hearing peers. The only difference between them is the approaches used by the teachers to channel knowledge to deaf students correctly and as effectively as possible. Hearing students typically have few problems studying in conventional learning environments, regardless of their intellectual level. The most typical conventional learning method is in class learning. Hearing students do not require any special methods to teach them obtain the best

result from the teaching itself. However, for those students who suffered from various disabilities, particularly deaf students, conventional methods of learning may not be suitable for them, especially if no accommodations are made to meet their needs.

Studying is not the act of receiving knowledge alone. It is a combination of communication with others and with the learning environment (Bisol *et al.*, 2009). Deaf students are taught in class using sign language, the universal language for the deaf community. Nevertheless, even using this method, teachers encounter difficulties teaching deaf students. This is where technology comes in handy for deaf students. Various types of technology have the potential to assist deaf students and each technological feature has its own advantages. The use of technology could help deaf students to access sound in their own way (Berndsen and Luckner, 2010). By managing to do so, the knowledge distribution to the deaf students can be done easier and could help the deaf students understanding the knowledge better.

Technology has become a vital part of our daily lives. Technology can alter our everyday lives as well as affecting our surroundings and routine activities (Ropke, 2001). It makes our works easier and faster. Without technology, most of our daily works would be harder and would take more time. The use of technology for educational purposes has also become important, both for teachers and students. It helps distribute information in the best way possible so that students can obtain the information needed for their lessons. With technology, information is distributed in more potent ways than the conventional ones, hence and it can affect a student's studying, and performance as well as some emotive attributes regarding of learning activities (Dogan, 2012). Eventually, it could help them to understand certain topics easier than the conventional in class learning. This condition especially took effect when the students are learning on their own after school hours without any help from their teacher. Therefore, by using the available technology that suited their requirements in learning could really help their learning process. Several learning methods that use technology have been created by researchers and developers. One of these learning methods is the use of an e-learning environment.

E-learning is one of the most popular platforms used for distributing information in educational departments. It makes the tasks of teachers and students easier in terms of relaying and obtaining the knowledge needed to meet educational goals by using some alternate approaches. Both teachers and students can collaborate with each other in a structured knowledge based environment, and students can benefit from the environment without any external control from their teachers (Singh, 2003).

Most technologies have been rapidly improving from time to time in every aspect. The improvements vary from its features to its functionality. When these aspects improve, it does not assure that every individual can make use of these improvements due to some constraints that may be occurred from the technology especially those caused by a lack of usable features for certain groups of users. In e-learning, these constraints also occurred because of a lack of awareness on the part of researchers or developers. Some of those constraints are related to usability, interface, compatibility or perhaps the suitability of its contents. Researchers and developers tend to forget about the wide group of users that might be using the system, some of which might have a disability such as hearing loss. Deaf students who use e-learning, could not get away to face this type of constraints. They often face problems such as the approachability of certain websites or e-learning environments, fixed time limits for online exams, the accessibility of digital audio and video, as well as a lack of adaptable knowledge sources (Fichten *et al.*, 2009). With the occurrence of these limitations and obstacles, it might lead to very difficult situations for the deaf students when it comes to acquire new knowledge in their learning process. This could hence negatively affect their understanding level of the certain contents that are available within the e-learning without any added features that met the need and requirement for better understanding.

Most of society would most probably assume that deaf individuals face problem related only to their hearing capabilities. However, the problems faced by deaf individuals extend beyond that. Depending on their time loss of hearing, these special individuals would face other difficulties such as reading or speaking in their native language. Deaf individuals that use sign language as their first language would

find difficulties when using their native language for reading and writing purposes (Wu, Chiu, and Guo, 2004). Hence, even though with advanced technologies they would probably still face some difficulties in studying. Thus, these advanced technologies must be suitable for deaf individuals, meaning those technologies must have features with attributes specially formulated for them. Therefore, in order to help them overcome these difficulties while using e-learning, an added feature must be included within the developed e-learning in order to help them using it in the best possible way.

This added feature is mainly focusing on the implementation of sign language within an e-learning environment. It is also hoped that this feature will help them getting the information needed in the most accurate way as possible. This is needed because most of the available information is not fully accessible by deaf students themselves such as some videos or movies that include audio for it to be fully understood. The developed e-learning environment might also be able to be helpful in improving the deaf students' performance in their studies by giving them a learning platform that is built based on their needs and requirement for better understanding of the contents that they are learning.

1.2 Background of Problem

Disability is a condition where an individual sustained from it must be face the world primarily created for able bodies individuals, in their own way. Regardless of how the condition is viewed, both by the normal or the disabled person, there are still difficulties faced by this group of individuals in their daily lives activities. However, the manner in which they faced these difficulties should be taken into account. French (1994) has stated that disabled individuals are not only viewed by their disability but they are also defined by their ability to cope and adjust to society, which can lead to some negative conditions such as sadness and depression. Many disabled individuals are seen as low interpolation within the society, simply because of their condition which consequently would limit their opportunity for education

and employment (Echevin, 2009). Therefore, they cannot simply use their disabilities as part of their excuses for facing the real world. The same goes for deaf students. Obviously deaf students would face some difficulties learning in school because of their low literacy levels. Technically, literacy is the main ingredient in learning because a student must be able to read and write what they have learnt in class. Subjects taught to deaf students are as the same as those taught to hearing students. Consequently, they must find a way to cope despite the difficulties because that is the only way for them to compete against hearing peers. One of the subjects taught to them is Science.

