CONCEPTUAL DESIGN AND DEVELOPMENT MODEL OF ASSISTIVE COURSEWARE FOR YOUNG LOW VISION LEARNERS (AC4LV)

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Abstrak

Fokus kajian ini adalah berkaitan teknologi (perkakasan dan perisian) yang dibangunkan khusus untuk golongan kelainan upaya (OKU), yang dikenali sebagai Teknologi Asistif (AT). Dapatan sebelum ini mendedahkan kajian yang berkaitan kandungan pendidikan di dalam koswer adalah tersangat kurang, terutamanya kepada pelajar-pelajar berpenglihatan terhad. Juga, kebanyakan model rekabentuk konsep bagi koswer yang sedia ada mempunyai kekurangan dari segi keperluan khas dan bukti empirikal yang dapat memenuhi keperluan pelajar-pelajar berpenglihatan terhad. Kajian-kajian awal membuktikan aplikasi kandungan sedia ada gagal memenuhi keperluan pelajar-pelajar berpenglihatan terhad dari segi keupayaan capaian maklumat, keupayaan navigasi, dan keupayaan menghibur. Oleh itu, kajian ini mengusulkan sebuah model rekabentuk konsep bagi koswer untuk pelajar-pelajar berpenglihatan terhad yang dinamakan sebagai *Assistive Courseware for Low Vision (AC4LV)*. Empat (4) objektif dibentuk. Metodologi Kajian Sains Rekabentuk telah diadaptasi. Lapan (8) komponen Model Rekabentuk Konsep AC4LV telah dibina dan diintegrasikan: struktur, komposisi kandungan, elemen AC4LV, teori pembelajaran, pendekatan pembelajaran, proses pembangunan, model rekabentuk pengajaran, dan teknologi. Model yang diusulkan telah dinilai dan dikomen oleh 12 orang pakar dan disahkan melalui pembangunan prototaip. Hasil penilaian menunjukkan, model yang diusulkan dapat diterima baik oleh pakar tempatan dan antarabangsa. Pembangunan prototaip mengimplikasikan model tersebut adalah berguna untuk dirujuk oleh pembangun baru dan kurang kemahiran teknikal. Selain itu, dapatan daripada pengujian pengalaman pengguna menunjukkan AC4LV dapat memenuhi keperluan pelajar-pelajar berpenglihatan terhad dari segi keupayaan capaian maklumat, keupayaan navigasi, dan keupayaan menghibur. Semua dapatan ini menunjukkan bahawa Model Rekabentuk Konsep AC4LV memperlihatkan pembangunan yang berguna untuk aplikasi kandungan serta memberi sumbangan dari sudut teori dan praktikal. Kajian ini menyediakan garis panduan untuk membangunkan kandungan pendidikan di dalam koswer yang dapat memenuhi keperluan pelajar-pelajar berpenglihatan terhad supaya kumpulan istimewa daripada OKU ini mendapat peluang pembelajaran yang sama rata.

Kata kunci: Teknologi Asistif (AT), Masalah penglihatan, Kandungan kreatif, Model rekabentuk konsep, Koswer.

Abstract

The focus of this study relates to technology (hardware and software) that is purposely designed for people with disabilities (PWDs), which is called Assistive Technology (AT). Previous findings reveal that studies related to educational content in courseware is highly lacking, particularly for low vision learners. Also, many existing conceptual design models of courseware lack of specific requirements and empirical evidences to cater the needs of low vision learners. Preliminary studies have proven that available content applications fail to cater the needs of low vision learners in terms of information accessibility, navigationability, and pleasurability. Hence, this study proposes a conceptual design model of courseware for low vision learners, named as Assistive Courseware for Low Vision (AC4LV). Four (4) specific objectives are formulated. The Design Science Research Methodology has been adopted. Eight (8) components of Conceptual Design Model of AC4LV have been constructed and integrated: structural, content composition, AC4LV element, learning theories, learning approaches, development process, instructional design model, and technology. The proposed model has been reviewed by 12 experts and validated through prototyping. It was found that the proposed model has been well-accepted by local and international experts. Prototyping has implicated that the model is useful to follow by novice and non-technical developers. On top of that, the findings of user experience testing indicate that the AC4LV is able to fulfill the needs of the low vision learners in terms of information accessibility, navigationability, and pleasurability. All these findings demonstrate that the Conceptual Design Model of AC4LV exhibits useful development for content application as well as providing theoretical and practical contributions of the study.This study provides guidelines for developing educational content in courseware that caters the need of low vision learners so that this particular group of PWDs may gain equal opportunities of learning.

Keywords: Assistive Technology (AT), Creative content, Low vision learners, Conceptual design model, Courseware.

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Nurulnadwan Aziz
Universiti Utara Malaysia
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List of Abbreviations

AAC	Augmentative and Alternative Communication
AC	Assistive Courseware
AC4LV	Assistive Courseware for Low Vision
ACS	American Community Survey
ADDIE	Analysis Design Development Implementation
ASHA	American Speech Language Hearing Association
AT	Assistive Technology
CAI	Computer-assisted Instruction
CAL	Computer-assisted Learning
CBT	Computer-based Training
CCTVs	Closed Circuit Televisions
CD	Conceptual Definition
CDHL	Center for Childhood Deafness and Hearing Loss
CDM	Courseware Development Model
EBU	European Blind Union
FCTD	Family Center on Technology and Disability
GRIT	Global Research Innovation and Technology
GUIDE	General User Interface for Disorder of Execution
GPS	Global Positioning System
IDEA	Individuals with Disabilities Education Act
ICT	Information and Communication Technology
IPO	Input-Process-Output

ID	Instructional Design
ISD	Instructional System Development
ILO	International Labor Office
JAWS	Job Access With Speech
KAIMal	Kemahiran Asas Individu Masalah Penglihatan
LD	Learning Disabilities
LFC	Leveraged Freedom Chair
MAB	Malaysian Association for the Blind
ML	Meaningful Learning
MOE	Ministry of Education
MI	Multiple Intelligence
NECIC	National Early Childhood Intervention Council
NICHCY	National Dissemination Center for Children with Disabilities
ODI	Office for Disability Issues
OD	Operation Definition
PWDs	People with Disabilities
PDAs	Personal Digital Assistants
PERS	Personalized Emergency Response Systems
PBL	Problem-based Learning
RLM	Reality Learning Media
SGD	Speech Generating Devices
TDD	Telecommunication Device for the Deaf
TTY	Teletypewriter

TC	Typical Courseware
UK	United Kingdom
UNESCO	United Nations Educational Scientific and Cultural Organization
UCD	User Centred Design
VI	Visual Impairment
VI	Visually-impaired
VOCA	Voice Output Communication Aids
WHO	World Health Organization

List of Publications and Awards

Journals:

- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2014). A comparative analysis on conceptual design model of Assistive Courseware (AC) for visually-impaired learners (AC4VI). *Australian Journal of Basic and Applied Sciences*, *8*(4), 75–80. Retrieved from http://ajbasweb.com/old/ajbas/2014/Special/75-80.pdf
- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2014). Critical analysis in proposing a conceptual design model of assistive courseware for low vision (AC4LV) learners. *International Journal of Computer Applications*, *92*(10), 18–25. doi:10.5120/16044-5173%0A
- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2014). The design principles of Assistive Courseware for Low Vision (AC4LV) learners. *ARPN Journal of Engineering and Applied Sciences, 3* (10), 1447–1456. Retrieved from http://www.arpnjournals.com/jeas/research_papers/rp_2015/jeas_0215_1614.pdf
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Chapter in Book:

- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2013). Preliminary investigation on creative educational content for visually-impaired (VI) learners. In H. Badioze Zaman, P. Robinson, O. Patrick, T. K.Shih, & S. Velastin (Eds.), *Advances in Visual Informatics* (3rd ed., pp. 408–417). Switzerland: Springer International Publishing. doi:10.1007/978-3-319-02958-0

Conference Proceedings:

- **Nurulnadwan, A**., Ariffn, A. M., & Siti Mahfuzah, S. (2013). A comparative analysis on conceptual design model of Assistive Courseware (AC) for visually-impaired learners (AC4VI). *Proceedings of the International Conference on Engineering and Technology (ICET '13)*, 75–80.
- **Nurulnadwan, A.**, Ariffin, A. M., & Siti Mahfuzah, S. (2014). Reviews and critiques on learning theories towards proposing a conceptual design model of assistive courseware for low vision (AC4LV) learners.

Proceedings of the 7th Knowledge Management International Conference (KMICe '14), 760–765.

- **Nurulnadwan, A**., Ariffn, A. M., & Siti Mahfuzah, S. (2014). Conceptual design model of Assistive Courseware for Low Vision (AC4LV) Learners. *Proceedings of the International Conference on Advances in Educational Technology (ICAET '14)*, 44–53.
- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2014). Integrating Multimedia Learning Theory in Assistive Courseware for Low Vision (AC4LV) Learners. *Proceedings of the 3rd International Conference on Interactive Digital Media (ICIDM' 14).*
- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2014). The design principles of Assistive Courseware for Low Vision (AC4LV) learners. *Proceedings of the Advancement in Information Technology International Conference (ADVCIT' 14),* 222-230.
- **Nurulnadwan, A**., Ariffin, A. M., & Siti Mahfuzah, S. (2015). First cycles of user experience on Assistive Courseware for young Low Vision (AC4LV) learners. *Proceedings of the 5th International Conference on Computing and Informatics (ICOCI '15),* 180-186.

Awards:

- **Bronze Medal** at the Malaysian Technology Exhibition 2013 (MTE 2013), Kuala Lumpur:
    - Project Title: *Assistive Learning Materials for Low Vision Learners*
    - Project Members: Ariffin Abdul Mutalib, **Nurulnadwan Aziz**, Siti Mahfuzah Sarif

- **Best Paper Award**
    - 3rd International Conference on Interactive Digital Media (ICIDM 2014) 2-4 December 2014.
    - The Pacific Sutera Hotel @ Sutera Harbour Resort Kota Kinabalu, Sabah.
    - Title: Integrating Multimedia Learning Theory in Assistive Courseware for Low Vision (AC4LV) Learners.
    - Author: **Nurulnadwan Aziz** , Ariffin Abdul Mutalib , Siti Mahfuzah Sarif.

- **Silver Medal** at the National Innovation and Invention Competition Through Exhibition 2015 (iCompEx '15), Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS):
    - Project Title: *Assistive Courseware for Low Vision Children*
    - Project Members: **Nurulnadwan Aziz**, Ariffin Abdul Mutalib, Siti Mahfuzah Sarif

CHAPTER ONE

INTRODUCTION

1.1 Overview

This introductory chapter provides some background of study which deliberates on issues that lead to the motivation aspects of the study, specification of the problem, preliminary investigation, extraction of research gap, and formulation of research objective. It also discusses the scope and limitations of the study, significance of study, theoretical and research framework, as well as operational definitions of terms used throughout the study.

1.2 Background of Study

Everybody is gifted with certain ability. It depends on how far a person can explore their potentials to utilize the abilities optimally. It is similar with disabled people but the approach is definitely dissimilar. In the process of exploring the potentials, learning should take place. However, it is not an easy task for disabled people especially the school-aged children to grasps new knowledge fluently as normal children. Eventhough it is not an easy task, generating knowledge is very important to everybody including the disabled because only knowledge could develop and differentiate the level among people. It is emphasized in the Quran clearly through Surah Az-Zumar [verse: 9]:

........قُلْ هَلْ يَسْتَوِي ٱلَّذِينَ يَعْلَمُونَ وَٱلَّذِينَ لَا يَعْلَمُونَ ۗ إِنَّمَا يَتَذَكَّرُ أُولُوا۟
ٱلْأَلْبَٰبِ ﴿٩﴾

Say, "Are those equal, those who know and those who do not know? It is those who are endued with understanding that receive admonition".

[Az-Zumar 39:9]

Also, in the Surah Al-'Alaq [verse: 1], Al-Mujaadilah [verse: 11], and Al-Baqarah [verse: 269], urging people to learn for making improvements in life.

Learning is one of the most challenging task in disabled peoples' life. Starting from organizing their personal care until reading, writing, and understanding the learning content; those tasks are very problematic and crucial for them to wade it independently. Usually, they expect assistants from parent in doing normal daily tasks. Nevertheless, there are some parents that have lack of knowledge on how to guide and train their disabled children to learn in organizing their basic routine independently. As a result, the potential of their disabled children are not well-explored perfectly. On the other hand, there are also parents who let schools and teachers to completely assist their disabled children in learning, with the hope that at least their children are able to organize themselves independently in future days.

In school, the disabled children are introduced to rough and fine motor learning skills for their cognitive and physical development. It is very tough to ensure that they can grasp the knowledge efficiently. Knowledge could be delivered in many forms; for children with disabilities, learning content application is one of the appropriate examples. However, most of the existing conceptual design model particularly for learning content application not catering specifically to their needs in learning activities. Hence, in accelerating this study, the phenomenon as described in the next section further clarifies these issues.

1.3 Motivation of Study

A few phenomena have triggered the acceleration of this study. Accordingly, this section summarizes those phenomena.

1.3.1 Current State of Disabled People in Malaysia

The number of people with disabilities (PWDs) has been increasing rapidly around the world. The statistics from World Health Organization [WHO], (2014) reveal that 15% of the world's population have some form of disabilities; which is one third of them are children younger than 15 years old (Melissa, Yen, & See, 2011). They are disabled differently including physical, learning, hearing, and visual. Among the various types of disabilities, visual impairment (VI) is considered the serious one. WHO (2014) reports that 285 million people in the world are visually-impaired (VI). Particularly 246 million of them have low vision and 39 million of them are blind. Approximately 90% of the VI people live in developing countries.

Meanwhile, in Malaysia the Malaysian Social Welfare Department reports that the officially registered disabled people as at December 2013 are 470,483 people (National Early Childhood Intervention Council [NECIC], 2013). It is estimated that

900,000 children suffer from various disabilities (Melissa et al., 2011). As at December 2006, there were 18,258 registered VI people, and then the number increased to 46,370 in December 2013 (Table 1.1). Referring to the facts in Table 1.1, it could be deduced that from the year 2006 until 2013, the registered VI people in Malaysia drastically increased to be double.

Table 1.1: Registered Disabled People According to Types of Disability, 2006-2013

Types of Disability	**Year**							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Visual Impairment	**18,258**	**20,039**	**21,204**	**23,738**	**27,363**	**31,924**	**40,510**	**46,307**
Hearing Impairment	29,522	31,715	32,850	35,368	39,303	43,788	53,357	58,706
Physical Impairment	66,250	73,559	78,036	86,485	106,252	123,346	148,461	162,215
Learning Problem	76,619	85,812	91,303	100,180	117,699	134,709	165,281	178,800
Others	6,870	9,125	10,546	13,147	15,023	25,436	20,673	24,455
Total	**197,519**	**220,250**	**233,939**	**258,918**	**305,640**	**359,203**	**445,006**	**470,483**

Over and above, in terms of employment as reported by the Social Welfare Department of Malaysia recently in developing countries there are 80% to 90% of PWDs of working age are unemployed, whereas in industrialized countries there are 50% to 70% are unemployed (Adnan, 2012). It is also reported that the official unemployment rate for disabled people of working age in most developing countries is at least twice that for those who are normal (Adnan, 2012). On top of that, PWDs are not given the right jobs according to their qualification (Meme, 2010; Adnan, 2012). In fact, in *Section 29 – Persons with Disabilities Act 2008: Access to Employment* state those PWD are entitled and have rights for employment (Adnan, 2012). Thus, this study believes that the potentials of the PWD have not been utilized properly. Further, in this digital age, this study anticipates that coming out with various types of technologies in forms of hardware and software to assist the disabled in carrying out their daily life could help ensuring that the disabled are not neglected further.

1.3.2 Government Support and Initiatives

Due to the above scenario, the government of Malaysia is taking serious effort in ensuring the disabled people have the rights especially in acquiring formal education in order to make sure that their achievement and their future life are not neglected (Melissa et al., 2011). In conjunction, the Ministry of Education Malaysia has established an Early Intervention Program (EIP) for children (aged five and above) with hearing, visual, and learning impairment (Haniz, 2007; Malaysian Ministry of Education, 2011). Besides, the disabled children in low income families are also supported through the implementation of TASKA OKU pilot project. The project caters six categories of disabilities namely down syndrome, autism, blind or partially-sighted, hearing and speaking, physical, and learning difficulties (Mohd Najib, 2012). All these explain that equipping children especially the disabled with basic education is really important in their early childhood life.

Inline with the above situation, the government of Malaysia is also considering serious efforts in promoting the usage of technologies among disabled people which could be seen through providing AT (hardware and software) in school (Khadka, Ryan, Margrain, Woodhouse, and Davies (2012). However, the availability of computer applications especially related to creative contents for PWDs including Malaysia is infancy and very expensive (Dawe, 2006; Muhammad Haziq, Syariffanor, & Shahril, 2009; Nurulnadwan, Nur Hazwani, Erratul Shiela, & Ariffin, 2011; Nurulnadwan, Nur Hazwani, & Ariffin, 2011; Maslinda, Wan Abdul Rahim, & Nurul Syahirah, 2011). In regards to that the Malaysian Communication & Multimedia Act 1998, defines content as "any sound, text, still picture, moving picture, or other audio-visual representation, tactile representation or any combination of the preceding which is capable of being created, manipulated, stored, retrieved, and communicated electronically" (Malaysian Commisioner of Law Revision, 2006, p.24). Further, creative content can be categorized into six clusters as listed in Table 1.2.

Table 1.2: Creative Content Clusters

Cluster	Example
Film and television	Movies, drama, documentary, and musical.
Animation and modeling	Animated series/full length, architectural fly-through, virtual reality, and 3D models.
Games	PC games, online games, and mobile games
Mobile	Games, animation, wall paper, screen savers, and music
Audio	Music and voice over

Since the past a few years, Malaysia's creative content industry has grown tremendously through great commitment, support, and concerted effort from the Malaysian government (June, 2011). To date, the potential of creative contents is certainly recognized by the government of Malaysia through its' Information Technology and Communication (ICT) sector and Economic Transformation Programme (ETP) to achieve high income country status (Sakini, 2011). As stated by the secretary general of Information Communication and Culture Ministry under the

My Creative Content Programme parallel with the ETP initiative, Malaysia targets to achieve a Gross National Income (GNI) of US$1 billion, creating 10,300 jobs, and securing an export of its GNI targets by 2020 (Sakini, 2011). In fact, in the 2012 budget speech, the Prime Minister of Malaysia stated that the creative content has the potential to be further developed and contributes to economic growth (Mohd Najib, 2011). It continues in the 2013 budget speech in which the Prime Minister of Malaysia encourages the researchers and developers to contribute in this sector by allocating research grants and funds to create unique creative contents (Mohd Najib, 2012). This means more contents application could be designed and developed specifically catering to the needs of disabled people. Moreover, initiatives in assisting the disabled people to use technologies have been growing in most developing countries (Wong & Cohen, 2011; Judge, Robertson, & Hawley, 2011; Savita & Nur Athirah, 2011).

1.3.3 Advancement of Assistive Technology in Education

In recent years, the development of technology has grown tremendously throughout the world in order to meet the humanity life demand for various fields including social aspects, economics, cultures, political, and education (Syamsul Bahrin, 2011). Nevertheless most people think that the products or services provided by technology can commonly be utilized by non-disabled people. Gradually, due to the awareness of researchers and developers the benefits of technology can also be enjoyed by PWDs. The technology that purposely designed for PWDs is called Assistive Technology (AT). It can be categorized into hardware (i.e. wheelchair) and software (i.e. screen reader). Besides, AT is also divided into service and product (is discussed further in the next chapter). The advancement of AT has triggered the meaningful impact to the various aspects of PWDs life. The trend is clear that recent devices are designed to be accessible by PWDs such as smart phones and tablets.

Inline with that, the field of education is not an exception and has been revolutionary impacted by AT. As evidence, there are increasing interest in the usage of AT with educational technologies to promote education formally and informally to the PWDs. As an example certain primary schools for special education equip their computer labs and classrooms with Closed Circuit Televisions (CCTVs), large monitors, braille printers, large speakers, screen magnification tools, and video magnifiers. All these AT are utilized as part of the teaching tools to support and improve the disabled learners learning activities in educational environment where they could acquire knowledge and learn.