Science is one of the major subjects taught to the students in schools, both primary and secondary. Science knowledge is very important since the knowledge within the contents are related to our daily lives, either directly or indirectly. Manifestly, statistics show that the result of Science subject during major exams is low compare to other subjects. For example, in South Africa, Reddy (2004) found that there were no improvements in terms of performance in Science from the year 1999 to the year 2003. The results of the Ohio Graduation Test reported that students had lower scores in Science compare to other subjects (Palmer, 2009). In Malaysia particularly, the overall performance of the Science subject for the Ujian Penilaian Sekolah Rendah (UPSR) has been declined (Kementerian Pelajaran Malaysia, 2011). This decline may be because the subject is not being pushed hard enough to be taught to the students who took the subject.

The conventional teaching methods used in a classroom are necessary, but they cannot assure that all of the students will be fully benefited from them. This is because in a classroom for example, there might be some kind of unwanted disruptions within the class itself that can interfere with a student's focus in class. Some of these disruptions are students talking while the teacher is teaching, the usage of communication devices, and the disrespectfulness towards other classmates. While the normal students face these problems, students with disabilities, particularly the deaf students would face the same problems, to an even greater extent. Learning in class, particularly in a Science class requires the students to be able to listen what the teacher is explaining at the front of the classroom. At the same time, they will

have to read from books related to what were taught by the teacher. After the lessons end, they typically have to write about what they were taught in order to recall the knowledge.

While we know the deaf students would most probably face hearing problems, we may not know that they also face difficulties when it comes to literacy (Moore and Martin, 2006). The problem becomes greater when they are required to complete multiple tasks at once in limited time provided. Learning is a continuous process that does not end when a student leaves their class. The students must keep studying the lessons that have been taught by their teachers to fully understand the lessons. For normal students, they can simply read the notes or books regarding the lessons all by themselves and rely on their understanding of the lessons. However, for deaf students, they will find it difficult to read from notes or books especially all by themselves without any guidance or help. This is because, the words used in books require some lingual explanations to be understood which is difficult for deaf students since they are lacking of the access to their native language (Wauters *et al.*, 2003). Consequently, this could most probably diminish their motivation level in studying.

Motivation plays a part in every action need to be taken, and it is no exception for the deaf students in terms of studying. One of the factors affecting deaf students' motivation level is the lack of communication skills not only by the deaf students themselves, but the hearing individuals, especially the family members of the deaf students. Their low communication skills towards the deaf would damage the deaf self-esteem. Some of the family members even set lower expectations towards their deaf and deny them not only casual daily conversations but also a proper access to knowledge itself (Scheetz, 2003). In school, the teachers should not expect anything negatively towards the potential that might be acquired by their deaf students. The teachers should keep in mind that these deaf students might encounter difficulties in reading and learning, but they are still capable of learning and more should be expected from them (Andrews *et al.*, 2000). When people lay more trust on these deaf, their self-esteem will be boosted and will motivate them in doing anything especially in learning. The inability to adapt with the knowledge sources

created for the normal hearing students would somehow negatively affect their performance of their studies generally, since the lacking of information and the desire to explore for more information. This shows that deaf students' motivation depends on their connection towards the knowledge sources. A proper learning environment should be developed so that these deaf students will get to study with high motivation.

Therefore, another alternative learning method should be provided in order to overcome these types of difficulties faced by these deaf students in their learning activities. This alternative method is particularly created for the deaf students to revise the lesson in their own time without any help from others. The usage of technology should help in this cause and lessen the burden faced by them. Knowledge attained from direct education through computer help increasing the motivational level in learning (Piquette, 1994). Computer oriented language activities conducted by Garcia and Arias (2010) have proven that it could help improve the students' motivation levels in terms of searching for available references that are much easy to attain. The employment of some game components within education has also showed that it could make learning activities fun and more interesting to do, hence increase the motivation as well as the performance levels (Boyce & Barnes, 2010). Past developers and researchers have developed number of systems and courseware using different type of information and communications technology (ICT) tools in order to help students with disabilities, particularly deaf students in their studying. Interactive multimedia learning environment and radio-frequency identification (RFID) are types of technologies have been used due to this particular cause. For example, Villani and Wright (2007) used the interactive 3D virtual environment while Huang, Smith, and Spreen (2008) implemented the RFID technology, both for the deaf learning environment. However, these types of technologies require high level of knowledge and some are expensive. Consequently, the usage of e-learning is more practical if these constraints are to be taken into account. E-learning is easy to be developed and there is some free open-source tools to be used within the development process. In addition, it is cost efficient, dependable, and easy to control and is very compatible with different machines (Ahmad, Udin, and Yusoff, 2001). Besides that, by putting these deaf students within

the online learning environment could indirectly increase their involvement in communicating with their teacher as well as their peers.

The usage of e-learning has been quite rapidly growing within the educational departments throughout the world. The usage of technology for the educational purposes has been proven very effective. Nowadays, the time constraints have been much of a problem for most people in this world. Everything, if ever, must be attained as soon as possible. Information is among the things that are important that must, if ever, be attained as fast as possible. Learning based information is part of information that will be benefited the users if it is being distributed without using much time. Compare to the conventional learning environment, e-learning is very interactional and improves information retention (Nur'Aini, Majid, and Yen 2002). By using e-learning, the information that is needed is just one click away and it is easy to be accessed. Since it is easy, the range of the users that can employ it is quite wide, from the young children to elderly people. Disabled people, particularly deaf students, are among this group and arguably will be benefited greatly from using the e-learning technology in their study. It will benefit them by giving them an alternate way of learning instead of the conventional method that has many difficulties particularly for them (Li & Xu, 2009).

It is generally assumed assume that deaf students face difficulties only in hearing. Although this might be true for some deaf students, but most of them face greater problems than hearing alone. Since they cannot afford to hear, they also find it difficult to read since basically what is written is based on language pronunciation been used when people are speaking to each other. The native language used by normal individuals would most probably not the first language for deaf individuals. Therefore, the usage of special language, in this matter the sign language designed for the deaf students is important, in collaboration with the technology of e-learning. It is vital since when the sign language is not the first language to be used, it will have some unwanted implications in the learning activities (Bochner and Bochner, 2009). The e-learning itself is useless if the deaf students could not understand its contents because of their disabilities. Sign language is basically the universal language for individuals with hearing problem and can be seen as their native

language. When normal hearing people can attend number of different foreign languages classes, the sign language is still in favor for the deaf individuals as their first language (Cunningham and Cunningham, 2011). Therefore, in order to employ the sign language within the e-learning, some other technology principles need to be implemented as well. Video stream technology is one of the best methods to collaborate with the sign language. It is implemented by translating those text blocks in the e-learning into the form of videos of sign language notations. This collaboration could help to improve the deaf students reading skills and also encourage them to work independently (Drigas and Kouremenos, 2005). The videos are not mere conversions to the sign language notations, but they are nurtured by some deaf experts' opinions and knowledge regarding anything about deafness so that they are fully adaptable for the deaf students. This is important, so that the deaf students will be exposed to a familiar environment while completing their studies using the translated videos within the developed e-learning (Bueno, Alonso, and Castillo, 2007).

Usability of an e-learning also could be one of the issues among deaf students. In e-learning context, usability or "*ease of use*" is defined as the effectiveness, efficiency and satisfaction (Karat, 1997) with which users can achieve specified learning goals in a particular environment, or using specific tools, or resources. Usability should play an important role in accessibility testing, since a resource presenting usability difficulties will generally present significant accessibility problems for disabled users (Sloan *et al.*, 2002). A web site that might have a high level of accessibility can yet have usability problems that may prevent people with disabilities from using them efficiently. Therefore, reasonable adjustments should be made to meet the needs of disabled students in accessing the curriculum. One such reasonable adjustment is addressing usability issues in e-learning developments. Nielsen (1994) introduced heuristic evaluation on usability and he came out with Nielsen Usability Heuristic dimensions, which were Visibility of System Status, Match Between System and the Real World, User Control and Freedom, Consistency and Standards, Error Prevention, Recognition Rather than Recall, Flexibility and Efficiency of Use, Aesthetic and Minimalist Design, Help Users Recognize, Diagnose, and Recover from Errors, and Help and Documentation.

Nielsen heuristics are basically generic, and might not encompass usability attributes specific to children or e-learning. The new Heuristic Evaluation for Child E-learning (HECE) created by (Alsumait & Al-Osaimi, 2010) would overcome these shortcomings.

A previous study conducted by Karal and Silbir (2010) on usability of a system investigated how deaf students responded to a visual dictionary developed for the deaf students. Their study also embedded visuals of sign language in a system to study deaf students' performance in learning language. The usage of e-learning among students with disabilities had been conducted by Buzzi *et al.* (2007), where they tried to identify problems often encountered by a blind person using screen reader and voice synthesizer when using e-learning systems. Kuzu (2011) also had conducted a study on the factors that motivate and hinder the students with hearing impairment to use mobile technology. His study did not focus on learning any specific subject but it is more concentrated on the general issues. The area of e-learning embedded with sign language videos in learning Science is still unexplored especially in finding the learning patterns of the used of e-learning among them that enhance performance in learning (Al-Bayati and Hussein, 2009). With the development of technology, the use of e-learning embedded with videos is possible to provide more interesting and dynamic learning environments to deaf students. These developed videos with their main content being the sign language and additional features such as animations and graphics as well as subtitles that appropriate to be used to meet the needs and requirements of the deaf students in their learning process.

1.3 Problem Statement

Disabled individuals could not avoid from problem in their routine activities. Activities that are easy to be executed by normal people are somehow difficult for the disabled people. Deaf individuals face the same obstacles, particularly deaf students in their learning activities. Due to their low literacy level, it is hard for them

to learn new knowledge and get a good understanding about the knowledge by simply reading. Unlike normal hearing students who can easily read from books and acquire the knowledge, the deaf students find it very difficult in understanding the knowledge through books, hence appropriate knowledge resources are needed in helping them to acquire the knowledge in the best way possible. These knowledge resources have to cope with these deaf students' limitations that could hinder their learning process to be effective for their better understanding of the knowledge. In term of learning the topics from the Science subject, it required a lot of reading since the contents are based on a lot of theories. This could give difficulties to the deaf students to clearly understand the contents of the subject. Therefore, the usage of suitable technology and features could overcome these difficulties.