Besides hardware and software, there are also various types of educational contents and applications readily available in the market such as mobile learning (m-learning), web-based or online learning, Computer-based Training (CBT), and edutainment or interactive courseware. The main reason of the designed content applications is to facilitate effective and efficient learning (Sobihatun Nur, Wan Ahmad Jaafar, & Azillah, 2010; Syamsul Bahrin, 2011).

To date, courseware has been one of the popular methods being used in educational environment. It could be in the form of stand alone (CD-ROM) or online (web-based). Courseware must be designed specially for the target learners, therefore some pedagogical or andragogical aspects and other learning concepts must be considered in the design and development process (Ariffin, 2009). Basically courseware combines multiple media elements including text, audio, video, graphic, and animation. Integration of all these elements creates different learning experience to the learners (Ariffin, 2009). The most prominent promises by courseware is students can learn on their own pace without restrictions to places; in classroom or outside; with or without instructor guidance; anytime and anywhere the location is. In conjunction, Table 1.3 lists five examples of coursewares that have been successfully implemented in education and have already been commercialized in the market.

Table 1.3: Example of Commercialized Courseware

Name of courseware	**Producer**	**Year released**
e-Learning for Kids	e-Learning for Kids	2004
School Plus Multimedia Resource Kits	Smart-Ed Dot Com	2006
SJKC Courseware	Connected Learning	2007
Good Kids	Good Kids Website	2010
Elite Kids Sciences	G-Elite Holdings Sdn Bhd	2014

On top of that, it is believed that there are many more interactive and edutainment courseware designed for kids or young students to assist them in learning activities. However, most of the designed courseware only emphasizes the non-disabled learners as their target users, eventhough many research found that the disabled learners also have the rights in gaining the benefits from educational technologies. In this study, the courseware for the disabled learners is called Assistive Courseware (AC). It is defined as a courseware that specifically designed according to the learners' restrictions abilities. It allows them to learn and enjoy the lesson similar to non-disabled learners, by applying special instructional approach and providing special elements that differentiate it from typical coursewares (TCs). In conjunction, findings from the literature search reveal the examples of AC (Table 1.4).

Table 1.4: Example of AC

Researcher	Name of AC
Ellis (2009)	*Auslan Children*
Norfarhana, Wan Fatimah, & Emelia Akashah (2010)	*Komputer Saya*
Morfidi, Papachristos, & Mikropoulos (2010)	*LT125ThinkingMind*
Sampson & Zervas (2010)	*eAccess2Learn*
Seo & Woo (2010)	*Math Explorer*
Siti Zaharah & Nor Azan (2011)	*MudahKiu*
Savita & Nur Athirah (2011)	*eBIM*
Nurulnadwan et al. (2011)	AC for VI learners
Rahmah, & Tengku Nazatul (2012)	*MEL-SindD*
Rahmah, Hafiza & Tengku Nazatul (2012)	Digital Storytelling for Remedial Students

1.3.4 Summary of Research Motivation

With such huge potentials in creative content applications, high demands in creative content markets, and supports from the government, there is a possibility of utilizing creative contents for PWDs in learning aspects. In other views, the various works carried out for PWDs especially in educational content applications indicate that PWDs also play important roles in contributing to the world similar to normal people. Therefore, this study anticipates that it should start with learning because learning is a common process for everybody (Ariffin, 2009). However, different approaches must be utilized for different types of people so that the knowledge could be delivered explicitly to the learners. One of the content applications that can be exploited as an interesting learning content for PWDs is courseware. However, it has to be realized that the components and elements in the courseware play an important roles in efforts to make the AC fully used by the disabled learners. Hence, the reasons for this should be further addressed.

1.4 Problem Background

Various researches have been conducted regarding educational content applications for young people and children including PWDs. As discussed in the previous sections, various educational content applications have been commercialized in the market such as courseware, e-book, and e-tutorial. This scenario indicates that education is very important for everyone to lead useful lives. Unfortunately, not everyone in this world can enjoy the learning activities offered to them especially for disabled people in developing countries.

The facts in the previous section reveal that the number of PWDs keeps on increasing drastically including VI learners (Table 1.1). Among the types of VI, low vision is considered the serious one and become the focus of this study (the reasons for this are further details in the next chapter). Therefore, exposing them to the world of education and technology is important because they should together be respected as a part of the resources for the country with the normal people. Unfortunately, Rasmeet and Ahalya (2011) reveal that 80% of education materials such as textbook and courseware are provided for fully-sighted students. This is because the main learning styles that prefer to use by normal students especially children is visual, followed by kinesthetic and further by auditory (Nor Azah, Roznim, & Khairunnisa, 2010; Norlina, Hasiah, & Noraidah, 2010; Ahmad Rizal & Mohd Noor, 2010). Due to that, low vision learners have to adapt this situation into their learning activities even though they face problems in terms of information accessibility and navigationability. Thus, they feel frustrated and have no pleasurability in learning (Ariffin, 2009), which could affect their quality of education.

On the other hand, AT is a type of technology that is purposely designed for PWDs (Liffick, 2003). Unluckily, the disabled people have to spend a big amount of money to afford for this kind of technologies because they are very expensive in the market (Dawe, 2006; Joyojeet, Manas, & Rakesh, 2011). As a result, the usage of AT is still limited and is usually used by the high income people (Dawe, 2006; Wong & Cohen, 2011).

On the other hand, United Nations Educational Scientific and Cultural Organization [UNESCO] (2012), Vaquer (2011), and Khadka et al. (2012) acknowledge that PWDs especially children and young people deserve to have quality education similar with the non-disabled students. Due to this, equipping disabled children with education and life skills training through the utilization of content applications can help them in achieving a brighter future life.

Besides, Khadka et al. (2012) reveal that in education, there is a large overlap in some activities and interests between VI students and fully-sighted students (Figure 1.1) such as physical education, music and dance lesson, computer and IT lessons, and Science, Mathematics, and English subjects. Study conducted by Khadka et al. (2012) also include low vision learners as part of the participats. So, these could be deduced that low vision students have similar interests with the fully sighted students eventhough they have restrictions in visualization. The study also found that low vision learners including children and young people prefer to learn lessons which are related to practical activities. It means that they like activities which allow them to interact with other participants and have pleasurability.

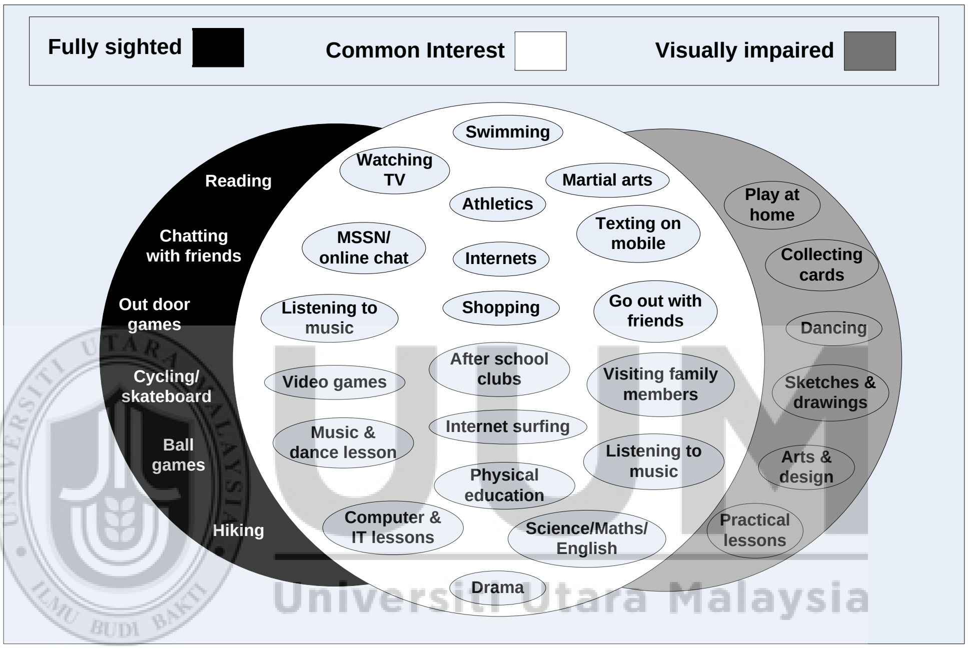


Figure 1.1: Activities and Interest between VI including Low Vision Students and Non-disabled Students

However, due to their restricted abilities and lack of specially-designed technologies especially in content creation, the learning activities are not carried out smoothly (Khadka et al., 2012). In addition, Khadka et al. (2012) also found that there are certain activities in education that low vision learners face difficulties and they have to struggle to achieve it because of their vision. Further, focus group interviews with children and young people of low vision found that geography is the most difficult subjects for them especially in reading maps. The study also found that most of the low vision learners hate reading because of getting eyes strain after some reading and the use of low vision devices such as magnifying glasses was problematic for them. It is because the optical devices make them look different compared to their fully sighted peers. This agrees with Khadka et al. (2012) who exhibit Table 1.5 that indicates nine learning activities considered challenging for children and young people with low vision.

Table 1.5: Challenging Learning Activities for Children and Young People with Low Vision

No.	Learning activities
1.	Reading maps in geographical subject
2.	Reading drama scripts
3.	Prolonged reading
4.	Handwriting
5.	Reading text messages
6.	Reading musical notes
7.	Reading story books and novels
8.	Reading colorful magazines
9.	Reading the board in the classroom

In other aspects, based on the literature search, this study finds that most of the research works focus on the development of hardware (i.e. CCTVs, large monitors, braille printers, and electronic braille display) and software (i.e. screen magnification, scan/read systems, portable note takers, video magnifiers, and digital book readers) (Limna, Sae-tang, Jantaraprim, Tandayya, & Niyompol, 2007; Connelly, 2010; Gowases, Bednarik, & Tukiainen, 2011). However, research related to educational content applications that purposely designed for PWDs as users is still lacking.

The platform to deliver educational content applications can be in many ways including courseware. A courseware should be designed based on appropriate conceptual design model. While there have been a number of studies in courseware development which relate to the design of conceptual model (as depicted in Table 1.6), most of these studies have not provided a set of proper specific requirements and enough empirical evidences to cater low vision learners as the users. The listed models are all courseware design models which cater to the theories, concepts, specifications, requirements, or components needed to be included when designing a courseware. Although this is the case, all of them do not investigate on how to develop AC for low vision learners. In fact, all of the listed conceptual design model highlights the non-disabled learners as the main users.

Table 1.6: Example of Conceptual Design Model of Typical Courseware (TC)

No.	Researcher	Name of Models/Frameworks
1.	Mazyrah, Wan Fatimah, Shahrina, and Suziah (2008)	Conceptual Framework of English Language Courseware
2.	Ariffin (2009)	Conceptual Design Model of Reality Learning Media (RLM)
3.	Syazwan and Wan Fatimah (2010)	ID Model of Multimedia Courseware for Lines and Planes
4.	Churchill (2011)	Conceptual Model for Small Screen Learning Application
5.	Nik Siti Hanifah, Tao, and Ping (2011)	Framework of Virtual World Courseware
6.	Zuraini and Wan Fatimah (2011)	ID Model of Li2D
7.	Efendioğlu (2012)	Courseware Development Model
8.	Rossafri (2012)	Input-Process-Output (IPO) Framework for Teaching History Subject
9.	Özyurt, Özyurt, Baki, and Güven (2013)	Conceptual Design Model of UZWEBMAT
10.	Garcia and Pacheco (2013)	Model of Constructivist Computational Platform

In addition to that, there are also a number of initiatives on designing AC which emphasize the disabled learners as the main user including low vision (as depicted in

Table 1.7). In these cases, not all of them carried out the research with a specific design model; in fact some of them come out with a set of guidelines on how to develop an AC. However, further investigations on the studies did not discover enough empirical evidences which relate to the concepts and theories. In addition, most of them do not suggest any specific conceptual design model that caters the low vision learners in detail. Whereas, the conceptual design model is important and supposes to be as a set of propositions which express the relationship between components or concept (Vaishnavi & Kuechler, 2007) and also as a reference for other developers to develop an AC for low vision learners in future.

Table 1.7: Example of AC with the Target Learners

Researcher	Name of AC	Target Learners
Ellis (2009)	*Auslan Children*	Hearing-impaired Children
Norfarhana, Wan Fatimah, and Emelia Akashah (2010)	*Komputer Saya*	Slow Learners Children
Morfidi, Papachristos, and Mikropoulos (2010)	*LT125ThinkingMind*	Severe Learning
Sampson and Zervas (2010)	*eAccess2Learn*	Motor Disabled and LV Trainee
Seo and Woo (2010)	*Math Explorer*	Learning Disabilities
Siti Zaharah and Nor Azan (2011)	*MudahKiu*	Hearing -impaired Children
Savita and Nur Athirah (2011)	*eBIM*	Hearing-impaired Children
Nurulnadwan et al. (2011)	AC for VI learners	VI Children
Rahmah and Tengku Nazatul (2012)	*MEL-SindD*	Down Syndrome Children
Rahmah, Hafiza, and Tengku Nazatul (2012)	Digital Storytelling for Remedial Students	Remedial Student

The issues discussed in the paragraphs indicate that the studies related to educational content applications that are purposely designed for low vision learners is deficient and need to be further researched. Due to unevenness access to educational content applications, low vision learners are still lag behind compared to non-disabled learners in accessing knowledge disseminated through computer applications including coursewares (Murray & Armstrong, 2004; Armstrong & Murray, 2007; Center for Childhood Deafness and Hearing Loss [CDHL], 2010; Meme, 2010; Wong & Cohen, 2011; Adnan, 2012). Furthermore, most developers and experts put very little concerns in creating courseware that address low vision learners as the users (Permvattana, Murray, & Hollier, 2006; CDHL, 2010). This can be seen in most of the e-Learning platforms that are available in the market which pose a number of different problems to low vision learners (Bocconi, Dini, Ferlino, & Martinoli, 2007). Small characters, crowded pages, pop up windows, iconic menus, fancy fonts, unsuitable audio, and full with animations are some examples of difficulties faced by low vision learners (Bocconi et al., 2007). All the facts indicates that, the existing coursewares are useless to low vision learners when the information/content is inaccessible and difficult to be used which then make them feel frustrated in learning. Due to that, the process of conveying knowledge could not be occurred in efficient way. In addition, lack of creative contents for the low vision learners creates a huge gap between them and non-disabled students (Murray & Armstrong, 2004; Armstrong & Murray, 2007; CDHL, 2010; Wong & Cohen, 2011).

In accordance, to further establish the research problem, preliminary investigations have been conducted and are discussed in the next section.

1.4.1 Preliminary Investigation

Three preliminary investigations have been conducted to confirm the research problem and to develop the research focus (Sobihatun Nur, 2010). The first study was conducted involving content expert perspectives on AC for low vision learners. It was followed by the second study which was conducted involving low vision learners as the respondents. Then, to gather the current information in supporting the research problem, again a study involving content experts was conducted in 2012. The compilation of preliminary studies which involves the content experts as the respondents are discussed in section *preliminary study I*, while *preliminary study II* that involves the low vision learners as the respondents are discussed in the next subsection. The analyses of these preliminary studies further strengthen the needs of this study.

1.4.1.1 Preliminary Study I

i) Method

The main objectives of this preliminary study are (i) to gather the information regarding the availability of courseware for low vision learners, and (ii) to clarify the factors that lead to the needs of courseware for low vision learners. Therefore, a series of interviews were conducted by involving five respondents, who are the content experts. They are the Deputy Chief Director of Special Education Department from Ministry of Education (MOE), Executive Director of Malaysian Association for the Blind (MAB), VI teachers, and Coordinator of Special Education Department from Integration Primary School (VI) (Appendix A). The interview sessions between this study and content experts were done one by one at different time and place. In the interview, 12 questions as listed in Table 1.8 were asked in a semi-structured format.

Table 1.8: List of Interview Question

No.	Items
Q1	Are the low vision learners exposed to the utilization of computer?
Q2	Are the low vision learners exposed to the utilization of AT?
Q3	What types of AT that are used by the low vision learners in their learning activities?
Q4	Does the AT (hardware and software) help the low vision learners in their learning activities?
Q5	Are the low vision learners exposed to the courseware provided by MOE?
Q6	Do the coursewares contain audio, graphics, animation, and video?
Q7	Do the coursewares assist the low vision learners during the learning process?
Q8	Is there any special courseware designed for low vision learners provided by MOE?
Q9	Are the low vision learners exposed to the courseware available in the market?
Q10	Are the coursewares available in the market suitable for low vision learners?
Q11	Is there any special courseware designed for low vision learners available in the market?
Q12	Do you recommend for a proper courseware that is specifically designed for low vision learners?

The questions were addressed to investigate the following conditions: (1) whether the low vision learners have computer literacy, (2) whether the low vision learners are familiar with the AT provided in school, (3) to identify the current AT (hardware and software) that are used by low vision learners in their learning activities, (4) whether the used of AT (hardware and software) could assist the low vision learners in their learning activities, (5) whether the low vision learners are exposed to the courseware that are provided within course teaching; the interview was proceeded if the low vision learners are exposed to the courseware, (6) whether the coursewares contain various media elements, as recommended by the design guidelines, (7) whether the courseware provided by MOE within text book are suitable to be utilized by low vision learners, (8) whether the MOE have already provided courseware that are specifically designed for low vision learners, (9) whether the low vision learners are disclosed to the courseware that are available in the market, (10) whether the courseware that are available in the market are appropriate for low vision learners, (11) whether the courseware for low vision learners have already available in the market, (12) whether the courseware is needed to assist the low vision learners in their learning process. In the end, the interviews managed to gather results as listed in Table 1.9.

ii) Analysis of Findings

Table 1.9: Respondents' Opinion on the Availability and the Needs of Courseware for Low Vision Learners

Q	Respondent 1 (MOE)	Respondent 2 (MAB)	Respondent 3 (VI teacher)	Respondent 4 (VI teacher)	Respondent 5 (Coordinator)
1	√	√	√	√	√
2	√	√	√	√	√
3	√	√	√	√	√
4					
5	√	√	√	√	√
6	√	√	√	√	√
7					
8					
9		√			
10					
11					
12	√	√	√	√	√

Referring to Table 1.9, all respondents responded positively to questions 1, 2, and 3. In primary school, the low vision learners were introduced to the basic Information and Communication Technology (ICT) skills and utilization of assistive device and assistive software such as braille machine, CCTV, magnifier, slate and stylus, and Job Access With Speech (JAWS) since they are in standard three through a module called *Kemahiran Asas Individu Masalah Penglihatan (KAIMal)*. It contains three submodules namely (a) *Module1: Orientation and Mobility*, (b) *Module 2: Code Braille Skill and Utilization of Assistive Devices*, and (c) *Module 3: Basic ICT for Visual Impairment* (MOE, 2012). Also, at MAB the organization offers some vocational training course such as computer literacy and computer programming for those low vision persons who are interested (Q1) (Q2). The study also found that not only primary schools but most of the VI training centers in Malaysia have introduced their students to the courseware and software (Q3) (Q5) (Q9). This indicates that, most of the low vision learners are computer literate or at least they have been recognized to computer technologies since they were children. However, some of the ATs provided for low vision such as magnifying glass and CCTV were not 100% assist them in their learning activities. Statement from Coordinator of Special Education Department from Integration Primary School (VI) indicates that the uses of CCTV was problematic for low vision learners because it requires them to struggle seriously in getting the information due to limited display (i.e. alphabet by alphabet or word by word) (Q4) (discussed in detail in Chapter 2).

For question 6 all respondents also agreed that the courseware were composed with various media elements (Q6). However, Table 1.9 also explains that majority of the respondents found that the courseware provided by MOE within text books and the courseware that are available in the market are not appropriate for low vision learners eventhough they contain various media elements and activities (Q7) (Q10). Figure 1.2 demonstrates the current learning activities that are utilized by low vision learners. They were found struggle to concentrate on the provided audio.