The usage of accessible technology among deaf students help them to communicate and socialize better with their classmates as well as make them more inclusive within the whole class which indirectly could increase their focus level and participate more within the class activities (Lartz, Stoner, and Stout, 2008). However, the suitable and practical methods have to be used in order for the technology to be used in the best way. E-learning is the technology that fits this criterion and is most likely the appropriate solution for the problems faced by deaf students such as low performance and low motivation level in studying. Selected technology that is appropriate to implement the sign language feature will be used based on the problem attributes faced by deaf students.

Therefore, this research developed an e-learning environment that is best suited for deaf students. The development of this e-learning concentrated on the implementation of the usage of sign language within the e-learning environment. Prior to the development, deaf students' e-learning readiness was identified. Finally, this e-learning would help the deaf students to learn Nuclear Energy topic in the best way possible. Hopefully, the outcomes of this study will raise the awareness of the developers in order to help the deaf students in using the e-learning.

1.4 Research Objectives

In order to attain the outcome of the study, the following objectives have been identified:

- i. To identify e-learning readiness of the deaf students.
- ii. To implement sign language feature within the e-learning environment on Nuclear Energy for the deaf students.
- iii. To identify e-learning usability and motivation to learn of the deaf students.
- iv. To examine the performance level of the deaf students in Nuclear Energy after using the e-learning environment.
- v. To synthesize the learning patterns of using the e-learning environment by deaf students in learning Nuclear Energy that enhances their performance.

1.5 Research Questions

The research questions are:

- i. What is the e-learning readiness level of the deaf students?
- ii. How is the sign language feature to be implemented within the e-learning environment on Nuclear Energy for the deaf students?
- iii. What is the e-learning usability and motivation to learn of the deaf students?
- iv. What is the performance level of the deaf students in Nuclear Energy after using the e-learning environment?
- v. What are the learning patterns of using the e-learning environment by deaf students in learning Nuclear Energy that enhances their performance?

1.6 Theoretical Framework

Theoretical framework is an outline that basically explains the interrelated concepts that were used throughout the course of the whole research. The theoretical framework was used as guidelines in the research as to determine what to be measured and to be evaluated any statistical relationships that might be occurred. Figure 1.1 and figure 1.2 show the theoretical framework as well as the conceptual framework of the whole research respectively.

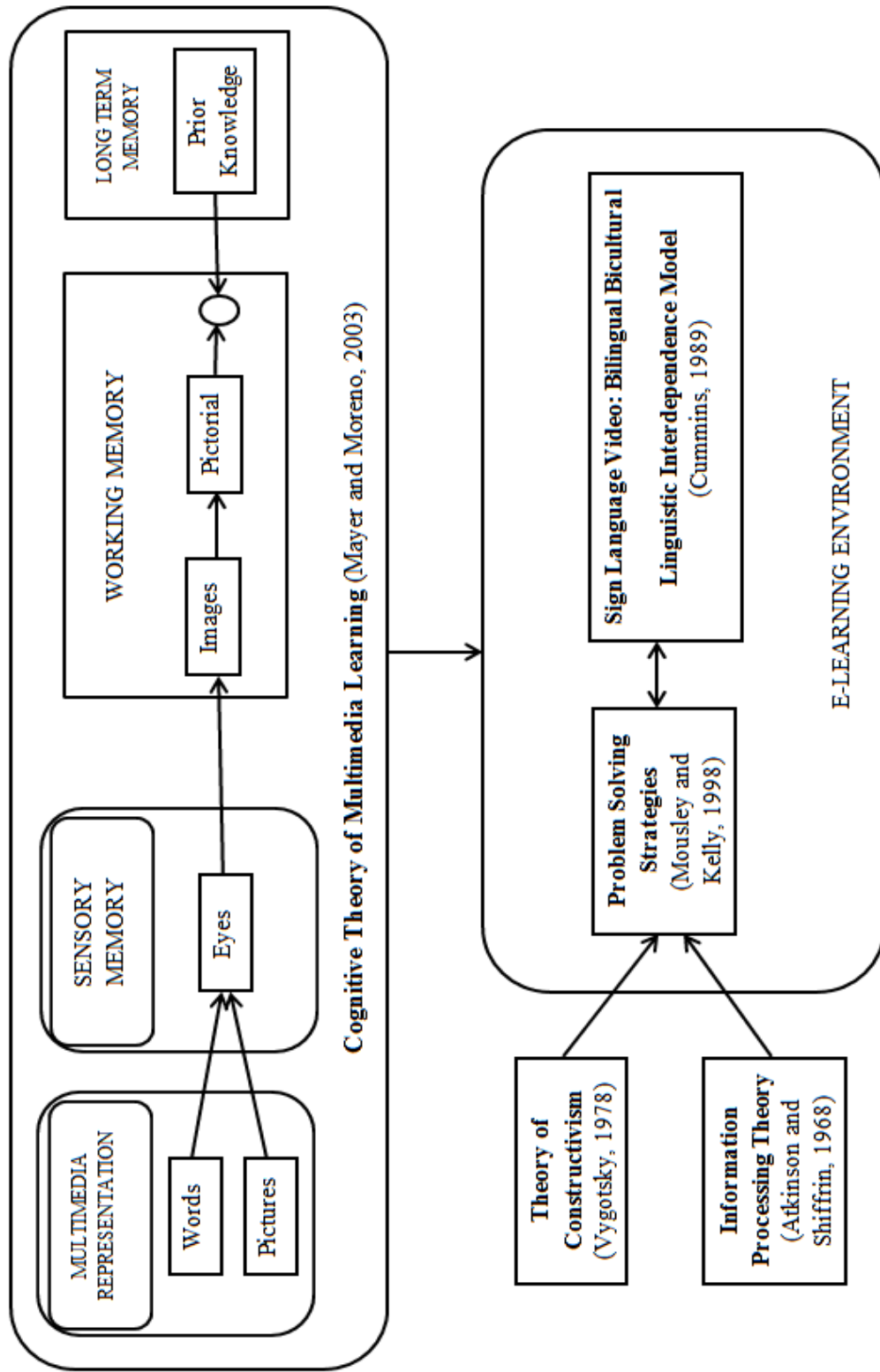


Figure 1.1 Theoretical Framework

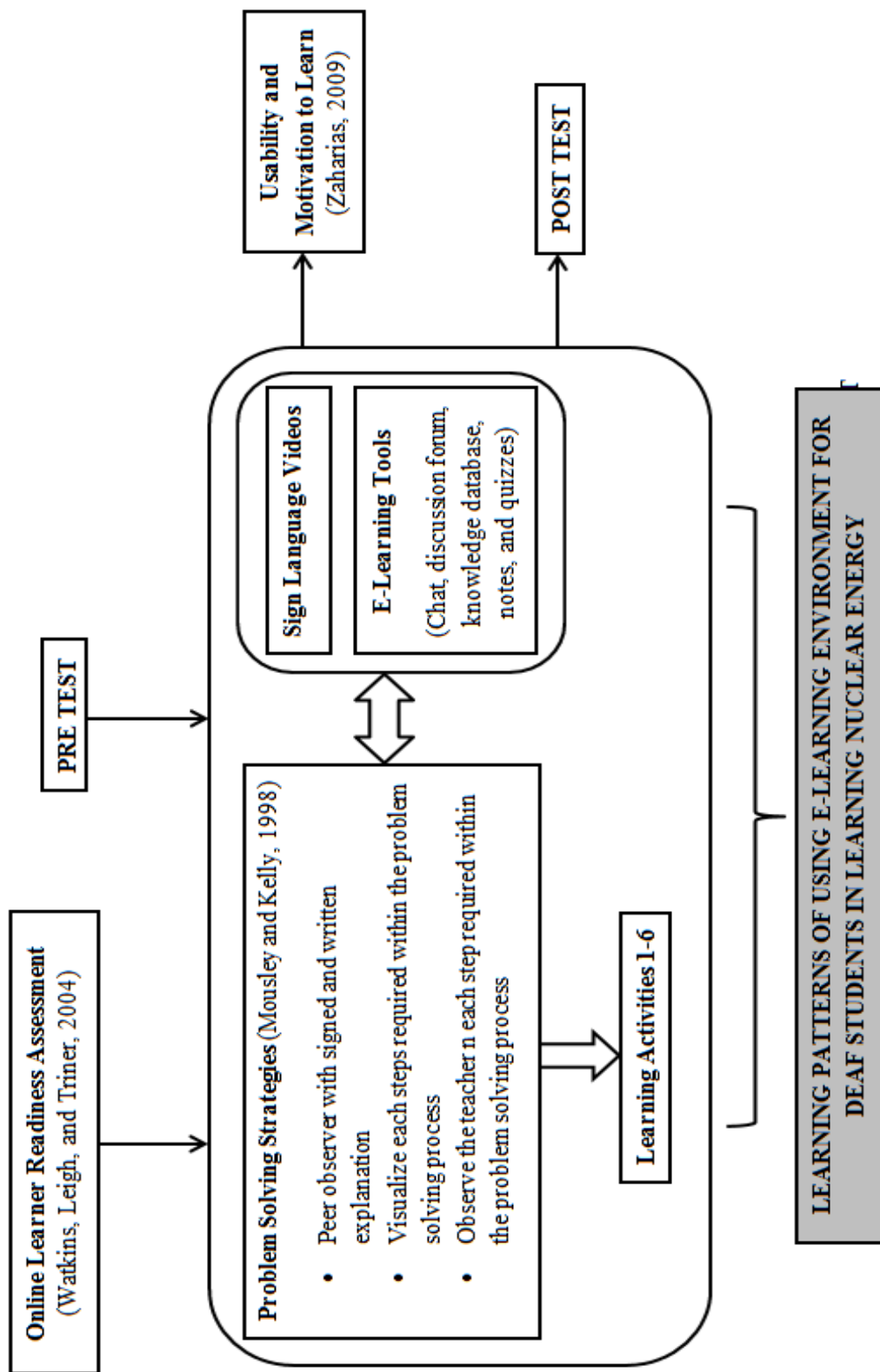


Figure 1.2 Conceptual Framework

1.6.1 Cognitive Theory of Multimedia Learning

Based on Mayer and Moreno (2003), in terms of learning, individuals tend to do better and more deeply understanding of the contents if it involves both words and pictures instead of the usage of texts alone. This is known as multimedia principles. In general, multimedia is considered by researchers as the combination of both images and texts. The process of learning through multimedia only does exist if a mental representation of both images and texts is built. The words used are either written or spoken, while the images can be in the form of any graphical representation such as photos, illustration, animation or video. The multimedia instructional design acts as the platform in combining both words and pictures in making sure that the learning process can be effective to the targeted learners.

There are several other theories that influenced the theoretical foundation of this particular cognitive theory of multimedia learning. Those theories are working memory theory by Baddeley and Hitch (1974), dual coding theory by Paivio (1986), and cognitive load theory by Sweller (1988). In terms of cognitive theory of learning, it involves the information processing model of cognition. Based on this particular model, information are resulted from the conversion of stimuli which is then stored in the form of memory (Moore, Burton, and Myers, 2004). The term cognitive refers to the act of perceiving and knowing. The mental process that occurs within the act of perceiving, thinking, remembering, understanding languages, and learning are being studies by cognitive scientists (Stilings *et al.* 1995). Hence, by using appropriate instructional technology, more in depth insight on the human nature and more importantly to discover more efficient methods in terms of the learning process (Sorder, 2005).

1.6.2 Constructivism

First of all, it has to be known that the primary idea of constructivism is mainly focusing on conceptualizing knowledge as well as the acquirement of it. In this particular matter, most constructivists view the nature of the knowledge itself

and how it can be developed into certain level, based on certain philosophical theories. The world of academic literature is somewhat not complete without the mentioning of the term constructivism, particularly to be used in many academic papers or journals and as well as in books that are widely used for teaching, learning, assessment, curriculum development and training for various types of courses and subjects. This includes the Science subject.

In Science education literature, the concept of constructivism is viewed by the constructivist in multiple versions in terms of students' learning (Good, Wandersee, and Julien, 1993). Even though these constructivists have distinguished philosophical point of view, they still share the same constructivist core. The most common constructivist core among them is *'the view of human knowledge as a process of personal cognitive construction, or invention, undertaken by the individual who is trying, for whatever purpose, to make sense of their social or natural environment'* (Taylor, 1993). Simply said, knowledge is not viewed as the exact attributes of the world or environment, but rather as some sort of construction process of the individuals themselves. Fransella (2008) implied that the acquisition of knowledge acquirement is not merely a transmission of pure knowledge to the individual themselves but instead a construction process by that particular individual. A principle within a constructivism theory by Von Glaserfeld (1983) stated that *'knowledge is not passively received but is built up by the cognizing subject'*. Based on this particular principle, it implies that it is almost impossible to transfer mere knowledge to students' thoughts, instead students will construct their own ideas and meaning of anything, for example words, images, sound etc that they see or hear. Therefore, the learner can be said as an active knowledge constructor instead of simply being a passive knowledge receiver.