Figure 1.2: Online Teaching Courseware is played to the Low Vision Learners

This leads to question: *Why the coursewares are not assisting the low vision learners?* and further questions were asked: *if you say the courseware include audio, graphics, animations, and video, then what makes the courseware not assisting the low vision learners?.* In addition, the Deputy Chief Director of Special Education Department addressed that there is no standard guideline or model engaged by MOE regarding the development of courseware for low vision learners (Q8) (Q11). Most of the respondents also suggests that the researcher should propose the courseware that focus on how far it can convey knowledge not only look fun and entertaining to non-disabled students without supporting the needs of low vision students (Q12). These issues need to be investigated deeply. Hence, to establish the research focus one more preliminary study has been carried out and is discussed in the next subsection.

1.4.1.2 Preliminary Study II

In spite of numerous educational content applications being provided through AT services, more studies on coursewares need to be accelerated to comprehend the needs and requirements of low vision users. Therefore, it is important to analyze low vision learners' demographic characteristics, their perceptions and thoughts in relation to learning via courseware. Previously, several studies have been carried out to investigate the challenges in learning activities (in general, not for educational content applications platform) from low vision learners' point of view as discussed in the previous section. Thus, in a quest of catering for the learning needs among low vision learners, this study seeks to understand their motivation in learning through courseware.

i) Method

At this stage, this study has come out with a low-fidelity prototype of AC[1]. The prototype contains three modules which are *Module1: Learning through songs, Module 2: Learning types of animals,* and *Module 3: Exercise*. Samples of snapshots are shown in Figure 1.3. The main objective of this study is to determine whether the users can accept the developed prototype satisfactorily. In a user testing procedure, this study employed 17 VI students from one of the special education primary schools in Malaysia. Out of 17, 10 of them were low vision and the remainders were totally blind. Data were gathered qualitatively through observation, interview, and practical testing. In this study, the observation was important in order to understand their natural feelings when using AC. On top of that, the interview was to find out their preferred media elements that have been integrated into the AC, and the practical testing was conducted to know to what extend the low vision learners can interact with the AC. The testing was operated in the school computer laboratory

[1] AC at this preliminary study is referring as low-fidelity prototype which defined detail in Chapter 3.

which was equipped with two large speakers, one personal computer, and one LCD projector for the instructor. In that context, every subject was equipped with a set of personal computer in front of them and one set of headphone. In order to obtain valid results the subjects were set to sit next to another and the laboratory was locked to ensure all the subjects were not disturbed by the external environment including their teachers. The next subsection analyses the gathered results.

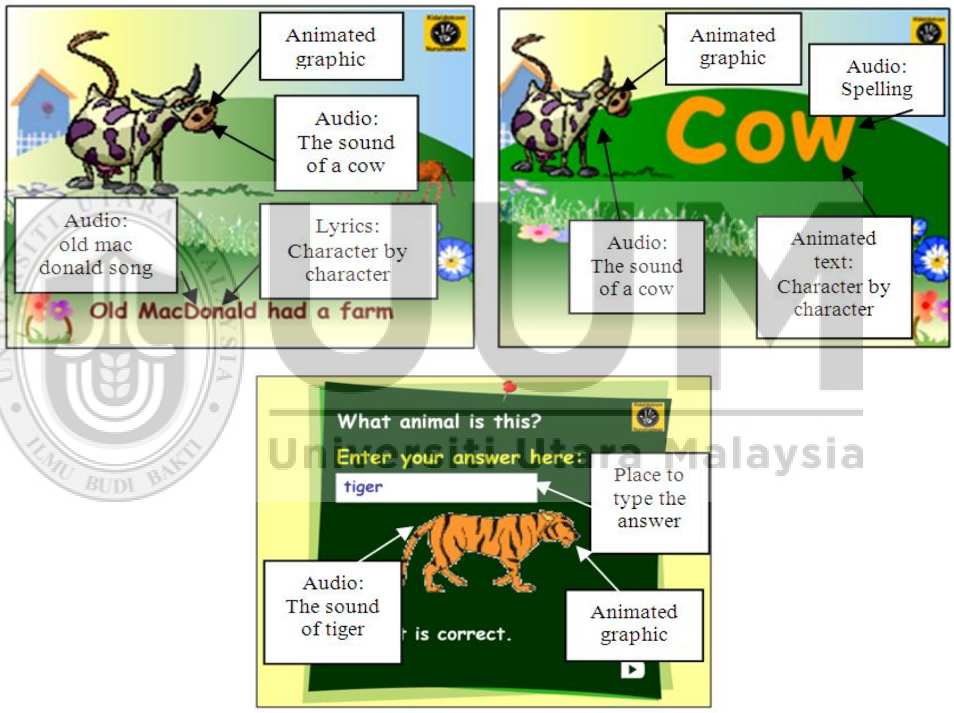


Figure 1.3: Snapshots of the Low-fidelity Prototype of AC

ii) Analysis of Findings

This section presents the findings and analysis of the main results which highlight the key issues that arise from the responses obtained. The findings of this preliminary study are categorized based on the data collection techniques (i.e. observation, interview, and practical testing). The testing was conducted in the subjects natural environment in which they were sitting next to peers as in their routine classes. Thus, they will communicate with their peers when interacting with the AC. Therefore, all of them were allowed to accompany each other. This study focused on user acceptance to the sample of low-fidelity AC hence, the user communication was treated as valuable data.

a) Observation

To understand the subjects inner feelings, the observation was done by applying think-aloud protocol in which the subjects were encouraged to speak aloud all their ideas about the AC while using it (Nielsen, Clemmensen, & Yssing, 2002). The experiment started with a short briefing about the purpose of the study and anonymity. Then the instructor played the AC to the subjects. The data were gathered through observation over the body language by annotating their comments and behaviors (Nielsen et al., 2002). In short, Table 1.10 summarizes the results.

Table 1.10: Data Gathered Through Observing Subjects' Behavior

Behavior criteria	Observation description
Fun	The subjects were found happy interacting with the AC through the way they sing together.
Laugh	The subjects were found laughing and smiling at certain parts of AC.
Enjoyable	When the AC ended, the subjects asked to repeat it for the second time.
Enthusiastic	Everyone was found enthusiastic because the AC is very new to them.
Excited	The subjects were found very excited interacting with the AC.
Humor	The subjects were making jokes with their friends when interacting with the AC.
Curiosity	The subjects were found trying to operate the AC on their own eventhough not instructed.
Focus	The subjects were found paying attention to the lesson especially to the audio.
Motivation	The subjects were found starting motivated after the instructor introduced them with the second song.
Difficulties	Some parts of the AC were found difficult especially when the attribute was animated.
Confuse	There are certain parts of the AC making subjects were felt confused especially among the totally blind.
Passive	One of the subjects was found passive all the time.

In the observation testing, two modules were introduced to the subjects which are *Module 1* and *Module 2*. The instructor demonstrated the AC to the subjects in front of the class. The *KAIMal Module* was not introduced to them yet. It was found that, 11 of the subjects were not computer literate. Therefore at this time the AC was very new to them. However, their disabilities were not restricting them to learn new knowledge. It was noticeable when 17 of the subjects found a little bit confused and curious for the first round the *Module 1* played to them. Eventhough they were not able to grasp the songs fully but they were trying to capture the songs gradually. The result changed to 16 when the songs played to them for the second round. At this time their motivation was enhanced. Their body languages showed that they enjoyed the songs by clapping their hands following the rhythm of the songs and sang together with the AC.

At the second part of the observation, *Module 2* was introduced to them. It was noted that 16 of them gave positive responses. They fought to be closed to the screen excitedly. The spelling part attracted them to stay focus to the speakers to hear the animal's sound carefully and guess the animals on the screen. Unfortunately, the observation found that the animated texts were not applicable for them. Most of the subjects face difficulties to grasp the animated words appeared on the screen. On the other hand, some of the subjects were also found chatting to each other when necessary, trying to clarify about the contents in the show.

b) Interview

The data gathered through interviews are categorized based on four elements provided by the AC which are audio, formatting style and text, graphics and animations, and general interaction.

Audio: Based on the interview, it was found that audio is the most important element for the subjects to understand everything that appear on the screen. Interviews with the subjects indicate that 17 of them depend on audio to recognize graphics and texts provided by the AC. In terms of clarity most of the subjects agreed that the audio provided by the AC was clear enough. However, the use of background music should be avoided because it disturbed their focus. These explain that, they are not able to differentiate between the background music with the desired information. Besides, sound effects can enhance their understanding. The results are summarized in Table 1.11.

Table 1.11: Characteristic and Level of Acceptance for Audio

Characteristic	**Level of Acceptance**		
	High	Moderate	Low
Usage of audio	√		
Clarity	√		
Background music			√
Sound effect	√		

Formatting Style and Text: In terms of formatting style and text, the interview found that most of the subjects agreed with the font size and font type provided in the AC. However, for font face and font color they unable to accept it because it make them difficult to read. In contrast, the animated texts should be avoided because it makes them more confused with the lesson as indicated in Table 1.12.

Table 1.12: Characteristic and Level of Acceptance for Formatting Style and Text

Characteristic	Level of Acceptance		
	High	Moderate	Low
Font size	√		
Font type	√		
Font face			√
Font color			√
Animated text			√

Graphics and Animations: Based on the interview, most of the characteristics for graphics and animations were acceptable in terms of meaningful and understandable. However, for the clarity, size, and color they able to accept it but some modification is required to improve the quality of graphics in terms of clarity, size, and color. Also, the number of graphics and animations provided by the AC was quite a lot. Again the subjects faced difficulties to understand the desired information in which Table 1.13 lists their acceptance.

Table 1.13: Characteristic and Level of Acceptance for Graphics and Animation

Characteristic	Level of Acceptance		
	High	Moderate	Low
Meaningful	√		
Understandable	√		
Clarity		√	
Size		√	
Color		√	
Minimum attributes			√

General Interaction: For the aspect of general interaction (Table 1.14), this study found that the usage of keyboard provided by the AC was too less whereas many studies prove that keyboard is the best method for low vision learners to interact with computer applications including courseware (Sandhya & Devi, 2011). Furthermore directions and interactions provided in the AC were not explicit due to the level of voice intonation from the instructor is too fast for them.

Table 1.14: Characteristic and Level of Acceptance for General Interaction

Characteristic	Level of Acceptance		
	High	Moderate	Low
Usage of keyboard			√
Directions and instruction			√

c) Practical Testing

Module 3 offers the subjects to interact with the AC. In doing exercise, it was found that, 6 of them achieved good performance; all the subjects were low vision students. Another 7 of the subjects were motivated to do the exercise however they needed the instructor to facilitate them all the time because for some parts of the exercise they were found stucked and misunderstand with the instructions. Meanwhile, the remaining were lost and not able to do the exercise at all (Table 1.15). They are totally blind students.

Table 1.15: Level of Acceptance for Practical Testing

Testing criteria	Level of Acceptance		
	High	Moderate	Low
Practical testing	6	7	3

Hence, based on the findings gathered from observation, interview, and practical testing it was found that the low vision learners able to accept learning through AC. Also, this preliminary study proves that the low vision learners need the content that specifically catering information accessibility, navigationability, and pleasurability to fulfill their needs in learning.

1.5 Problem Statement

At this initial stage, both of the preliminary studies have clearly shown that the research problem for this study is relevant. There are clear evidences that the conceptual design model of AC for low vision learners is still lacking and this research is necessary due to the findings that revealed from the preliminary studies and previous research. To clarify all the discussed facts, Table 1.16 summarize the problems, method of teaching, and materials that are currently used in teaching and learning of low vision learners.

Table 1.16: Current Problems and Methods of Teaching and Learning for Low Vision Learners

Details	Problems
Low vision learners	• The low learners face difficulties in grasping the knowledge delivered through conventional teaching method and available courseware. • Their difficulties are in terms of information accessibility and navigationability. • Due to facing a lot of difficulties, these influence them not to have pleasurability in learning activities.
Teaching method	• Conventional teaching methods are similar with normal students which are conducted in class or computer lab.
Material	• Typical text book, flash cards, book with pictures (i.e. big size), demo from the teachers, Close Circuit Television (CCTV), magnifying glass, online TC (i.e. nursery rhymes).

It indicates that the need for educational content application for low vision learners is high and it is urgently necessary. In addition, it was found that the AC involved in preliminary study are useful and acceptable, it has not only been proven in the comparative study but also through analyzing the comments from actual users in the interview, observation, and practical testing. The findings reveal that, low vision learners depend 100% on audio to recognize everything around them. Texts, graphics, and animations are the important elements in the AC. However, it has to ensure that the elements are accessible to the low vision learners. Meanwhile, general interaction is the supporting element to ensure the low vision learners could navigate the AC on their own. Achieving both of the aspects of information accessibility and navigationability it ensuring that the low vision learners achieve the pleasurabilty in learning. Also, the above study tested only several characteristics; it is believed that more characteristics are needed to be standardized to incorporate into the conceptual design model. Therefore, a deeper research should be run in order to make the AC for low vision successful in learning environment.

1.5.1 Research Gaps

Based on the problem as discussed in the previous section, the following research gaps are extracted:

i) Conceptual design model of AC specifically for low vision learners is lacking and insufficiently explored.

ii) Most of the conceptual design models of courseware exclude the low vision learners as part of the user.

iii) Some design elements and guidelines that should be considered when developing the AC for low vision learners are not clearly identified in the existing models.

iv) Most of the proposed courseware often pose a number of different problems that have to be faced by low vision learners such as mouse interaction, crowded objects, fancy font face, inappropriate font size, and unsuitable animations and audio.

v) Most of the existing courseware is useless for low vision learners particularly in terms of information accessibility, navigationability, and pleasurability aspects.

1.6 Research Question

Hence, this leads to the following research questions:

i) What are suitable components and elements of the conceptual design model of AC for low vision learners?

ii) How to design the conceptual design model of the AC for low vision learners?

iii) Is the conceptual design model of AC for low vision learners useful?

1.7 Proposed Solution

In conjunction to solving the described problem and to fill the research gaps including the questions posed previously, this study proposes a conceptual design model of learning materials particularly courseware which is called Assistive Courseware for Low Vision (AC4LV) learners. First, the elements of conceptual design model are determined. Then, the design principles for each of the elements are explored based on the previous learning theories and approaches as well as User Centred Design (UCD) approach to determine the user needs. Implementing the conceptual design model and translating it in the form of courseware is hoped not only giving new experience to low vision learners but also is useful for them in terms of information accessibility, navigationability, and pleasurability in learning. In accordance, this study attempts to achieve the objectives stated in the next section.

1.8 Research Objective

The main aim of this study is to propose a Conceptual Design Model of AC4LV, in supports of low vision learners learning needs. Therefore, to accomplish the main aim, the following specific objectives are also formed:

i) To determine the components and elements of the Conceptual Design Model of AC4LV.

ii) To develop the Conceptual Design Model of AC4LV.

iii) To validate the developed Conceptual Design Model of AC4LV through expert review and prototyping.

iv) To investigate user experience of AC4LV in terms of:

- Information accessibility,
- Navigationability, and
- Pleasurability.

This study defines the terms as:

- Information accessibility: *the characteristics of the product that enable the low vision learners to capture the learning content presented to them.*

- Navigationability: *the characteristics of the product that make it accessible for low vision learners to navigate it on their own.*
- Pleasurability: *the characteristics of the product that make the low vision learners feel amused, enjoy, and release in learning* (Ariffin, 2009).

1.9 Scope of the Study

This study is carried out to develop a Conceptual Design Model of AC4LV. Hence, in order to avoid any mistaken perceptions, this study is restricted as described in the following point:

i) The domain area of the study is in Malaysian context. This reflects that respondents and places involved in this study are located in Malaysia.

ii) The prototype of AC4LV is developed based on the following criteria:

   - The target low vision learners are focused for children in primary school of standard three to six. This is based on the finding from preliminary study. The reasons for this are discussed detail in the next chapter.
   - The subject area of learning content is school subject (i.e. Science). This is based on the communication with expert in *preliminary study I.*

iii) This study concerns on evaluating the usefulness of the proposed conceptual design model as a guide for the interested developers to develop an AC4LV rather than the learning effectiveness of using the AC4LV.

1.10 Significance of Study

This study is inline with the current scenario in educational technologies where the utilization of AT could trigger new and different learning experiences to the low vision learners. Therefore, the theoretical and empirical study which leads to the design and development of AC4LV that ensures it is useful is timely. In conjunction, the specific significance of this study can be categorized into theoretical, conceptual, and practical. The following subsections summarize the significance of this study.

i) Elements and Design Principles of AC4LV

This study puts forward the idea of learning through courseware for low vision learners particularly for children. Preliminary studies point up that many more specific elements have to be researched deeply in attempt to cater the needs of low vision children in learning by utilizing multimedia elements. Searching from the literature study also reveal that the needs of low vision children in terms of multimedia presentation is different from normal children. For that reason, this study introduces the specific multimedia elements and design principles embedded into the AC4LV. These identified elements and design principles make the AC4LV accessible, navigable, and pleasurable in learning. This make the intended courseware is different from other available courseware.

ii) Conceptual Design Model of AC4LV

The Conceptual Design Model of AC4LV is the main contribution of this study to the body of knowledge. It comprises components that were derived from existing models of courseware. To achieve that, 10 existing models of TC and 10 existing models of AC are compared in comparative studies to determine components and elements for Conceptual Design Model of AC4LV. Subsequently, the conceptual design model was presented (i.e. colloquium, conference), discussed with peers and verified by experts. The model is comprehensive; which comprise of the structural components, content composition components, elements, and design principles of AC4LV, learning theories and approaches, development process, Instructional Design (ID) model, and technology. It acts as a reference and guides anyone (with or without technical skills) who is interested to develop a courseware for low vision learners. The proposed model was validated through expert review and prototyping and discussed in detail in Chapter 4 and Chapter 5.

iii) Prototype of AC4LV

A prototype of AC4LV was developed by applying the proposed model which is known as the main contribution of this study. It is important to ensure the conceptual design model works as intended. As suggested from the preliminary study the learning content in AC4LV is school subject (i.e. Sciences). The prototype of AC4LV was contributed in terms of tangible artifact which can be a beneficial form of content selling. Further, it could enrich the source in the market particularly for low vision learners.

iv) Comparative Analysis of Existing Models

In finding out the generic components and theoretical foundation underlying the proposed model, two comparative analyses have been carried out. These analyses explore and compare the existing TC models and AC models particularly to identify elements, theories, approaches, and instructional strategies as well as their target learners to form the research gap and to identify the generic components. Also, three ID models related to courseware development are analyzed to explore the instructional approach. This is one of the significance techniques that can be used as guidance for future researcher to provide the research gap and to identify the generic components.

1.11 Theoretical and Research Framework

This study is carried out based on theories and concepts related to AT and educational technologies which focus on courseware. Figure 1.4 visualizes the theoretical and research framework throughout this study which is based on five phases as discussed in Chapter 3. In identifying the research problem and scope, preliminary investigation and elicitation from literature were conducted. Literature study and content analysis regarding concepts and theories were performed in determining the components, elements, and design principles of AC4LV. Additionally, comparative analyses on two types of existing models (TC and AC) have been carried out to confirm the research gap as well as identifying their generic components. The Conceptual Design Model of AC4LV was developed based on the outcome gathered in Phase 2. The proposed model is then validated through expert review and prototyping. Pilot test has been carried out before the proposed model tested to the actual subjects. Finally, in the conclusion stage the results are analyzed by answering the research objectives and research questions.

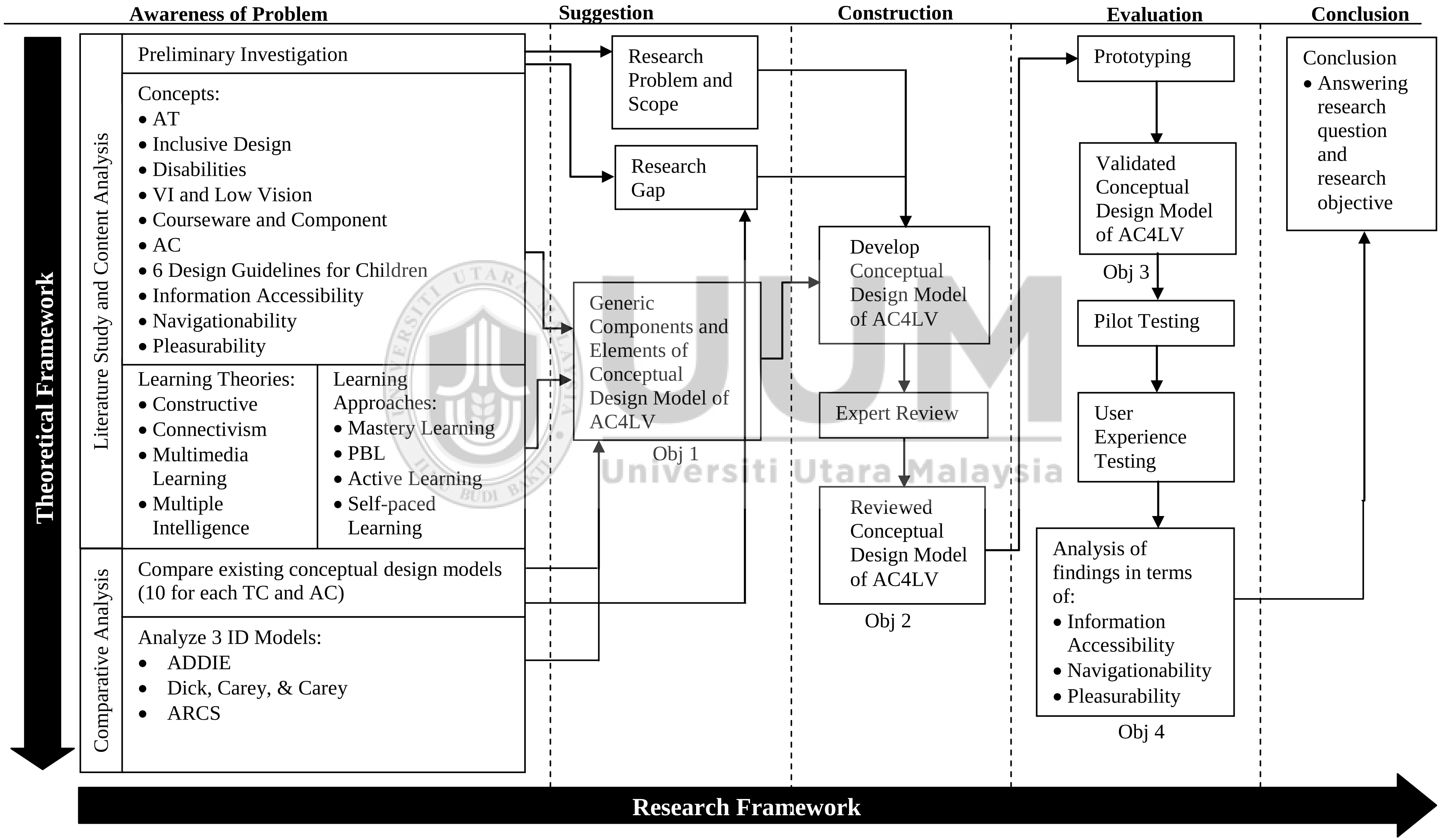


Figure 1.4: Theoretical and Research Framework

1.12 Operational Definitions and Terminologies

This section describes the terminologies related to this study which lead to the operational terminologies that are used commonly throughout this thesis.

1.12.1 People with Disability (PWD)

PWD refers to people who have loss or reduction of ability or function in certain parts of their body (mentally or physically that restrict them to perform normal day-to-day activities). In executing their routine tasks independently, they need helps from AT. Disability is possible to occur to anybody. It depends on the types of disability. In accordance, this study considers children with average age nine to 12 years old with low vision as the primary subject.

1.12.2 Assistive Technology (AT)

AT refers to any form of hardware or software that are exclusively designed for use by PWD. However, AT in the form of software has been chosen for the context of this study.

1.12.3 Assistive Courseware (AC)

AC refers to courseware that is designed for PWD. It may be constructed incorporating certain media elements and instructional design that differentiate it from TC. The assistive features make the courseware able to help the PWD in accessing knowledge independently anytime and anywhere. In the context of this study the AC is designed exclusively for low vision children by referring to the proposed conceptual design model.

1.12.4 Visual Impairment (VI)

VI refers to the loss of vision function at certain degrees. It comprises of three diagnostic conditions which are totally blind, legally blind, and low vision. Low vision has been chosen for the purpose of this study. People with low vision have defects in vision functions that are unable to be corrected via spectacles, or contact lenses, or medical or surgical treatment but are able to utilize AT such as magnifying glasses or telescope to perform normal tasks.

1.12.5 Low Vision

Low vision refers to a person who has a profound visual disability, but still retains some useful eyesight. Low vision is resulted from two possible sources which are reduced visual acuity and restricted field of view. In the context of this study low vision refers to reduced visual acuity which means having a limited ability to discriminate visual detail.

1.12.6 Conceptual Design Model of AC4LV

Conceptual design model is the arrangement of components with flows and connections. In this study, the Conceptual Design Model of AC4LV comprises of structural component, content composition component, AC4LV elements, learning theories, learning approaches, development process, ID models, and technology. The production of a set of conceptual design model for this study enables the future developers to come out with AC for low vision children.

1.13 Thesis Structure

This thesis comprises seven chapters in total. The whole contents of each chapter are outlined as follows:

Chapter 1: Introduction – As an introductory this chapter provides some background of study that underlies to the detail elaboration on motivation of the study, the issues and problem that discuss on the scenario and justification which then lead to the chosen research topic. In supporting the research problem, result of preliminary investigation are also discussed which then guide to the formulation of research gap, research question, and research objective. To avoid any mistaken perception; scope, significance, and operational definition and terminologies are also provided in this chapter

Chapter 2: Reviews on Concepts and Theories – A systematic and in-depth reviews on concepts and theories are needed before beginning with designing the conceptual model. It is important in making sure the conceptual design model is correspond to the components and elements needed and complying the research objective. Thus, reviews on concepts and theories underlying this study are express comprehensively in this chapter, as well as the critical analysis on the previous model and how it implicate to this study are also discussed profoundly.

Chapter 3: Research Methodology – This chapter comprises of step by step from the beginning to the end on how the objectives which formed in Chapter 1 are achieved. Overall, Iterative Triangulation Methodology has become as the root for the whole of the study joined with design science research to produce artifacts in the form of conceptual design model and AC4LV.

Chapter 4: Construction of Conceptual Design Model of AC4LV – The works involves in achieving objective one and two are discussed detail in Chapter 4. It explains the process engage in constructing the Conceptual Design Model of AC4LV also validation from the expert review.

Chapter 5: Prototyping of AC4LV Conceptual Design Model – The complete conceptual design model then have to be transformed into a working prototype. Prototyping making sure that the proposed model is validated. So, Chapter 5 discussed specifically each of the process involve in the development of AC4LV.

Chapter 6: User Experience on AC4LV – In achieving the fouth objective of this study, the prototype of AC4LV were evaluated on the experience of using it in terms of information accessibility, navigationability, and pleasurability aspects. Also, the testing procedures provided for this study are discussed at length and expansively.

Chapter 7: Conclusion – Finally Chapter 7 deliberates on the findings of this study by answering all the research question and research objective. Also, concluding the whole works in this study particularly in considering the implications of AC4LV conceptual design model to the body of knowledge, theory, and practical as well as recommendations for future directions of the study.

1.14 Summary

Having explored the issues related to the conceptual design model and the needs of low vision learners in learning, this introductory chapter has strengthen the research problem and research gap by conducting two cycles of preliminary studies. Information accessibility, navigationability, and pleasurability were found as the needs of low vision learners in their learning activities. Also, through the preliminary studies, it leads to the formation of research questions as stated in Section 1.6. Hence, in answering the research question, four sub-objectives were formulated; (i) to determine the components and elements of the Conceptual Design Model of AC4LV, (ii) to develop the Conceptual Design Model of AC4LV, (iii) to validate the developed Conceptual Design Model of AC4LV through expert review and prototyping, and (iv) to investigate user experience of AC4LV in terms of information accessibility, navigationability, and pleasurability. Also, scope and significance of the study were clarified in this chapter. Besides, throughout this study a number of concepts and theories were referred and reviewed which provide fundamental understanding of the issues related to this study and supported all the suggestion made. It was visualized in the form of framework. The next chapter reviews and critiques all those concepts and theories.

CHAPTER TWO

REVIEWS ON CONCEPTS AND THEORIES

2.1 Overview

This chapter provides a systematic review which targets to analyze the literature for the purpose of looking for concepts and theories related with this study. An exhaustive review of literature on critical analysis of existing models, and several learning theories as well as learning approaches have been analyzed extensively throughout the scope of this work. The review reveals on the necessity in an attempt to produce a more complete Conceptual Design Model of AC4LV.

2.2 Assistive Technology (AT)

To date, technology has become very important in human life. Every single thing of human activity is assisted with technology-supported product either it is low or high technology. It is common for people to start their day by driving with guidance of Global Positioning System (GPS), communicating through wireless smart phone, and in fact enjoy shopping at home via online transactions. Eventhough the human is perfect with mental and physical capabilities, still the usage of technology is a part of necessity in accelerating the human daily activities in this digital age. Due to that, the life of PWDs also has been impacted by the rapid evolution of modern technological developments. The standard term used for them is called AT. Whereas, the common definition of AT is any form of hardware and software that are purposely designed for PWDs to assist them in undergoing their daily routine. Various definition of AT has been formed by many researchers and organization as well as societies based on their preferences and perceptions. In this study the term AT refers to any piece of equipment in terms of hardware or software that are specifically designed for PWDs.

Gamble, Dowler, and Orslene (2006), Parette, Blum, and Boeckmann (2009), Kelly and Smith (2011), Dove (2012), and Andrea (2012) define AT as it has been defined by Individuals with Disabilities Education Act [IDEA] (2004). From legal perspective, AT can be divided into device and service. AT device is "any item, piece of equipment, or product system, acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with disabilities" (IDEA, 2004, p. 2652). Then, IDEA further define AT service as "any service that directly assists an individual with a disability in the selection, acquisition, or use of an AT device" (IDEA, 2004, p. 2652). Additionally, Bernd, Van Der Pijl, and De Witte (2009) classifying AT as any special devices, equipment, instruments, technology, or software that produced to ease, compensate, and observe the person who has any impairments or restrictions in doing daily activities (European Standard EN ISO 9999, 2010). On top of that, Freitas Alves, Martins Monteiro, Rabello, Freire Gasparetto, and Carvalho (2009) agreed with Cook and Polgar (2007) who explain AT as inter-domain of knowledge including products, resources, methodologies, strategies, practices, and services. Both of the group agree that the main objective of AT is to promote functionality among the PWDs in multiple aspects of human life ranging from autonomy, education, independence, quality of life, and social inclusion.

Apart from that, there are also several researchers state the idea that AT range from high-tech to low-tech equipments (Konicek, Hyzny, & Allegra, 2003; Thomson, Bakken, Fulk, & Peterson-Karlan, 2004; Dulgan, Millborne, Campbell, & Wilcox, 2004; Lee & Templeton, 2008; Hersh & Johnson, 2008; Reichle, 2011; Dove, 2012). Usually the high-tech equipment operate electronically contrasting with low-tech equipments that operate manually (without electric intervention) (Salminen, 2008). Although high-tech AT are incorporated with electricity, that does not mean that high-tech is expensive and categorized as sophisticated AT (Scherer & Glueckauf, 2005). However, O'Dea (2012) considers it as mid-tech AT. A mid-tech AT can be as simple as low-cost switch that controls battery-operated toy, portable FM sound loops, and posture control walker (Family Center on Technology and Disability [FCTD], 2012). On the other hand, there are also high-tech AT that are too complicated for the PWDs and family itself to utilize it. Some examples of high-tech AT is CCTV and Augmentative and Alternative Communication (AAC). Meanwhile, some examples of low-tech equipments include pencils grips, mouth sticks, mechanicals hoists, mathline, and self-opening scissors.

On the other hand, AT are also designed to improve the ability of PWD in accelerating certain parts of their activities such as CCTV that are used by low vision person to increase their capabilities in reading textbook (Scherer, Craddock, & Mackeogh, 2011). This indicates that AT provides opportunities for the PWD to interact with the environment by circumventing the barriers that hinder them to participate in any activities around them (Stumbo, Martin, & Hedrick, 2009; Ripat & Woodgate, 2011; Zhou, Parker, Smith, & Griffin-shirley, 2011). Inline with that, it enables the PWDs to maximize their personal independence and indirectly could avoid them from feeling humblest in increasing their participation in works and social life domains (Stumbo, Martin, & Hedrick, 2009; Steel & Witte, 2011).

One of the major components that should be considered by developers in designing AT is that the products must be flexible enough to be used by the PWDs without requiring any other supported AT products or modification (Kerkmann, 2012). In conjunction, O'Dea (2012) recommends that AT device or service are not tailored to each PWD based on disability, grade level, or educational environment. Instead, they are decided based on the specific tasks the individual faces, which refers to difficulties to perform or unable to perform at all.

All the above definitions lead to a conclusion that AT can be in the form of hard or soft technology (Waldron & Layton, 2008). Hence, they are special tools provided for PWDs to help them in undergoing their life routine. The necessity of AT is high for PWDs especially for the severe disabilities. On the whole, it could improve their quality of life in various domains including education and social.

2.2.1 The Widespread Use of AT

To date, thousands of AT products have been designed and developed by many researchers and established companies as their social responsibilities to the society as well as making profit. From the simplest to the most complex and sophisticated AT products have been designed since in the past years. Among factors that result in the widespread use of AT include:

i) the increasing number of ongoing research on AT.

ii) to ensure that PWDs could achieve their success in education, employment, and living independently (Stumbo et al., 2009).

iii) at one point of the human life from infancy to old age each individual may face a range of possible impairments, either in the form of physical, emotional, or cognitive part (Dove, 2012).

2.2.2 The Categories of AT

Based on the definition as described in the previous section, AT can be categorized into several types. The next subsection discusses the categories of AT products that have been used widely around the world.

2.2.2.1 Computer-based AT

Computer-based ATs provide a wide range of modifications that allow the PWDs to access information from anywhere and anytime (Dove, 2012). Apple Incorporated (2013) is one of the international companies that is committed in providing computer-based AT to the disabled user through their products. Since 20 years ago Apple Incorporated has concerned with the needs of PWDs. Particularly, accessibility is the main function that is emphasized in their product. Therefore most of their innovative products include AT as a standard feature and enables the PWDs to access and enjoy them without any additional costs. As an example, a screen access technology that provides screen magnification and voice over give opportunities to the blind and low vision people to use iPhone, iPad, iPod, and OS X. Besides, for those who have difficulties in using mouse, every Mac computer could assist them with *mouse keys*, *slow keys*, and *sticky keys* that function based on the user needs and capabilities. Another sophisticated invention is braille mirroring which allows multiple braille users including deaf and blind students to work, collaborate, and learn together on the same computer at the same time without having to share the same braille display. At the same time they also can follow the teacher's demonstrations to their sighted classmates (Apple Incorporated, 2013). With the advancement of computer-based AT people with severe disabilities are also able to use computers by using their gestures such as eye movement and breath (Dove, 2012). The gesture technology also has been introduced by Apple Incorporated through their voice over technology by using simple gestures such as tap and flick (Apple Incorporated, 2013).

Further, Microsoft Corporation (2013) also offers numerous modern AT products in terms of hardware and software which are designed with additional accessibility for those who have difficulties and problem in vision, hearing, dexterity and mobility, language and communication, and learning. The examples of this are described in Table 2.1:

Table 2.1: Examples of Microsoft AT Products

Name of AT Products	Function	Target User
Braille embossers	Convert the computer-generated text into braille that can be printed on the embosser.	Totally blind
Keyboard filters	Assist user in typing such as word prediction utilities and add-on spelling checkers to reduce the keystrokes. It allows users to quickly access the required letters and avoid user to select the unnecessary letters.	Learning impairment
Light signaler alerts	Alert user with the light signal rather than the computer sound. It is useful for the hearing-impaired users.	Hearing impairment
On-screen keyboards	Allow user to select keys with a mouse, trackball, touch screen, joystick, switch or electronic pointing device through the keyboard image that are displayed on computer screens.	Dexterity or mobility impairment
Reading tools and learning disabilities programs	Help people who have difficulties in reading or learning English language. The functions include scanning, reformatting, navigating, or speaking text loudly.	Learning disability
Refreshable braille displays	Present the output of information in the form of tactile. The users use their fingers to read the letters on screen by refreshing the display.	Totally blind
Screen enlarges	Enable users to zoom in and out any particular area on screen.	Low vision
Screen readers	Convert everything on the screen including text, icon, graphics, and menus into a computerized voice. It is also called audio interface.	Totally blind
Speech recognition	Allows users to give commands or enter data through their voice rather than using mouse or keyboard by using microphone attached to the computer.	Totally blind
Speech synthesizers	Allow users to hear what they are typing on screen. Provide voice for those who have difficulties in communicating orally but can communicate through typing.	Totally blind, learning and speech disability

In addition, Microsoft Corporation (2013) also provides several types of alternate input devices which enable the disabled users to control their task without using standard keyboards or pointing devices as provided for non-disabled users. Most of this AT devices and systems are designed for physical impairment (Table 2.2).

Table 2.2: Examples of Alternatives Input Devices

Name of AT Products	Function
Alternatives keyboards	For used with one hand either it is larger or smaller than standard keys or keyboard with alternative keys configurations.
Electronic pointing devices	Using ultrasound, infrared beams, eye movements, nerve signals, or brain waves to control the cursor on the screen.
Sip-and-puff systems	The user has to inhaling or exhaling to activate the system.
Wands and sticks	Used to press the keys on the keyboard by worn it on the head, held in the mouth, or strapped on the chin.

2.2.2.2 Augmentative and Alternative Communication (AAC)

AT that is designed specifically for people who have difficulties in communication or speech is known as AAC. It refers to any method of communication other than speech that are designed for people who have impairment in speech or writing language due to cerebral palsy, unintelligible, down syndrome, and autism (Worah, Douglas, McNaughton, & Kennedy, 2010; Ann & Theng, 2012). Based on the term itself AAC is divided into two categories, which deals either in terms of augmentative or alternatives communication (Heracleous, Beautemps, Ishiguro, & Hagita, 2011; American Speech Language Hearing Association [ASHA], 2013). Augmentative communication is designed for people who are able to speak but have some limitations to use their speech fluently. It is used to support or as supplement for them to speak verbally (Heracleous et al., 2011; ASHA, 2013). In contrast, alternatives communication is the term used for people who are unable to speak at all and must used another method of communication to express all their thoughts, ideas, needs, and wants (Heracleous et al., 2011; ASHA, 2013). An example of AAC electronic device is Speech Generating Devices (SGD) or also known as Voice Output Communication Aids (VOCA). It can produce voice output by recording natural speech digitally or through computer-generated speech (Lee & Templeton, 2008). The capabilities of this technology have currently been integrated into smart phone.

2.2.2.3 Environmental Control AT

Environmental control AT mostly provides devices or tools that allow the PWDs to control things around them. This includes remote controls, touch pads, switches, eye trackers, braille signs, visual fire and smoke alarm signals, visible signaling appliances, and handrails and mobility ramps (Yamauchi, 2009). Most of these types of AT devices assist the PWDs including with severe disabilities to live independently without helps from their parents (Reichle, 2011). This is because most types of alarm signals either in the form of sound, visual, or vibrating enable the PWDs to set their daily routine as reminder methodically. Also, modifications that are suitable with their inabilities criteria have been made such as at home or public areas to facilitate them in daily living (Copolillo & Ivanoff, 2011). These include facilities in bathroom such as specially designed bathtubs, shower stalls, toilet seats as well as grooming aids[2]. There are also specialty equipments in kitchen to assist them in cooking and eating such as cooking devices and eating utensils[3].