Hence, in order to encourage students to be an active knowledge constructor, learning strategies used must allow students to be an active learner. One of the learning strategies that seems suitable is problem solving.

1.6.3 Problem Solving

Bransford and Stein (1984) stated problem solving strategies as a set of steps required in order to solve problems that are occurred within the way to achieve a certain objective. Alternatively, it also can be defined as "*problem-solving cycle*". Some of the steps needed within this particular cycle are such identify the problem, specify the problem, design a series of steps needed to solve the problem, classify any knowledge known or unknown from the problem, and finally assess the most appropriate solution for the problem. In addition, Blanchard-Fields (2007) claims that problem solving can be seen in two sides, rather than just a single side. One side focusing on the types of problems which can have only a single possible solution that can be accepted, such as those of math questions or questions that are based on mere facts. The other side of it is focusing on problems which can have multiple solutions, or a dynamic solution that can keep changing from time to time, regards of its current situation.

Three problem solving strategies for deaf students have been developed by Mousley and Kelly (1998). The first problem strategy that will be implemented requires the involvement of peer observer by giving them an explanation in the form of sign language. This particular understanding of the certain topic that has been acquired will then be transformed into a solution in a written form. Two main purposes of this strategy is to show that the deaf students clearly understand the problem solving rules through the explanations and to evaluate whether the deaf students' reading levels would influence the explanations made through sign language as well as the written form. Based on Pau (1995), it is said that the problem solving performance of deaf individuals are somehow related to their reading ability. The two explanation methods, sign language and written response, were found based on the method suggested by Woditsch (1991) in assisting the deaf students in enhancing their thinking ability through a process, in this matter, problem solving process. The second problem solving strategy required them to visualize what is to happen within the problem solving process, from start to finish. This style is vital in making sure that the students will be able in developing a thoughtful strategy required in solving the problem given to them. Appropriate series of steps are

necessary in order for the students to acquire the best solution possible to the certain problem, and not only merely solve the problem. The last strategy required the deaf students to observe their teacher on each and every step needed within the problem solving process for each problem given to them. This particular strategy encourages the deaf students in translating the sign language instruction given by their teachers into the actual steps needed in solving the problem, instead of simply writing it down.