[2] http://www.nidirect.gov.uk
[3] http://www.livingmadeeasy.org.uk

2.2.2.4 Telecommunication AT

Assistive telecommunication devices which are often developed for people who face difficulties in hearing is known as telecommunication device for the deaf (TDD) (Mills, 2010). It can also be used for people who have disabilities in speech. It is an electronic device or teleprinter which is designed for text communication over the phone line. Some developers and researchers call it as teletypewriter (TTY). The common name in Europe is textphone, and in United Kingdom (UK) people named it as minicom. It functions by allowing persons who are unable to hear or speak to communicate over the phone. However there are only certain countries that have special telephone services to carry the TDD functionalities (Mills, 2010).

Other than telecommunication devices there are also telecommunication systems that are provided for PWDs to handle them especially in emergency situation. It is called Personalized Emergency Response Systems (PERS) or in UK it is called Telecare Systems. A PERS has three main components. There are a small radio transmitter which consists of a help button that is carried or worn by the user; a console that is connected to the user telephone; and an emergency response center to monitor user calls. It helps parents and caregivers to manage risk and train the PWDs to live independently (Dove, 2012).

Additionally, a recent sophisticated AT product is created for hearing loss people is called Enabled Talk. It was created by a team of Ukraine students to help those who talk using sign language to communicate with those who are normal. Enabled Talk is a set of gloves fitted with a series of sensors, gyroscopes, and accelerometers. It is able to translate sign language into text, and then followed by spoken words (Knox, 2012).

2.2.2.5 Cognition AT

AT for cognition could help people with cognitive disabilities in variety of domains regarding cognitive process including planning, execution, attention and memory, literacy, social and behavioral, self regulation, navigation, emotion recognition and management, and sequencing activity (LoPresti, Bodine, & Lewis, 2008; Gillespie, Best, & O'Neill, 2012). As an example a WatchMinder is an alarm wristwatch that solves the socio-behavioral issues. It works by proving cues for a behavioral modification program (LoPresti et al., 2008). Another example is General User Interface for Disorder of Execution (GUIDE) which is an interactive verbal prompting system. It works by reminding people to perform a task at an appropriate time and enables them to manage their time properly especially for the dyslexia person (Yamauchi, 2009).

2.2.2.6 Mobility AT

For those with mobility impairment and live in developing countries, AT provides them with an innovative lever powered mobility aid namely Leveraged Freedom Chair (LFC) (Borg et al., 2012). It has been introduced by Global Research Innovation and Technology (GRIT) and is available at a low price (GRIT, 2012). LFC is 80% faster than the conventional wheelchair. It can be handled easily on rough and unpaved roads by using hand levers provided on the right and left side of

LFC (Winter et al., 2010). The adjustable speed allows users to control it calmly. In addition, LFC is also compact and it does not have any complicated parts for users to handle independently. Furthermore it can be ridden and repaired anywhere (GRIT, 2012).

Through the reviews, numerous types of AT products are used widely around the world. In regards to this study, AC4LV is fall under the category of computer-based AT. It could be seen that, most of the computer-based ATs are produced in the form of hardware and software but AC4LV is a type of content application. So, through the review it indicates that computer-based AT in the form of content application is highly lacking.

Besides AT, other types of technology that consider disabled people as the user is inclusive design which discussed in the next section.

2.3 Inclusive Design

The term inclusive is roughly explained as "acceptance in a whole", which means general population including PWDs has equal access and opportunity in each field (i.e. education and social) (Bendová, Čecháčková, & Šádková, 2014). Known as Design for All in Europe and universal design in the USA (John Clarkson & Coleman, 2013) it is broadly defined by Keates, Clarkson, Harrison, and Robinson (2000) as products, services, or environment that are able to be used and accessed by all individuals to the greatest extend possible irrespective of age and ability (Nantanoot, 2013). This has to be ensured by the designers that their products or services address the needs of the widest possible population (John Clarkson & Coleman, 2013). In the context of software design particularly on learning materials, Ohene-Djan and Shipsey (2008) debate that most of the educational technologies fail to give equal access of the learning materials to the learners with impairment. Based on that issue, they have proposed the following six principles for inclusive software design of learning tehnologies:

i) *Adaptive content*: implemented as multiple representations of learning materials that are accessible in any case of learners' impairment (i.e. presentation of sentence may be read aloud and provide subtitles for video presentation).

ii) *Adaptive interaction*: implemented as multiple methods of user interaction that could be applied regardless of learners' impairment (i.e. typing, talking, and using a mouse, keyboard, or joystick).

iii) *Adaptive presentation*: implemented multiple presentations of learning materials that concern on users' visual, hearing, or motor impairment needs (i.e. students have choice to increase the size of the button and to have textual or graphic presentation).

iv) All *adaptive features should be revisable*: users have option to turn on or off any inclusive features provided in the software.

v) The *content level and complexity* of the learning materials should remain the same without regard to the method of interaction and presentation.

vi) The software should be *feature complete* irrespective of any form of adaptive content, interaction, or presentation method employed.

Besides, Siu and Lam (2012) also argue that most of the current Computer-assisted Learning (CAL) facilities are not VI friendly due to high price and the learners face a lot of barriers in terms of the design such as difficult to access, manipulate, and use the facilities. So, they applied the universal design principles, identified, and discussed some key directions for improvements to the design policy of public CAL facilities for the children of VI including low vision to have inclusive learning. Some of them are (Table 2.3):

Table 2.3: Universal Design Principles in Public CAL for VI Children

Universal Design Principles	**Application in Public CAL**
Equitable use	The design is useful, accessible, and marketable for people with diverse abilities which mean public CAL is designed not only able to be used by children with VI but also to anyone irrespective of their motion, sensory, and cognitive abilities and disabilities.
Flexibility in use	Provide a choice of method of use in approaching and reaching the CAL facilities as example provide keyboard and mouse-based interaction, electronic-Braille output device and tactile image printer to facilitate the VI children read the information from the output devices.
Simple and intuitive use	The design is easy to understand, irrespective of the users' experience, knowledge, language skills, or current concentration level for example providing simple and direct keyboard input buttons operated by one hand is more convenient for VI children.
Perceptible information	This principle means public CAL facilities should provide all basic information in variety modes such as Braille, tactile symbol, audio, audio tactile and synthesized non-speech sound.
Tolerence for error	Public CAL has to have careful design to prevent the users from accidental movement that cause problems such as

	accidentally dropped and damaged.
Low physical effort	The design should be used efficiently and comfortably, with a minimum fatigue which means the VI children should be possible to input and access data in a similar way of other people.
Space for approach and use	Public CAL facilities should provide appropriate space for VI children to use the facilities such as a larger table space for reading Braille was sometimes necessary.

With regards to this study, that focuses on designing a courseware specifically for low vision learners, some of the discussed design principles are considered. However, this study intends to focus on the design of the content narrowly to low vision learners which has not been covered exclusively in the inclusive design or universal design.

2.4 Disabilities

Various definitions and variation of study regarding disability has been discussed and compared internationally. Previously the prevalence definition of disability was frequently coined with medical condition of an individual (Alhajj et al., 2010; Krahn & Campbell, 2011). However, to date the definition of disability is not just covering the aspects of health and medical but it is also broadly referring to individual functionality. In the context of this study, the disability (inability) is referred to individual who has reduction of ability or function in certain circumstances to execute tasks in normal measurement compared to those who are normal. Profoundly, the term disabilities refer to restriction of individual function either in physical, cognitive, mental, sensory, emotional, and developmental or any combination of these (Brault, 2012). However, there is also a study that consider behavioral handicap as disability (Minou & Manuchehr, 2012).

On top of that, Brault (2011) and his team of American Community Survey (ACS) discuss the concept of disability as having difficulty in vision, hearing, cognitive, ambulatory, self-care or independent living. It has also been supported by Walsh-Gallagher, Mc ConKey, Sinclair, and Clarke (2013) who bring out the disability as a consequence of impairment in physical, sensory, or intellectual. As a result, one of these three types of impairment could affect the performance of day to day activities (Wheeler, Yang, & Xiang, 2009). Not only that, Walsh-Gallagher et al. (2013) view it as the result of various barriers that exist in organizational, attitudinal, and environmental.

Under WHO (2013), disabilities is an expansive concepts that cover three aspects which are impairments, limitations of activities and restrictions in participations. In detail, impairment refers to having some problem in function or structure of individual body. Whereas, an activity limitation refers to individual who faces some difficulties in performing a task or action. While, participation restriction refers to the problem or difficulties undergone by disabled person in taking part in their life situation (WHO, 2013).

On the other hand, the Malaysian Government (2013) describes the disabled person as anyone who is unable to acquire the normal requirements for him/herself and community either fully or partially due to impairment in physical or mental. Apart from that, the Malaysian Department of Social Welfare (2013) explains disabled person as it has been defined in Disability Act 2008 that refers to those who have long term reduction in physical, mental, intellectual, or sensory that restricts them to interact or participate with external environment and society.

In the workplace organization, such as International Labor Office (ILO) of Geneva comprehends the disability concept as ‘evolving concept’ which leads to the meaning of PWD as a person who faces long term impairment in physical, mental, intellectual or sensory which hinder them with various barriers to allow them to interact with themselves and society fully and effectively with the basic activity equally with others (Retournard & Evans-Klock, 2010). On the other perspectives, in its *Code of Practice on Managing Disability in the Workplace,* the ILO further discuss the concepts of disabled person as “an individual whose prospects of securing, returning to, retaining, and advancing in suitable employment are substantially reduced as a result of a duly recognized physical, sensory, intellectual, or mental impairment” (Retournard & Evans-Klock, 2010). The loss of ability may be able to happen since birth or occur during the individual’s lifetime resulted from injury, disease, or aging (Malaysian Goverment, 2013).

On top of that, the UK government through its Equality Act 2010 embraces all the above describes perspectives and provides the guidance regarding the definition of disability as well as the main elements of disability (Office for Disability Issues [ODI], 2010). The main element of disability is the disabled person itself, which is marked out as a person that has a substantial and long-lasting conditions of impairment in physical or mental which negatively impact their ability to fulfill day-to-day activities normally (ODI, 2010; Shandra, Avery, Hogan, & Msall, 2012). This lead the meaning of disability to the following elements (ODI, 2010):

- The person must have impairment either physically or mentally;
- The impairment must have negative implications which are substantial;
- The substantial negative implications must be in long-term period; and
- The long-term period of substantial negative implications must effects the normal day-to-day activities.

Hence, by compiling and analyzing all the definitions discussed above this study defines disability as any lack or loss of function in any part of human body physically or mentally which hinders them to perform their basic daily task as normal people for a long-term period. The disability is possible to occur to anybody including children. The next subsection further discusses the types of disabilities.

2.4.1 Types of Disabilities

By taking out all the significant elements of disabilities, it is classified into seven categories as outlined and described in Table 2.4 (American Department of Justice, 2010; Brault, 2011; Alberta Education, 2012; Mates & Booth, 2012; Malaysian Department of Social Welfare, 2013).

Table 2.4: Category of Disabilities

Category	**Description**
Hearing	Unable to hear clearly in both ear without using hearing aid or have no hearing at all although by using hearing aid. In detail it refers to persons who have trouble in distinguishing at certain frequencies, localizing sounds, or hearing at certain pitch. Hearing impairment are divided into four stages namely: minimum: 15 < 30dB (children) 20 < 30dB (adult), medium: 30 < 60dB, severe: 60 < 90dB, and profound: ≥ 90dB.
Visual	Discussed in detail in the next section.
Speech	Unable to speak or speech disorder which means not able to communicate properly and could not be understood by those who interact with him or her. This condition is permanent and could not be recovered.
Physical	Permanent disability in any part of body limb whether due to loss, shortage, or inability which could affect their function in doing fully basic activity such as personal care, movement of any part of limbs, and changes of body position. These circumstances can happen due to injury or disease in nerve system, cardiovascular, respiratory, hematology, immunology, urology, hepatobiliary, musculoskeletal, gynecology, and others which cause any loss of function. The examples of physical impairment are limb defects, stroke, achondroplasia, and cerebral palsy.
Learning	Having brainpower problem which means the brainpower was discordant with the biological age. Those who included in this category were slow learners, down syndrome, and intellectual disabilities. This category also include any circumstances which affects the individual learning capabilities such as autism, Attention Deficit Hyperactivity Disorder (ADHD), and specific learning problem such as dyslexia, dyscalculia, and dysgraphia. People with learning disabilities unable to read or understand text, unable to see numbers, or execute the simple mathematical function.
Mental	Heavy mental illness that can cause whether a part or fully loss of function in his related case or relationship in society. Some types of mental illness are serious and chronic such as schizophrenia, paranoid, mood disorder, and other psychotic disorder such as schizoaffective disorder, and persistent delusional disorders.
Multiple	Having more than one type of disabilities and generally unsuitable to be classified in any category as discussed above.

Disability is a complicated phenomenon in which it is not just considered as a health problem but it is more than that. This is because the disabilities are able to reflect the interaction between features of PWDs and features of environment or society around them (WHO, 2013). In accordance, to overcome the problem and difficulties faced by PWDs especially relate to children in education, social and environmental barriers it requires some intervention programmes as discussed in the previous chapter. Thus, the next subsection discusses the concept of disabilities in children environment.

2.4.2 Children with Disabilities

As mentioned in the previous chapter, this study is scoped to disabled children. Therefore, to understand the concept of disabled children this section provides some analysis from previous works regarding that scope. Plant and Sanders (2007), Brault (2011), and Shandra, Avery, Hogan, and Msall (2012) agree with IDEA (2004) that defines disabled children as:

> Any child who has mental retardation, hearing impairment (including deafness), speech or language impairments (including blindness), serious emotional disturbance, orthopedic impairments, autism, traumatic brain injury, other health impairment, or specific learning disabilities; and who by reason thereof needs special education, and related services. (IDEA, 2004, p. 2652)

This definition is supported by Minou and Manuchehr (2012) who noted that children with disabilities refers to millions of children in the world that have physical, mental, or behavioral handicaps which requires special education so that they obtain benefit from it. Inline with that, children with disabilities require more complex needs as opposed to normal children in terms of learning, developmental issues, behavior, and health (Shannon & Tappan, 2011). It seems that each part of the definitions emphasize the aspect of education in indicating children as the primary subject.

Despite the various disability definitions, there are also numerous researches those determine the category of age for disabled children. Hence, age five or six to seventeen years old are appropriate (Martin & Choi, 2009; American Department of Justice, 2010; Brault, 2011; Minou & Manuchehr, 2012; Mâsse, Miller, Shen, Schiariti, & Roxborough, 2012; Haynes, Gilmore, Shochet, Campbell, & Roberts, 2013). This is because their abilities were incongruous with their actual age. Normally the studies also called this group of disabilities as school-aged children. However there is also a research that specifies the disabled person between twelve to eighteen years old as disabled adolescents (Bult, Verschuren, Jongmans, Lindeman, & Ketelaar, 2011).

On top of that, by reflecting the definition of disabilities as discussed by ODI (2010), it leads to the meaning that the person who is below than six years old is not classified as disabled. This is due to the implication of impairments possibly not appearing in infant or young children for the reason that their abilities and capabilities are too young to be developed whereas the disability has to be in long-term (Wheeler et al., 2009; ODI, 2010; Shandra et al., 2012). In contrast, there are some studies that identified the children as disabled person since there are one or two years old (Bult et al., 2011; Tsai, Kung, & Wang, 2012).

It seems that, many factors were contributed to classify the person as disabled baby, children, or adolescents. It depends on the types of disabilities (Breau & Camfield, 2011), level of abilities and capabilities (Matson, Mahan, & LoVullo, 2009), parental care and support (Martin & Choi, 2009; Boström, Broberg, & Bodin, 2011), disabilities' service provided by the country including health and education (Miles et al., 2011), AT that has been exposed to them (Kamei-hannan, Howe, Herrera, & Erin, 2012), and the environment surrounding them (Shandra et al., 2012).

Various arguments have been addressed concerning on the concepts of children with disabilities. Having blended all the discussions and facts in previous research, this study decides to scope the subjects of study among children with average age nine to twelve years old. Besides, the scope has also been decided based on the results of preliminary study as well as the suggestions by content experts in which in Malaysia context, the disabled children are exposed to the ICT world since they are in standard three. In accordance, the next subsection further details the subject of study.

2.5 Visual Impairment (VI)

In defining VI as an important term for this study, it is realized to mean the three diagnostic categories of VI including legally blind, totally blind, and low vision as addressed by Maćesić-Petrović, Vučinić, and Eškirović (2010) and Loiacono, Djamasbi, and Kiryazov (2013).

Inline with that, in classifying the definition of those three diagnostic terms, this study intends to refer to various fields of previous works intensively and extensively. In a simple word, totally blind is referred to no light perception at all; legally blind refers to those who are unable to improve their vision better than 20/200 and have 20 degrees or less of visual field; low vision refers to lack of vision function which is unable to be corrected with contact lenses or medical and surgical treatment (Southwell & Slater, 2012) and color blindness is a type of low vision that impairs one's ability to identify certain pairs of colors (Loiacono et al., 2013). On the other hand, Dursin (2012) found that, VI is a condition where the individuals are able to see severely or are unable to see at all resulting from genetic or functional diseases of eyes. Apart from that, the persons who have 10% and less eyesight are classified as VI and those who need extra tools to see, read, and write efficiently are categorized as low vision (Dursin, 2012). Apart from that, Maurel et al. (2012) recognize that blind persons are those who have level of perception less than 1/100 after being corrected or when the width of visual field is below than 20 degrees whereas the standard degrees is 180.

Nevertheless, there are various of formal definitions of VI (i.e. IDEA, 2004; National Dissemination Center for Children with Disabilities [NICHCY], 2012; WHO, 2012; European Blind Union [EBU], 2013) that encompass a wide spectrum of people who range from totally blind to partially sighted (Beverley, Bath, & Barber, 2011). According to public law IDEA (2004) sternly states that VI including blindness means "impairment in vision that, even with correction, adversely affects a child's educational performance. The term are includes both partially sight and blindness" (IDEA, 2004, p. 2652). Later, NICHCY (2012) further outlines the degree of impairment that a child can have, it can range from mild to severe and it depends on:

- The specific eye condition that the child has;
- The cause that affect the visual system (i.e. unable to detect light, shape, or color; unable to see things at distance, up close, or peripheral); and

- The level of corrections that is possible to be corrected via spectacles, contact lenses, medical or surgical treatment.

Also, according to NICHCY (2012) the term blindness does not necessary mean the child cannot see at all because if they suffer from legally blind (discussed in the next paragraph) they still can see light, shapes, colors, and objects even indistinctly.

Going deeper to ophthalmologist aspects, VI is resulting from loss of vision functions' rather than the eye disorders itself (Schneider, Leeder, Gopinath, Wang, & Mitchell, 2010). The cause of VI is either from disease, trauma (Sinha & Baumann, 2010), congenital (Tan et al., 2007), or degenerative conditions that cannot be corrected by refractive correction, medication, or surgery (Schneider et al., 2010). Congenital blindness is a condition that may happen before birth in which damaged genetic of a pregnant mother is transmitted to the fetus. In this cases, protozoan parasite called Toxoplasma gondii (Tan et al., 2007) is a good example. In contrast, the conditions that may cause after birth are as listed in Table 2.5 which have also been determined by Malaysian Department of Social Welfare (2013). Further, to avoid confusion, VI is classified based on certain categories as discussed in Table 2.6.

Table 2.5: Cause of VI Afterbirth

Cause	Description
Amblyopia	Sight impaired in one of the eyes caused by lack of use of that eye since early childhood (Al-Rowaily, 2010).
Cataracts	Cloudy vision at certain part or all of the lens' eyes (Furtado et al., 2012; Miyata et al., 2013).
Diabetic retinopathy	Occurs because of diabetes which caused damage of tiny blood vessels in the retina (Alghadyan, 2011; Sivaprasad, Gupta, Crosby-Nwaobi, & Evans, 2012).
Glaucoma	Damaging of optic nerve due to increment of pressure inside the eye (Weinberg, Salim, & Shields, 2010; Furtado et al., 2012).
Macular degeneration	Deterioration at the most sensitive region of retina called macula gradually and progressively. This condition then leads to central field loss of vision. It normally happen to older adults but possible to happen to anybody (Furtado et al., 2012).
Trachoma	Occur irritation in the eye due to a very infectious microorganism called chlamydia trachomatis (Baneke, 2012).