In addition to learning strategies, since this research is focusing on the use of e-learning in learning Nuclear Energy, therefore interaction among students and students and students and teacher must be based on certain human computer interaction principles.

1.6.4 Information Processing Theory

There is flexibility advantage when it comes to learning through the process of gathering information. It will give the learners certain options if there is any unexpected occasion occurs. Instead of using any fixed responses which could be a problem if there are no other options available. Computer analogy has become the main foundation for researchers are designing any model of memory. Atkinson and Shiffrin (1968) have proposed with the most influential model of memory to date. Based on the model, it was assumed the environment itself is where all the information came from. This information is then processed by a number of temporary sensory memory systems (a part of the process of perception) and eventually led to the limited capacity of short term store. This is called the working memory. This particular system allows the information that is held to be used in performing a number of cognitive tasks as well as transferring and retrieving it from the long term memory.

Baddeley and Hitch (1974) has come out with a proposed model of working memory, in distinguishing the processes that occur within the long term memory and

short term memory. This model consists of three parts which contain a central executive control system that controls two other systems, which are the phonological loop and visuo-spatial. The phonological loop responsible in coding any acoustic information while the visuo spatial responsible in coding any visual information gathered.

1.6.5 Linguistic Interdependence Model

In deaf education world, most bilingual-bicultural models implemented are based on the theoretical idea by Cummins (1989), called linguistic interdependence model. This particular model implies that all languages used worldwide bear a common proficiency. Based on this model, it can be said that deaf individuals which have solid grasp of their native sign language can use this advantage in supporting the usage of languages used by normal hearing individual in a written form during their learning activities. This allows the knowledge to be transferred without any occurrence of language barrier. Nevertheless, the knowledge transferred are mainly on academic and literacy skills rather than all types of skills.

The existence of linguistic interdependence within the deaf education world is rather clear, in very defined and specific ways. A very strong and firm correlation has been identified between the reading as well as the writing skills in the native language and mastering the same skills for that particular language (Treger and Wong, 1984). Hence, the usage of this model was vital in making sure that the deaf students could master the literacy skills in that native language, in addition to the sign language.

1.7 Rationales of the Study

The whole study consisted of several phases which are connected to each other. Firstly, the sign language was chosen to be the main element for the e-learning environment was simply because it is the language used by these deaf students in their learning activities. The main knowledge resources within the developed e-learning environment are in the form of sign language videos. However, with the collaboration with the e-learning technology it could give some advantages if it is to be compared to the usage of sign language conventionally. The ability to use the e-learning especially after class hours could help the deaf students learning using other alternative ways instead of the conventional method of reading notes. The usability of the e-learning investigated deaf students' point of view towards the developed e-learning environment in learning the Nuclear Energy. The deaf students will responses on how the think of the implementations of this developed e-learning environment toward its usage during their learning process. The e-learning environment usability assessment based on the affective human computer interaction model was an appropriate way to measure the usability of the deaf students since it involves the assessment on the deaf students' motivation to learn as well. Finally, the learning patterns identified could be used as guidelines in developing any other e-learning environment not only for the Nuclear Energy but perhaps for other subjects that seem appropriate. This learning patterns show on which features are more important than others in terms of its effectiveness in making the deaf students to attain better performance level during the performance test.

1.8 Importance of the Study

This study could be benefited to various numbers of parties including the deaf students, teachers as well as e-learning environment researchers and developers.

1.8.1 Deaf Students

The study was based on the deaf students from a selected school in Johor Bahru. The findings of the study are expected to be able to help those deaf students to enhance their knowledge and their skills of the Nuclear Energy topic. It could benefit the deaf students in terms of giving them knowledge source for this particular topic which could cope with the limitations and met their requirements in their learning process.

1.8.2 Teachers

The teachers can be benefited from this study by gaining more knowledge about the fast growing technology that could assist them in teaching their students. They will realize that they do not have to depend entirely using the conventional method in order to teach these special students. A more specialized teaching method particularly for deaf students that may have been unknown to them can be used to enhance their teaching skills and creating a more interactive teaching and learning environment.

1.8.3 E-Learning Environment Researchers and Developers

For those e-learning researchers and developers particularly in Malaysia is hoping to be more mindful about these students with special needs. Undoubtedly, there are a lot of researches and developments regarding education particularly for normal students, but the number is small for the ones with disabilities. Hence, with this study it is trying to raise awareness among these group in assisting deaf students and disabled students generally by developing and doing more researches regarding suitable e-learning environment for these disabled people.