Table 2.6: Category of VI

Category	Description
Totally blind	Totally blind is refer to persons who have little or no light sensitivity at all due to severe physical destruction of the eyes or visual nerves (Demissie & Solomon, 2011).
Legally blind	Legally blind is refer to persons who have visual acuity of 20/200 feet or less even after rectification. This means that, they unable to see until 200 feet as normal people, but they able to see just until 20 feet. In addition, their widest diameter of vision field also no greater than 20 degrees compared to normal is 180 degrees (Demissie & Solomon, 2011).
Low vision	Low vision is refer to persons that have lack of visual acuity and visual field permanently which means unable to be corrected by glasses due to several eye disease as discussed above (Targher, Occelli, & Zampini, 2012). It is divided into moderate and severe (WHO, 2012).
Partially sight	Partially sight is referring to people that have less severe of vision loss compared to the three categories that discussed above. They are able to see close up or far object and able to function at normal levels with corrective lenses (Hollands et al., 2009; ICD-10, 2010).

In addition, this study classifies the above categories in Table 2.6 based on the current version of International Statistical Classification of Diseases and Related Health Problems [ICD-10] (2010) which has been revised and formulated under the WHO (Schurink, Cox, Cillessen, Rens, & Boonstra, 2011; Fürst & Vogelauer, 2012). According to ICD-10 (2010) the visual acuity for normative vision reflects to

1 which means 6/6 or 20/20. With reference to the range in Table 2.7, a child with visual acuity of less than 0.3 but better than or equal to 0.05, and/or their visual field loss are less than 20 degrees is categorized as low vision (Schurink, et al., 2011; Fürst & Vogelauer, 2012). The moderate and severe VI (WHO, 2012) means that at visual acuity of 0.3 the children are able to discern symbols at 6 meters or 20 feet contrast with normative which are able to discern symbols at 20 meters or 67 feet (Schurink, et al., 2011; Fürst & Vogelauer, 2012). Meanwhile, the visual acuity for blindness which includes totally blind and legally blind is less than 0.05 corresponding to their visual field loss of less than 10 degrees (Schurink, et al., 2011; Fürst & Vogelauer, 2012).

Table 2.7: VI Categories based on Visual Acuity Range

Category	**Visual acuity range**
Mild or no visual impairment	≥ 0.3
Moderate visual impairment	< 0.3 and ≥ 0.1
Severe visual impairment	< 0.1 and ≥ 0.05
Blindness	< 0.05 and ≥ 0.02
Blindness	< 0.02 or light perception
Blindness	No light perception

The above discussion is parallel with Malaysian Department of Social Welfare, (2013), which defines VI as blindness for both or one side of the eyes, or have limited eyesight (low vision) for both or one side of the eyes, or the reduction of vision field, or any permanent eyesight disorder. Going deeper, the people who have problem in eyesight means they carry either one symptom of the following:

- Limited eyesight (low vision): the vision that is severe than 6/18 but is equal or better than 3/60 that is unable to be corrected with contact lenses or spectacles but can be reduced by using vision aid such as magnifying glasses and telescope. It means they are only able to see the object at six meters whereas the normal people can see the same object at eighteen meters (Figure 2.1).

- Or reduction of vision field: less than 20 degrees.
- Or combination both of low vision and reduction of vision field.
- Or blindness: the vision is less than 3/60 or vision field is less 20 degrees.

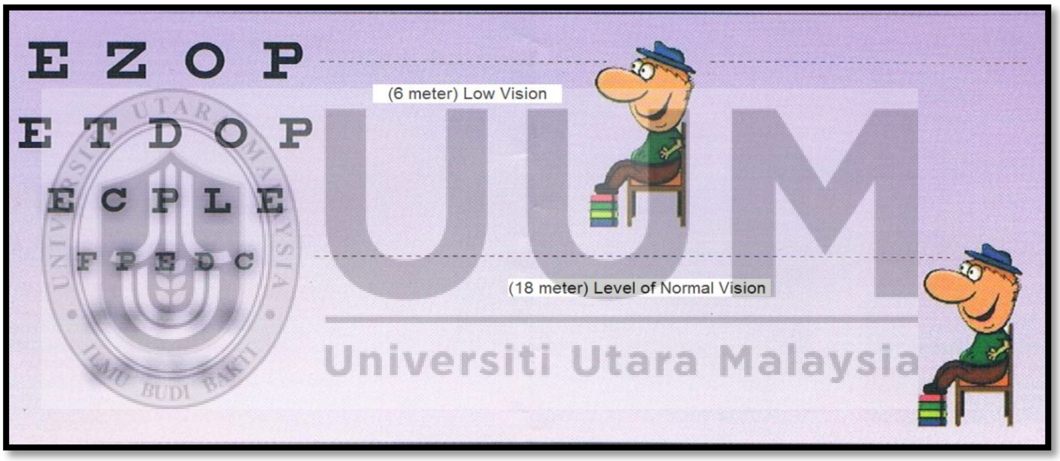


Figure 2.1: Level of Limited Eyesight

Figure 2.2: Normal Vision

Figure 2.3: Low Vision

Figure 2.4: Central Field Loss

Figure 2.5: Certain Field Loss

Figure 2.6: Reduction of Vision Field

On the other hand the above image shows the comparison between the normal vision (Figure 2.2), low vision (Figure 2.3), and example of visual field loss such as central field loss (Figure 2.4) that caused by macular degeneration, certain field loss (Figure 2.5) that caused by retinopathies diabetes, and reduction of vision field (Figure 2.6) that caused by retinitis pigmentation (Malaysian Department of Social Welfare, 2013).

Thus, for this study which reflect to Malaysian context, it is decided to scope the subject of VI specific to low vision children that have no disturbance with vision field (Figure 2.3). This means they have the limited ability to discriminate the visual detail but have no problem with field of view (Fraser & Gutwin, 2000). The rational of focusing to low vision learners because:

i) Based on the communication with expert in *preliminary study I* low vision often occurs to children rather than reduction of vision field, certain field loss, or central field loss. They normally happen to old people. This explains that low vision is appropriate because learning process starts in the childhood as discussed previous section.

ii) As discussed in previous studies (explains in previous section and Chapter 1) the use of magnifying glasses and CCTV or other AT devices was problematic for them either because of they incapable to buy that equipment, they missing the equipment, or psychologically they do not like to use AT as well as do not like to look different between their sighted peers (Malaysian Ministry of Education, 2011; Khadka et al., 2012).

iii) Preliminary studies results that transformation of learning content to multimedia application in terms of graphics, texts, audio, and animations are more applicable to be utilized by low vision learners compared to others (i.e. totally blind, visual field loss).

iv) As suggestion from the content expert (i.e. VI teachers, school coordinator of special need department) to make this study useful for them in future.

2.5.1 AT Devices for Low Vision Learners

Recently, most of the special need schools including in Malaysia are equipped with AT devices to be utilized by low vision learners in their learning activities. The most popular AT devices are CCTV (Figure 2.7) and magnifying glass (Figure 2.8).

Figure 2.7: CCTV

Figure 2.8: Magnifying Glass

i) CCTV[4]: CCTV or also known as video magnifier is a combination of customized camera, mount arm, a viewing screen/monitor, zooming lenses, and viewing modes with lighting, and contrast modes. It is also equipped with a viewing platform which allows users to easily locate their item such as books or images to be magnified. The information is displayed on the monitor. Even though CCTV is able to view a full range of visual needs and solve the learning problem (in visualization aspect) that occurs to low vision learners, it still requires them to struggle seriously in getting the information due to limited display (i.e. alphabet by alphabet or word by word). This makes them feel frustrated with the learning activities.

[4] http://www.enhancedvision.com/low-vision/cctv-magnifiers.html

ii) Magnifying glass[5]: before starting the expansion of technology, traditional magnifying glass is the formal device used by low vision learners in their learning activities. In fact, until now in certain schools especially in sub-urban area they still use magnifying glass to visualize the learning contents. Compared to CCTV which is more advanced, magnifying glass requires more hard work from low vision learners to view the learning contents due to limited magnification, failed to offer lighting support, magnification strength options, and overall significant visual support. Over again, the learners feel frustrated followed by unmotivated to learn.

In a nutshell, it is important for this study to discuss this issue to reveal the extent the low vision learners undergo their learning activities day by day in conformity to formulate the research gap. Thus, the next subsection continues to reveal the challenging task faced by low vision learners and their abilities.

2.5.2 Challenging Task and Ability of Low Vision Learners

The learning perspective of low vision learners should be determined according to their ability and performance rather than looking at physical characteristic and technical accessibility only (Khairuddin, Noor Faezah, & Md. Jan, 2010). In fact, most of the content providers ignore this aspect because of their accessibility understanding is limited to technical accessibility which is discussed later in the following section (Khairuddin et al., 2010). According to Jacko and Vitense (2001) the ability of human are classified into four categories as listed in Table 2.8.

[5] http://www.enhancedvision.com/low-vision/low-vision-equipment.html

Table 2.8: Types of Human Ability

Cognitive	**Perceptual**	**Physical**	**Psychomotor**
• Oral comprehension • Oral expression • Written comprehension • Written expression • Fluency of ideas • Originality • Memorization • Problem sensitivity • Mathematical • Reasoning • Number facility • Deductive reasoning • Inductive reasoning • Information ordering • Category flexibility • Speech hearing • Speech clarity	• Visualization • Near Vision • Far vision • Depth perception • Visual colour discrimination • Night vision • Peripheral vision • Glare sensitivity • General hearing • Auditory attention • Sound localization • Speed of closure • Flexibility of closure • Spatial orientation • Perceptual speed	• Static strength • Explosive strength • Dynamic strength • Trunk strength • Extend flexibility • Dynamic flexibility • Gross body coordination • Gross body equilibrium • Stamina	• Control precision • Multilimb coordination • Response orientation • Rate control • Reaction time • Arm–hand steadiness • Manual dexterity • Finger dexterity • Wrist–finger speed • Speed of limb movement • Selective attention • Time sharing

The discussion in the following paragraph is based on the analysis conducted by Jacko and Vitense (2001) and Khairuddin et al. (2010).

In utilizing computer and computer-based learning applications, most of the abilities listed in Table 2.8 are required except for physical ability (Jacko & Vitense, 2001). The psychomotor task (i.e. accessing the visual information) requires the low vision learners to use an alternative method of controlling device such as keyboard. Accordingly, they have to struggle to operationalize computer tasks that require limited time such as internet based exam due to their inability in controlling the pointing device (i.e. mouse) (Khairuddin et al., 2010).

The limitation of cognitive aspect occurs to low vision learners due to their infirmity in visualization ability. This is because they only depend on singular memory skill which is audio memory. Learners with low vision have limited skills in visual memory but they rely more on auditory memory. However, the learning environment today not trained their visual memory to be as good as audio memory. It is difficult for them to comprehend the floating blocks such as tables, diagrams, and charts as well as vocabulary due to restriction in word references which is more on visual presentation. Consequently, this direct affects their performance in mathematical, language, and logical reasoning. In view of that, low vision learners might have limited skill in language competency or mathematical (Jacko & Vitense, 2001; Khairuddin et al., 2010).

In perpetual ability, low vision learners definitely have limitation in visualization, near and far vision, depth perception, color discrimination, night and peripheral vision, glare sensitivity, flexibility and speed of closure, spatial orientation, and perpetual speed. This is due to their limitation in physical characteristic and the level of impairment. Conversely, they have strength in general hearing, auditory attention, and sound localization (Jacko & Vitense, 2001; Khairuddin et al., 2010).

As a result, to comprehend the learning contents are more challenging rather than technically change the texts and graphics into the audio format. Thus, cognitive and perpetual aspect is really important to be emphasized as well as technical accessibility.

2.6 Courseware and Component

Previous studies have proven that many different methods have been used in implementing computer-based teaching and learning such as educational game, PowerPoint presentation, mobile learning, virtual classroom, web-based software and the most popular is courseware (Efendioğlu, 2012). Courseware is educational software that contains specific instructional content and instructional delivery systems to generate the instruction (Nik Siti Hanifah, Tao, & Ping, 2011). The main aim of the courseware is to facilitate the learning process (Efendioğlu, 2012). To achieve that aim, the courseware should be designed in the sense of able to (i) catch the learners' attention to the subject matter, (ii) demonstrate the facts clearly, and (iii) provide learners with comprehension explanation (Efendioğlu, 2012). In that sense, the courseware should have some fundamental pedagogical qualifications similar to teacher (Efendioğlu, 2012) including learner friendly, interactive, and able to assist the learners to learn independently (Thao & Quynh, 1997).

On top of that, Thao and Quynh (1997) suggest that courseware consists of three basic components as discuss as follow:

i) **Content component:** the content area depends on the course (i.e. lesson 1: introduction to Science) whereby each of the content area consists of sub-components including modules (lesson-typed presentation), problem solving tasks (learning by doing), basic terminology (key concepts), review (recall the lesson), and key references (important reading).

ii) **Facilitating experience:** learners are provided with activities to increase the comprehension of the lesson. Such of the activities are stimulating questions (to raise the intellectual curiosity), and test (mini-test with result).

iii) **Learning experience:** focusing on practice exercise which the learners can do it independently or assisted by the instructor. As example is practicing works.

In the context of this study courseware is refer to AC which further describe in the next section. Nevertheless, this study also considering the component of courseware as discussed above in designing the Conceptual Design Model of AC4LV.

2.7 Assistive Courseware (AC)

There were few researches carried out the specific definition or concept of AC despite there is a number of studies that research on the development of courseware for disabled learners (Ellis, 2009; Norfarhana et al., 2010; Morfidi et al., 2010; Sampson & Zervas, 2010; Seo & Woo, 2010; Siti Zaharah & Nor Azan, 2011; Savita & Nur Athirah, 2011; Rahmah & Tengku Nazatul, 2012; Rahmah et al., 2012). It was found that, all of them do not refer to their courseware as AC except for the work carried out by Muhammad Haziq et al. (2009), Nurulnadwan et al. (2009), Nurulnadwan et al. (2010), Nurulnadwan et al. (2011), and Zatul Amilah et al. (2011). In fact, the definition of AC is still limited and it is only found in the study by Nur Hazwani et al. (2010), which refers AC is for VI learners and defines it as "a courseware that is designed for VI people to learn and enjoy lesson like normal people, applying special instructional approach, and provide special elements for VI people" (Nur Hazwani et al., 2010, p. 1).

Although those studies do not provide any specific definition for AC, and in fact not use the term AC in their studies, but most of them agree on the same idea in terms of component, element, theory, approach, and instructional strategies which is further discussed in the Section 2.13. Also, they agree that the development of AC should consider the aspects of instructional strategies and approaches which depend on the types of disability and the level of ability. Both aspects formulate that the AC is different from TC.

With regards to the discussion on the concept and definition of AC, this study defines AC as a courseware which is exclusively designed for disabled learners by including special components, elements, and instructional strategies, as well as applying learning theories and learning approaches with the purpose to assist, facilitate, and encourage users to learn independently, enjoy the lesson, and grasp the knowledge anytime and anywhere the location is. In relation, this study refers AC with the aim of particularly designed for low vision learner that focuses to low vision children. Hence, specific design guidelines to cater children in learning via computer-based application were taking into account. Next section provides the details about that.

2.8 Six Category of Design Guidelines for Children

As suggested by Gilutz and Nielsen (2007) there are six categories of guidelines in designing web-based learning application for children. Wan Ahmad Jaafar and Sobihatun Nur (2010) has adapted these guidelines in designing the information interfaces and presentation of a persuasive multimedia learning environment (PLME) for children. Although this study does not cater all the guidelines into the development of the proposed model, but certain guidelines is important as the main user of AC4LV is children. Table 2.9 lists all the intended guidelines:

Table 2.9: Six Categories of Design Guidelines for Children

Category	**Design Guidelines**
General interaction	• Design for no scrolling • Create immediate success • Ensure that every features works well • Provide explicit directions • Use icons and symbol in familiar ways
Text	• Use simple and relatively large fonts • Do not used animated text • Use easily understandable and succinct text only • Provide instructions that are always accessible
Multimedia	• Use motion and sound to attract child attention and engage them • Show users the status of multimedia downloads and playtimes • Allow the user to control the multimedia clip • Make intro animations short and interesting • Consider using rollovers for narration
Navigation and search	• Use standard navigation and search schemes • Create meaningful category names • Present noticeable feedback to users • Make clickable items looks clickable
Graphical user interface	• Add simple visual rollovers to images that can be clicked
Content	• Design characters that kids can identify with • Allow users to control or interact with characters

On top of that, since this study focuses on low vision learners as the main subject, information accessibility, navigationability, and pleasurability should be part of important issues in designing learning content application for them. It is discussed at length in the following section.

2.9 Information Accessibility

In the field of information technology people access information through user interface. However, mostly people with disabilities are the users affected by accessibility barriers (Díaz-Bossini & Moreno, 2014; Martínez & Pluke, 2014; Miñón, Moreno, Martínez, & Abascal, 2014). Scholars defined information accessibility as how the information is organized to make it accessible to the users (Teo, Chan, Wei, & Zhang, 2003; Hsu & Liao, 2014). As this study concerns on the information accessibility issues, so it provides discussion on accessibility criteria related to low vision learners. Based on their usability testing Pernice and Nielson (2001) has come out with 75 guidelines to improve the design of websites, which is accessible by disabled users. For the purpose of this study, not all of those accessibility guidelines are considered since these guidelines are for website, which is not exactly meeting this study. However, there are certain guidelines that seem to be applicable for this study. Therefore, Table 2.10 lists the proposed guidelines.

Table 2.10: Accessibility Guidelines

Categories	Accessibility Guidelines
Do not abandon the good design rules	• Follow basic rules of good design
Graphics and multimedia	• Minimize the use of graphics • Gives all graphics understandable names • Do not blur the picture to indicate unavailability • Provide information for useful graphics • Do not shrink down a picture of the actual page and create it as a button to link to other page. • Provide clear graphics • Do not create text-only version
Pop-up windows, rollover text, and new windows	• Avoid using pop-up windows • Avoid opening new browser windows • Do not use rollover text to convey information
Presenting text	• Provide good contrast for text colors • Do not use very small text for body text • Create good contrast between text and page background • Do not use background image to create contrast with text • Test the text fonts and colors with screen magnifiers • Use text concisely and do not use superfluous text

With regards to the information accessibility issues, this study extracts the applicable guidelines with intention to adapt it in the proposed model. Next section discussed on navigationability issues which also related to the needs of low vision learners in learning.

2.10 Navigationability

Besides information accessibility, navigationability is also an important aspect in designing a courseware for the low vision learners to make it works and meaningful for them. Pernice and Nielson (2001) also address on navigationability issues in which they come out with the guidelines exhibited in Table 2.11.

Table 2.11: Navigationability Guidelines

Categories	Navigationability Guidelines
Links and button	• Limit the number of links on a page • Avoid using very small buttons and tiny text for links • Provide space between links and buttons • Avoid using images as a link button • Underline all links • Create links within text when it makes sense • Use additional button when it is necessary
Page organization	• Minimize the need for scrolling • Design pages consistently
Intervening pages	• Avoid superfluous or cover pages before enter to the actual page • Include only necessary pages.

The model by Pernice and Nielson (2001) is highly relevant to be considered in designing the AC4LV. However, some of the guidelines are irrelevant to be adopted such as "underline all links" which could make the low vision learners difficult to recognize the links especially if text is created as a link.

Besides Pernice and Nielson (2001), this study also discovered a study carried out by Jiang and Yi (2011) who also emphasized on navigationability aspect. The study makes them up-with navigation design of electronic teaching material including the design of page layout. They found out that browse navigation and skip among different pages is important to help the learners enter to some pages directly. Also, interlinking between the main interface and content pages, as well as content page with content page is required. The button should be at the right bottom of each page. To help the learners view the basic information and relevant operation method the

Help button should be provided (Jiang & Yi, 2011). Although, Jiang and Yi (2011) did not consider the low vision learners as part of the user but their suggestions such as skip among different pages is sounds significant to this study especially after the users have learnt the content on that page. So, hybrid navigation style and linear navigation are found significant for the AC4LV to support navigation among modules and next-and next task sequence within modules. Next section reviewed on pleasurability aspect in making sure the content is meaningfully delivered to the low vision learners.

2.11 Pleasurability

As explored by Bolonkin (2012), pleasurability is a positive mental state of human experience that includes enjoyment, worth, happiness, entertainment, ecstasy, and euphoria. It is about how people respond when dealing with positive things such as funny pictures and reward (Kring & Barch, 2014). Kim, Kang, and Choi (2014) also agree that experiencing positive effects can evoke the feelings of pleasurability. As pleasurability and learning are intimately connected, this study finds pleasurability as an important approach to attract the emotion of the low vision learners (Applasamy, Gamboa, Al-Atabi, & Namasivayam, 2014), which could encourage their learning development (Marzita, Mazlini, Mohd Hairy, Noraini, & Che Nidzam, 2014). Derived from the definition, this study finds out ten feelings that could be associated with pleasurability. Worth is fractionated into release and comfortable; which means, by learning through the AC4LV it gives the learners the feeling of valuable and sufficiently good in learning (Brucker, Scheiter, & Gerjets, 2014). Ecstacy is the overwhelming feeling (Oxford Dictionary, 2014) which could lead to the feelings of excited, enthusiastic, curiosity, and interested. Meanwhile, euphoria is the feeling of intense happiness or too happy (Synofzik, Schlaepfer, & Fins, 2012) which this study relates it with sense of humor. All of them are reviewed in Table 2.12.

Table 2.12: Fraction of Pleasurability

Pleasurability		**Details**	**Example of Related Works**
Enjoyment	Enjoyment	Enjoyment is defined as the extent to which the activity of using technology is perceived to be pleasurable to the individual in their own right without thinking the possible consequences (Giannakos, 2013). This study found enjoyment is significant in explaining the positive stimulation of the learners while using the AC4LV (Bart, Jarus, Erez, & Rosenberg, 2011). So, enjoy in this study is defined as the degree to which the activity of using the AC4LV is perceived to be personally enjoyable which express spontanously.	EGameFlow: A scale to measure learners' enjoyment of e-learning games (Fu, Su, & Yu, 2009). Enjoy and learn with educational games: Examining factors affecting learning performance (Giannakos, 2013). The evaluation of users' satisfaction towards the multimedia elements in a courseware (Khedif, Engkamat, & Jack, 2014).
Worth	Release	Release means feeling free from anything that restrains. It is also about allow something to move, act, or flow freely (Oxford Dictionary, 2014). This study define release as feeling free learning through the AC4LV that allow them to learn and do the activities smoothly without any restrictions in term of the content.	Children's early learning and development (French, 2007). The experience of education: The impacts of high stakes testing on school students and their families an educator's perspective (Dulfer, Polesel, & Rice, 2012).
	Comfortable	As defined by (Oxford Dictionary, 2014) comfortable is feeling free from stress or any contrains. It could stimulate the intellectual activites, increase social interaction, and liminating any negative behavior (Marzita et al., 2014). So, in this study comfortable means through the AC4LV the low vision learners could learn physically relax without any pressure.	Online learning: Getting comfortable in the cyber class (McCord & McCord, 2010).
Happiness	Happy	Happy is a state of mind that portrayed as the feeling of	Examining students' online interaction in a live video

		contentment, love, satisfaction or joy (Giannakos, 2013). These includes the combination of frequent positive affect, infrequent negative affect, and high level of satisfaction after experience certain thing (Rashid, Sharif, Narina, & Rosman, 2014). In this study happy is a state of mind where the low vision learners express their positive thought and behavior during and after using the AC4LV.	streaming environment using data mining and text mining (He, 2013). Modelling students' flow experiences in an online learning environment (Esteban-Millat, Martínez-López, Huertas-García, Meseguer, & Rodríguez-Ardura, 2014).
Entertainment	Amuse	The experience of positive feeling that evoked by a funny event (Samson, Lackner, Weiss, & Papousek, 2012). This study defined amuse as feeling funny that evoked by the content of the AC4LV.	Gamifying learning experiences: Practical implications and outcomes(Domínguez et al., 2013). EZ-Arabic for children: A virtual learning resource tool for Malaysian primary schools(Sabri, Firdaus, & Shahrizal, 2013).
Ecstacy	Excited	Excited means very enthusiastic and eager (Oxford Dictionary, 2014). In learning, excited is related to seek opportunity for exploration using the imaginations or past experience (Johnson & Gooliaff, 2010). In this study, excited means the desire that the learners express during they explore the AC4LV.	Interactive multimedia learning object (IMLO) for dyslexic children (Abtahi, 2012).
	Enthusiastic	Enthusiastic is about showing intense, eager enjoyment, interested, and motivated to take part in the activity (Bart et al., 2011). In this study, enthusiastic is about showing intense, motivation, and momentum of the learners taking part in learning activities start from the beginning until the end of the AC4LV.	User-tuned content customization for children with autism spectrum disorders (Silva, Gonçalves, & Silva, 2014).
	Curiosity	Curiosity is the feeling of individual that have a strong desire to know or learn something (Oxford Dictionary, 2014). They are inclined to recognize and find out new information or experience (Kaczmarek et al., 2013). They are individual who usually like to try to find out opportunity for self-change which they prefer for a new and unusual	Evaluation of learning outcomes using an educational iPhone game vs. traditional game (Furió, González-Gancedo, Juan, Seguí, & Rando, 2013).

		activities (Kaczmarek, Kashdan, Drążkowski, Bujacz, & Goodman, 2014). Based on the definitions curiosity in this study means the thought and behavior of the low vision learners that showing they have a strong desire to know and learn through the AC4LV.	
	Interested	Interested means feeling curiosity or concern about something (Oxford Dictionary, 2014; Zhang, 2014). Implicate to this study interested is about feeling to learn through the AC4LV continuously. It is contrasted with bored.	Learning moral values through virtual technology: The development and evaluation of Malaysian virtual folktales- Hikayat Land (Masmuzidin, Jiang, & Wan, 2012).
Euphoria	Sense of humor	Sense of humor is fractionated into appreciation (enjoy the jokes), production fluency (making jokes), and production success (making funny jokes) (Moran, Rain, Page-Gould, & Mar, 2014). It is about the incident that could make the people laugh (Azizinezhad & Hashemi, 2011; Cann & Matson, 2014). In this study sense of humor means the content of the AC4LV that make the low vision learners laugh spontaneously.	Not-so-serious games for language learning. Now with 99.9% more humour on top(Lombardi, 2012).

Having explained the concept of pleasurability, this study understands that to make the low vision learners feel pleasurability in learning through the AC4LV it could be achieved through information accessibility and navigationability (Wan Fatimah, Emelia Akashah, & Sarah, 2010; Chen & Wang, 2011).

On top of that, it is incomplete if this study only relies on the existing accessibility, navigationability, and pleasurability guidelines to propose the Conceptual Design Model of AC4LV. For that reason, analysis on existing conceptual design models is also provided in the next section in attempt to determine their common components, elements, theories, approaches, and instructional strategies.

2.12 Conceptual Design Model

Analyses of conceptual design model by previous works are used for this study to further construct the Conceptual Design Model of AC4LV. Generally a conceptual design model is important part in software development process. It provides fundamental elements and act as the point of reference for the designers to further develop the product or system (Mazyrah, Wan Fatimah, Shahrina, & Suziah, 2008). Besides, Rogers, Sharp, and Preece (2011) clarify that a conceptual design model is a formation of concepts and the associations between them to form a basis of product or system. It is important to highlight that a conceptual design model is not a portrayal or description of user interface but it provides a working strategy or framework on the concept needed and the relationships among them (Ariffin, 2009). Basically a conceptual design model should consist of the following components (Table 2.13) (Preece, Rogers, & Sharp, 2007).

Table 2.13: Components of Conceptual Design Model

Component	Description of function
Metaphors and analogies	To understand the user about the purpose and the use of the product or system.
Concepts	To expose to the user the task-domain object, attributes, and operations that can be perform by the product or system.
Relationships	The relationship of each of the concepts either it is a part of another concepts, or it contains another objects, or it contain actions with other objects.
Mappings	The mapping between the concepts of the product and experience of user in using the product.

From multimedia perspectives, a conceptual design model provides a basic function of the represented product. Churchill (2007) puts forward that a conceptual design model is a particular type of learning object, which is represented in the form of visual or interactive manner. It illustrates a concept or a number of related key concepts that supports conceptual learning through multimedia (Churchill, 2011). Churchill (2011) also address that with the advancement in multimedia technology, the design of conceptual design model can be presented in multimedia form. It can be designed in visual form such as diagrams, illustrations, pictures, videos, effects, and animations. These visual form of conceptual model can also be designed to be interactive by including sliders, buttons, hot-spots, text-entry, audio, or others interactive features (Churchill, 2011).

The initiative of designing visual and interactive conceptual design model especially in educational field is not new, but it has been inspired by a number of respectable previous literatures instead, such as visual and multimedia display (Mayer, 1989), conceptual model (Mayer, 2003), external multimedia representations (Schnotz & Lowe, 2003), dynamic visualization (Ploetzner & Lowe, 2004), and dynamic and interactive visualization (Bodemer, Ploetzner, Feuerlein, & Spada, 2004). All of these theoretical works suggest that the design and application of conceptual design model in the form of visual and interactive offer a great opportunity for teaching and learning activities to be more effective (Churchill, 2011). Churchill (2011) also recommends that the guidelines on how the conceptual design model should be designed in producing multimedia learning materials (Table 2.14) which adopts multimedia learning theory by Mayer (2001).

Table 2.14: Recommended Design of Conceptual Model

Guidelines	Description
Information presented visually	For the most part, the information provided in the conceptual design model should be presented in visual form such as illustrations, diagrams, photographs, graphs, colors, icons, and symbols. Utilization of redundant information should be managed carefully such as text and audio presented simultaneously in the same screen.
Design for interaction	The relationship provided in the conceptual design model should be presented interactively which allow users to control the parameters (i.e. by clicking the button) and observe the output (i.e. numbers, graph) which can be in display in single mode or several modes at a time.
Design for holistic scenario	All the design elements should be integrated appropriately in all areas of the screen to represent the learning application.
Design for a single screen	To allow the user to have a holistic focus on all the elements required in the conceptual design model then it should be displayed in a single screen.
Design for small space	All the required properties, information, relationships and elements should utilized in necessary screen space for the reason that the user have to focus on the visual presentation in order to understand the whole flow of the conceptual design model.
Use audio and video as option	The audio and video element should be utilized if it is effective to enhance the user comprehension on the conceptual design model.
Use color in moderation	The utilization of color should focus on simplicity and clarity of the presentation rather than for artistic beautification which means the combination of color should be presentable.
Avoid unnecessary decorative elements	Unnecessary decorative elements such as cartoons should be avoided this is because the conceptual design model should be design in purpose to serve as a reference for the developers to develop the final product. Unless it serve as the important elements in making the conceptual design model is useful to the user.
Design with a single font	The utilization of a single font styles, size, and color is important to avoid the conceptual design model give the negative impression to the user.
Use frames to divide the screen area logically	Frame should be utilized to split the screen area logically based on its function.

By considering all the facts, components, and guidelines proposed by the previous literatures, this study understands that conceptual design model can be presented manually or interactively. Inline with that, most parts of the information must be presented in visual either in the form of diagrams, illustrations, or symbols. Relationships between each of the related concepts and objects are important, to show the flow and structure of the whole represented product. Meanwhile, interactive conceptual design model could increase user understanding. More importantly, the conceptual design model has to serve as guidance for the developers to develop the final product.

In conjunction, this study considers the four components suggested by Preece et al. (2007) and the design guidelines recommended by Churchill (2011) in designing the Conceptual Design Model of AC4LV. Hence, previous conceptual design models of courseware are reviewed and critiqued in several perspectives but within the scope of this study and discussed in the following subsection.

2.12.1 Reviews and Critiques on Existing Conceptual Design Model of Typical Courseware (TC)

In proposing a Conceptual Design Model of AC4LV, analysis on conceptual design model of courseware is important. It should identify common components, and elements, as well as theory and approach that are adapted in the conceptual design model.

In response to that, this study reviews and critiques ten conceptual design models for the past six years (i.e. 2008-2013): (i) Conceptual Framework of English Language Courseware (Mazyrah et al., 2008), (ii) Conceptual Design Model of RLM (Ariffin, 2009), (iii) ID Model of Multimedia Courseware for Lines and Planes, (Syazwan & Wan Fatimah, 2010), (iv) Conceptual Model for Small Screen Learning Application (Churchill, 2011), (v) Framework of Virtual World Courseware (Nik Siti Hanifah et al., 2011), (vi) ID Model of Li2D (Zuraini & Wan Fatimah, 2011), (vii) Courseware Development Model (Efendioğlu, 2012), (viii) IPO Framework for Teaching History Subject (Rossafri, 2012), (ix) Conceptual Design Model of UZWEBMAT (Özyurt et al., 2013), and (x) Model of Constructivist Computational Platform (Garcia & Pacheco, 2013). They were selected from various countries including Malaysia by taking into account that this study is scoped to Malaysian context.

i) Conceptual Framework of English Language Courseware

Mazyrah et al. (2008) propose a conceptual framework of courseware for learning English language as depicted in Figure 2.9. It consists of six components, which are objective, teaching and learning medium, perpetual navigation, indirect learning approach, pedagogical approach and educational theories, and holistic teenager development. Meanwhile, texts, audio, graphics, and animations are the multimedia elements incorporated in this framework, which are categorized under teaching and learning medium. Besides, to form the basis of pedagogical approach three main teaching and learning theories were adopted which are cognitive, behaviorism, and constructivism. By incorporating these three respectable theories in the courseware modules, it indicates that this courseware provides positive values which are good for the teenager development. On the other hand, this conceptual framework utilizes storytelling approach as an indirect learning approach to influence the adolescent students to learn English language through the courseware. This approach could indirectly avoid students facing difficulties in learning English as well as achieving the learning objective. On top of that, it is modeled based on ADDIE to provide instructional elements in the courseware, which could allow students to learn on their own pace without guidance from their instructor. In addition, the structure of this framework is easy to understand with the help of the organized links, components, and elements. The details of each of the components are also provided except for the multimedia elements. As an example the designer should clarify the type of font or color that are suitable to attract the users.

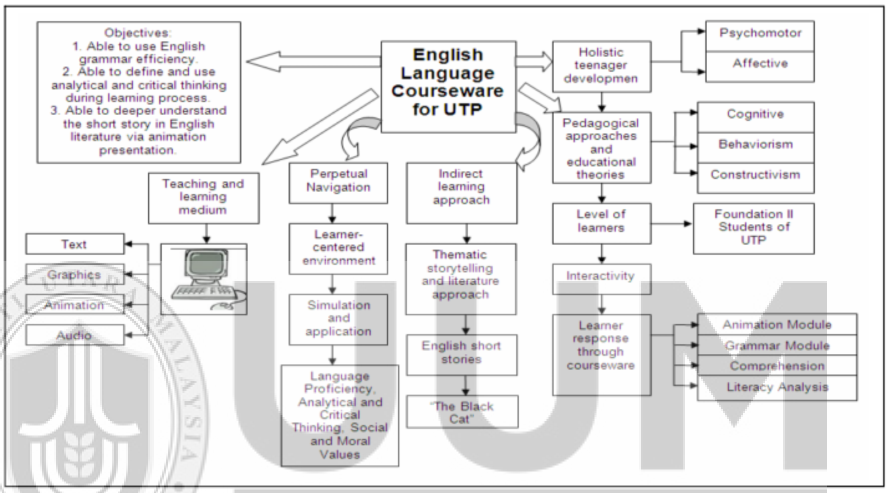


Figure 2.9: Conceptual Framework of English Language Courseware (Mazyrah et al., 2008)

In short, the learning theory and approach adapted in this courseware can be considered in designing the Conceptual Design Model of AC4LV. However, the provided elements do not cater the low vision learners as part of the user. Also, the study claims that the modules are designed to develop critical thinking among the teenagers, which is unsuitable to be applied for low vision children.

ii) Conceptual Design Model of RLM

At first impression, the model displayed in Figure 2.10 requires complex works to be developed. Proposed by Ariffin (2009), the conceptual design model of RLM comprises of six main components which are structural components, content composition components, learning approaches, technology, process of developing, and learning theories. All of these components are organized structurally to form the RLM.

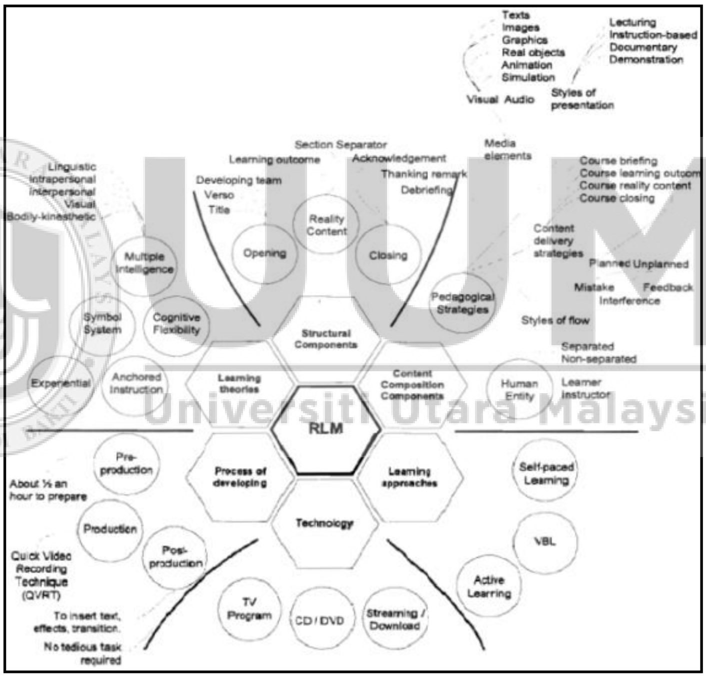


Figure 2.10: Conceptual Design Model of RLM (Ariffin, 2009)

The aim of this model is to produce RLM applications that contain entertaining and fun elements as the approach to deliver the knowledge to the learners in uninhibited situation. This model provides evidences that integrate fun and entertaining in the learning application does not mean that the students are unconcern with the learning process or not taking learning seriously, which could impede the learning activities as argued by Churchill (2011). Thus, other than considering multimedia elements, this study also emphasizes on pleasurability aspects as the approach to attract the low vision learners to learn via courseware.

iii) ID Model of Multimedia Courseware for Lines and Planes

ID model of multimedia courseware as illustrated in Figure 2.11 is suggested by Syazwan and Wan Fatimah (2010) for developing a courseware in learning lines and planes in 3-Dimension topic. The model consists of four components which are source, learning theory, learning approach, and content. There are two learning theories underlying this model, which are cognitivism and constructivism. Both of these theories are applied in the provided lessons and exercises. ADDIE model is being used as methodology to produce this model.

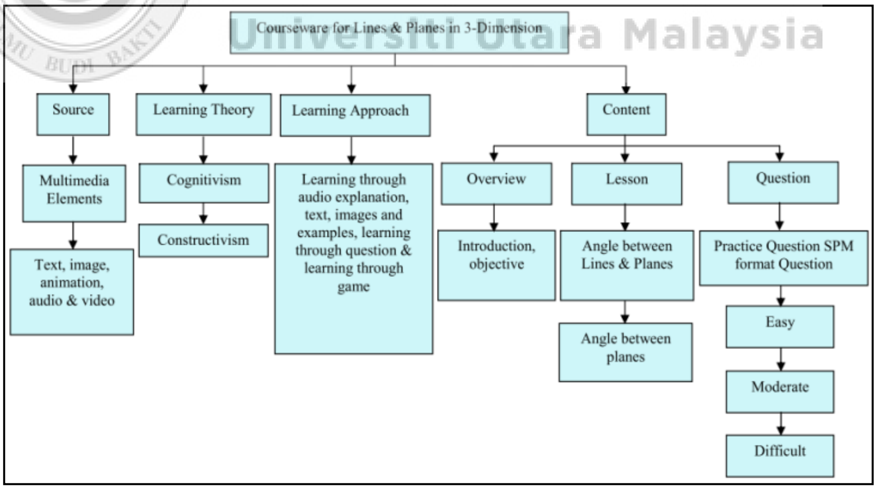


Figure 2.11: ID Model of Multimedia Courseware for Lines and Planes (Syazwan & Wan Fatimah, 2010)

Additionally, the construction of this model considers the user background and their preference to ensure the learning outcome is achieved. In line with that, this model stresses on visualization aspect when their preliminary studies found that there were teenager students having visual problems in learning mathematics. For that reason, the learning approach applied in this model is learning through audio explanation together with text, image, animation, and video to support the visual explanation. The usages of multimedia elements in terms of colors, font size, navigation, and icon are also stated.