1.9 Scope and Limitation of the Study

The study is mainly focusing on the development of the e-learning environment for deaf students in learning the Nuclear Energy topic. The scopes of the study are as follows:

- i. Deaf students in a selected school in Johor Bahru.
- ii. Science teachers who teach deaf students.
- iii. E-learning environment with sign language video

There are several limitations of the study that have been recognized. First of all is the teachers' knowledge about the technology of e-learning. The development of the e-learning environment is partially based on the disadvantages of conventional teaching methods, mainly in class learning and e-learning for normal students. The teachers would most probably have no problem giving information about the former method but the problem occurs regarding the information of the latter method, due to their inadequate knowledge about the technology itself. Secondly, the developed e-learning is specialized for only the Nuclear Energy subject. Therefore, the findings are not necessarily suitable to be used for other subject. This is because each subject that is taught has different nature of its contents. Finally, the type of disability that is being studied is only focusing on the deaf. This does not cover other disabilities such as blindness, mute or physical disabilities. Therefore, the sign language feature used in the developed e-learning might not be working in order to assist other type of disabled students in their learning activities.

1.10 Operational Definition

There are several key terms used throughout the whole study. Explained below are those key terms alongside with their definitions respectively.

1.10.1 E-Learning Environment

There are several definitions for the letter "e" within the term e-learning. Luskin (2010) suggested that it can be described as "*exciting*" or "*energetic*" in addition to "*electronic*", while Parks (2000) prefers to recognize it as "*everyone*" or "*everything*". Generally, an e-learning always related to multimedia learning, technology enhanced learning and web based learning, depending on the techniques or methods used for the information to be distributed to the users, particularly students. Sometimes, e-learning is also defined as virtual learning. The term virtual is basically the term used in order to explain the learning activities which happen without practicing the conventional face to face in class learning therefore a virtual world is a substitute to the conventional classroom so that students do not have to go to real classroom for their learning activities.

In this study, e-learning is referred to as an environment for deaf students in learning Nuclear Energy by implementing the sign language features in the form of video as its main knowledge source. In addition it has other usual e-learning features such as notes, quizzes, glossaries, forum sections, and chat rooms.

1.10.2 Deaf

In deaf community, there are a quite number of definitions in terms of explaining or recognizing the individual with hearing disability. The most common used is deaf. Deaf is used for any person who has completely loss their hearing capability or very severe that they are almost completely could not hear anything. The next term is deafened which related to a person who lost their hearing capability due to accident or any unfortunate event that cost their hearing. Simply said these types of people were born with normal hearing capability but loss it and could face greater challenges compared to who has loss their hearing since born.

In this study, the term deaf will be used since it is the common term used within Malaysia community. This term is used for all type of deafness level based on its severity. In addition, the sample used has a variety of deafness level. Hence this term is most suitable to be used.

1.10.3 Sign Language

Sign language, sometimes to be referred as signed language or signing, is type of body gestures used as a substitute to typical sound in communicating to each other. Each of the gestures is different from the others and has its own meaning. These gestures include hand shapes, movements of arms as well as the face expressions. Sign language is not only used by the deaf community but by the mute community as well, since sign language consists of the similar attribute to the spoken language (Stokoe *et al.*, 1965).

In this study, sign language will be referred as the body gestures used through video that will be used as the prime language used within the e-learning environment for deaf students in learning Nuclear Energy.

1.10.4 Nuclear Energy

Nuclear Energy is one of the topics included within the Science subject for Form 4 students. The topic is based on theories and required a lot of reading in understanding the contents. Therefore, the chosen of this particular topic seems appropriate in helping the deaf students to achieve better understanding of the contents instead of using the conventional learning process of reading the knowledge resources.

In this study, the topic consists of 6 particular sub topics. They will learn from how the nuclear energy can be created and how it can be advantages or even disadvantages to our daily lives.

1.10.5 Usability

The term usability testing or assessment has multiple interpretations according to different past researchers. Shneiderman and Plaisant (2005) pictures the process as anything that related to the users themselves. This also included the field of the studies of the sample being measured. Preece, Sharp, and Rogers (2002) denotes it as any approach taken in making the system being designed to be usable in a positive way and that it can be useful to the users. However, instead of mentioning more on the approach itself, Dix *et al.* (2004) thinks that it is more of the continually evaluation that is happening at the same time as the participation of the users towards using the developed system.

In this study, usability is focusing not only on the functional side of the e-learning environment itself. It also focuses on the emotional state of the deaf students, which is their motivation to learn which will be assessed alongside the functional usability of the e-learning environment.

1.10.6 Performance

Meyer (2013) has defined performance as '*outcomes or efficiency of behavior or achievement*', while Nichols (1978) defined it as "*the results of the actions*". Performance can be divided into two main ingredients, which is behavior and achievement. Performance occurs when people do something and accomplish something due to that action. Behavior can be categorized as the cost needed in order

to reach certain goals. Finally, achievement is the expected positive results that are gained.

In this study, performance will be assessed by looking at the increment of the grade of the deaf students' from their pre-test scores and their post test scores. The performance will be evaluated based on different increment category that has been set before the tests were given.

1.11 Summary

The usage of technology should be capitalized especially for educational purposes, not only for normal students but for the disabled students as well, particularly the deaf students. Their difficulties in using the conventional learning method should be taken as an opportunity for the e-learning developers and researchers in helping them by creating a learning environment that could help them in a variety ways. The development of this e-learning environment should help them in boosting their performance in learning the Nuclear Energy topic. In the next chapter, some theories that have been discussed or yet to be discussed will be elaborated in more details for more clear understanding.

on the contents the most, especially in terms of the sign language videos, would achieve the best performance level among all deaf students involved.

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