This study believes that, this model is appropriate to be adapted in designing AC4LV. Nevertheless, the target user is not clearly discussed even though the study claims that this model highlights on visualization aspects. Furthermore, there is lack clarification in terms of each of the multimedia features to point the low vision learners as part of the users.

iv) Conceptual Model for Small Screen Learning Application

Conceptual model of small screen is composed of three sets of design recommendations namely (i) design for presentation, (ii) design for small screen, and (iii) design for learning uses. The work is projected by Churchill (2011) and built upon previous established work of Mayer et al. (2001). These three sets of design recommendations may be used effectively by designers of multimedia resources and professionals who engage in instructional applications (Figure 2.12). Each set of the design recommendation is listed with specific guidelines to form a multimedia resource in learning application.

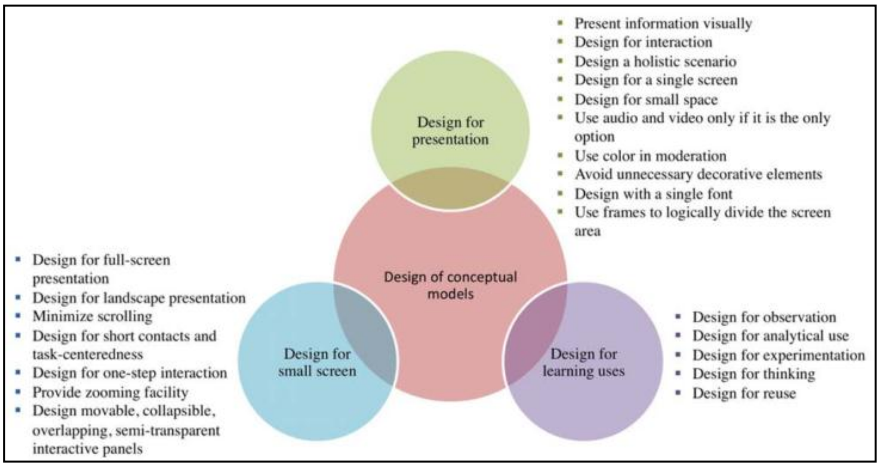


Figure 2.12: Conceptual Model of Small Screen (Churchill, 2011)

Presentation as the first design recommendation refers to how the learning content should be displayed. With ten listed guidelines it provides some general ideas for the designers to tailor with construction of AC4LV design model. The guidelines are also integrated with a well-known learning theory that is multimedia learning theory (Mayer et al., 2001). The second recommendation is design for small screen which is specific to design learning applications for small screen handheld devices such as Personal Digital Assistants (PDAs) and mobile phones. It seems that the recommended guidelines are not fully considering the low vision learners as part of the user, especially in Malaysian context. However, some of them can be utilized in AC4LV design model such as providing zooming facility, which might be useful to low vision student. Meanwhile, the third set of recommendation specifically addresses the issue of designing learning application to be used via handheld. Such guidelines are design for observation, design for analytical use, design for experimentation, design for thinking, and design for reuse.

In a nutshell, the benefits of this conceptual model is seen in its flexibility, even though most of the time the study stresses that the conceptual model is addressed for learning via handheld and never ever state the low vision learners as part of their user. The flexibility enables this study to consider all the recommended guidelines to be incorporated in the Conceptual Design Model of AC4LV.

v) Framework of Virtual World Courseware

Framework of virtual world courseware is a design model that focuses on learning through immersive environment or virtual reality (Nik Siti Hanifah et al., 2011). It was designed to cater students in medical education which always face problems in understanding the subject, especially those requires practical tasks. As depicted in Figure 2.13, the framework relatively looks simple with a single flow and only illustrated on content aspects, in which this only one component consists of objective, tutorial, enhancement, quiz, and test.

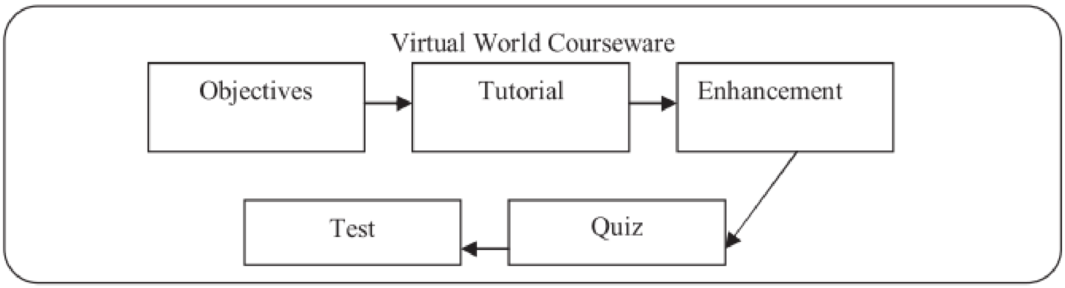


Figure 2.13: Framework of Virtual World Courseware (Nik Siti Hanifah et al., 2011)

This contrasts with the suggestion by Thao and Quynh (1997) that a courseware should comprise of at least three components. Also, the framework of the courseware content seems similar to other ordinary courseware. On the other hand, each of the elements that is said to be embedded in the immersive environment courseware is not clearly discussed. Furthermore, there is no learning theory or approach applied in the courseware content.

In conclusion, although this framework is an effort of researcher from respectable university in UK with suppressive title, it does not mean it is adaptable in modeling the AC4LV.

vi) ID Model of Li2D

As seen in Figure 2.14, the ID model for Li2D (Zuraini & Wan Fatimah, 2011) comprises of seven components which are design principle, scope, source, teaching and learning module, learning model, learning theory, and teaching and learning strategy. ADDIE is adopted as the design methodology to model the Li2D. In particular, there are five learning theories underlying this model, which are behaviorism, cognitive, constructivism, mastery learning theory, and Van Hiele model. By adapting all this learning theories into the courseware, it could increase the quality of learning, which reflects to the user need.

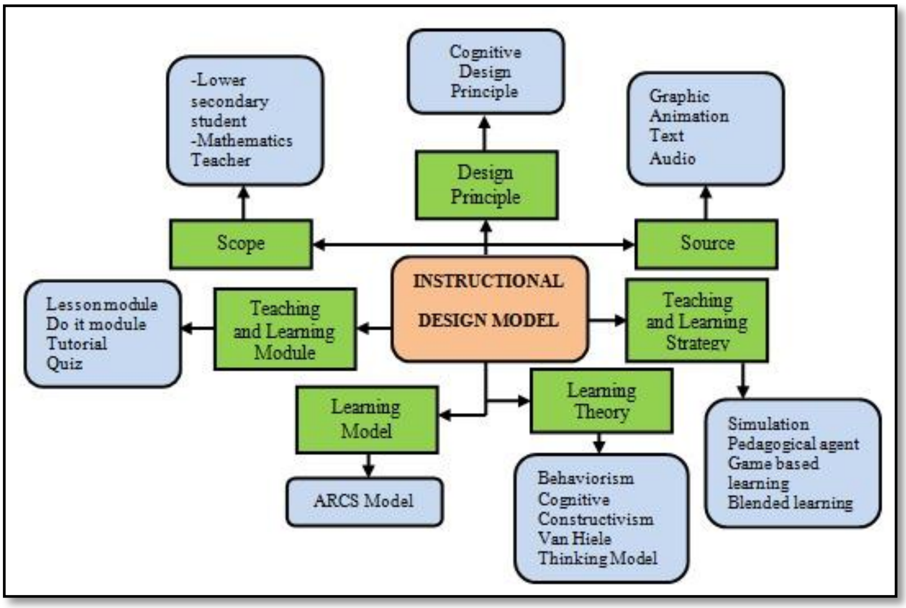


Figure 2.14: ID Model of Li2D (Zuraini & Wan Fatimah, 2011)

Also, there are various styles of teaching and learning strategies in this model: (i) simulation, (ii) pedagogical agent, (iii) game based learning, and (iv) blended learning. All this are included with the aim to attract users to learn through the courseware. Additionally, the components are also discussed clearly in the study especially on how it tailors to the modules designed in the courseware. Also, graphics, animations, texts, and audio operate as the medium to deliver the knowledge to the students.

To sum up, seven understandable components act as the root to the proposed model and most of them are discussed properly. However, clarifications about the multimedia elements are not specifically described. This means that this model does not reflect that low vision learners to be as part of the users.

vii) Courseware Development Model (CDM)

CDM (Figure 2.15) by Efendioğlu (2012) encompasses three components which are content (C), learning theory entitle as meaningful learning (ML), and multimedia (M). C and M are configured according to the principles of meaningful learning theories to support the pedagogical features in the course. With that, to provide meaningful and easily understood knowledge, five principles are included in the ML components: (i) advances organizers, (ii) bidirectional relationship between previously learned knowledge and newly learned knowledge, (iii) information and connections among the information units, (iv) consistency and coherency in new teaching information, and (v) transfer.

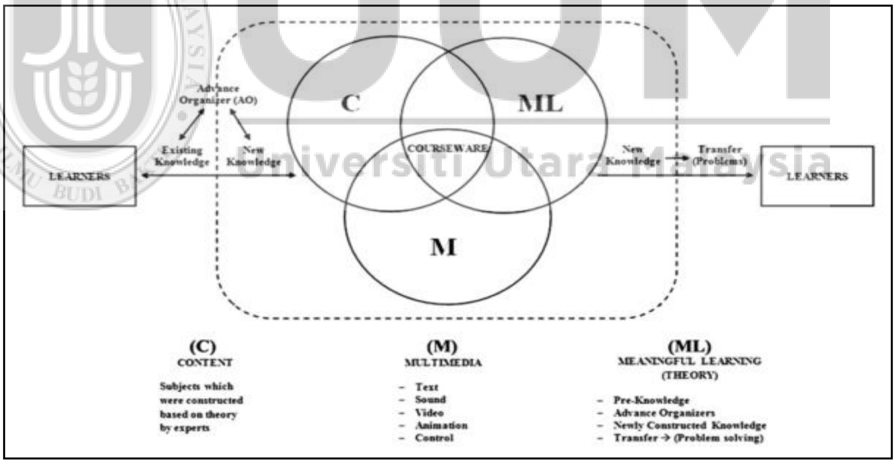


Figure 2.15: CDM (Efendioğlu, 2012)

In the interim, to produce structured contents, four principles were built-in in the C, which are (i) general and holistic view of content, (ii) divide content into small knowledge units, (iii) concrete each of the knowledge units with samples of problems, and (iv) setup connections between knowledge units. Also, there are several rules incorporated in ML component on how to control the use of texts, sounds, animations, and video in courseware. All this mean that the CDM is designed to give an idea about the synthesis of C and M under the ML. It is a general conceptual design model, which is designed to be applied to any subject. However, in CDM the designers are able to utilize any learning method to catch the attention of the students such as simulations, problem-based, and scenario-based learning. So, any courseware that is developed using CDM would constitute a synthesis of this model. In short, a set of high-quality design principles have been proposed in this model. In fact, it has been tested and provides positive empirical evidence. However, the proposed design principles, especially the ML still describes for general use, which is not specific for low vision learners or at least taking them into consideration.

viii) IPO Framework for Teaching History Subject

Proposed by Rossafri (2012) the model as exhibited in Figure 2.16 takes in three components which are input, process, and output. The design and development of IPO framework for teaching History subject is adhered to ID model proposed by Allesi and Trollip (2001). Each component has its own functions but the second component, which is process points up the framework of the courseware. In terms of theories, three learning theories are adapted which are multimedia learning theory, learning theory Gagne, and cognitive load theory. According to the title itself, this courseware is designed for teachers who teach History subject.

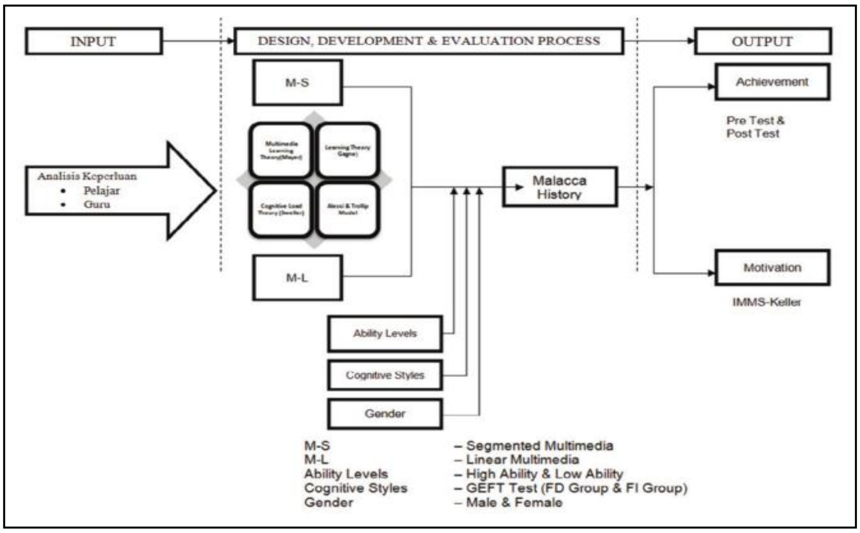


Figure 2.16: IPO Framework of Courseware for Teaching History Subject (Rossafri, 2012)

Conclusively, based on the analysis, this framework seems quite common like other frameworks that are designed for ordinary people. More importantly, it does not touch in terms of multimedia elements which play a significant function in developing courseware for low vision learners. Furthermore, each of the built-in components in the framework is not well explained.

ix) Model of UZWEBMAT

Özyurt et al. (2013) proposed the UZWEBMAT with an aim to design an adaptive and intelligent e-learning environment based on student learning style and expert system. So, their model is designed more to architecture form as portrayed in Figure 2.17. Focusing on individual learning styles (i.e. visual, auditory, and kinesthetic) this model prepares three different learning objects in three different ways to provide the most proper learning environment for the learners as well as add force to conventional classroom education. As creating the content of UZWEBMAT constructivist learning approach acts as the basis of the model. Following are characteristics of UZWEBMAT that differentiate it from other e-learning applications:

a) Content is compliance with constructivist approach – the content of UZWEBMAT are prepared in accordance with constructivist approach. This means the intended information for the learner is not given directly. In contrast, this application provides Learning Object (LO) elements that enable the learners to construct their own knowledge.

b) Innovation adaption – UZWEBMAT functions dynamically based on learners' performance, which directs the learners in three different learning styles as mentioned above.

c) Intelligent solution supports – UZWEBMAT is provided with LOs that rich with solutions supports and tips which may adjust according to the learners performance.

d) Online and on-live visualization – All the leaner activities while using the UZWEBMAT were automatically monitored and recorded as well as reported to teachers.

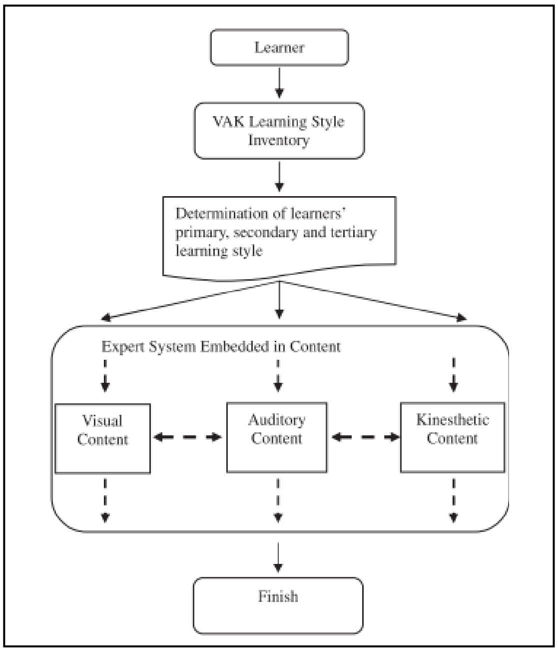


Figure 2.17: Architecture of UZWEBMAT (Özyurt et al., 2013)

An important part in the model of UZWEBMAT is the provision of LO. It was designed separately for each of the learning style. As an example for those who learn visually, special attention should be given on creating figures, flow charts, pictures, and animations. Similarly, voice instruction, warnings, and feedbacks, should be designed exclusively to those who learn audibly. Correspondingly, special LO (i.e. interactive animations) should be designed for those who learn kinesthetically.

Although an expert system underlies the UZWEBMAT jointly with three different LOs in three different learning styles, still the model is not intended for low vision learners. The discussion is more on how the user could access the application, not on the content. This points out that the low vision learners are not their target user.

x) Model of Constructivist Computational Platform

Model of constructivist computational platform by Garcia and Pacheco (2013) is based on constructivist theory with an aim to develop a computational platform that support the traditional education in learning mathematics among the elementary school students (Figure 2.18). It contains three main components which are input, process, and output. This web-based interactive platform allows the users to take part in the constructivist learning. This means the children with minor participation in class have a chance and motivated to involve in the learning activities. Going deeper in terms of the tools appear in this learning platform, it contains topic browser, toolbox, games or test explorer, workspace, communication interface, learning modules, and tutorial wizard. All this tools allow the teachers to configure based on students' intellectual ability. Although this model illustrates that they have characteristics of interactive platform as one of the sub-components but this is poorly discussed in their study.

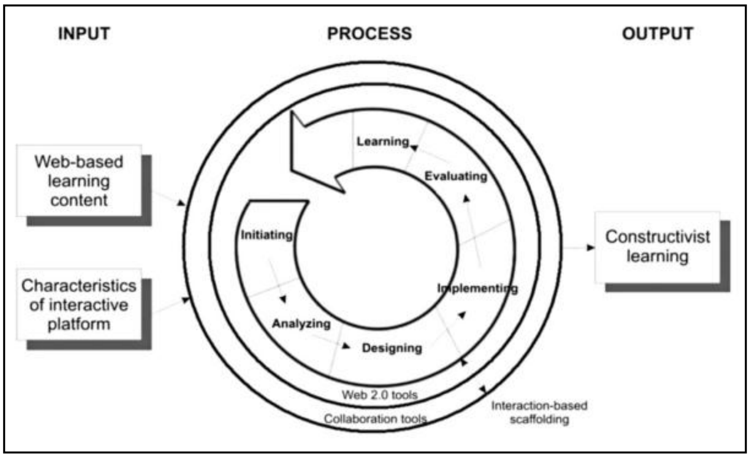


Figure 2.18: Model of Constructivist Computational Platform (Garcia & Pacheco, 2013)

Eventhough this is the current model and the content is developed special for elementary school children, still the designers not consider low vision learners as part of the users. The discussion also states that the uses of mouse in one of their learning activities have created the children knowledge which totally contrasts with the needs of low vision learners.

An analysis over the ten design models has been carried out to identify their common components, learning theories, and learning approaches as well as instructional strategies. After analyzed, reviewed, and critiqued the existing design models of TC, some were found complicated to be developed and some of them give the impression of being sophisticated with their own respective objective. Although, there are design principles, elements, learning theories, and learning approaches in the models was found appropriate to be adapted in this study, still they are not address low vision learners to be as part of the user. More importantly, there is no enough empirical evidence among this existing model that highlight the low vision learners specifically as the user of the courseware. Also, information accessibility, navigationability, and pleasurability aspects were not emphasized in those studies as the important learning needs. Thus, the next section further continues the investigation of analyzing the existing design models that are specifically develop for disabled people which is called AC design model.

2.12.2 Reviews and Critiques on Existing AC Model

As discussed in the previous section, the concepts of conceptual design model are divided into visual and interactive. By considering that facts, this study selects ten models of AC which were outlined in the past five years (i.e. 2009-2012) from various countries and respectable journals. They are (i) *Auslan Children* (Ellis, 2009), (ii) *Komputer Saya* (Norfarhana et al., 2010), (iii) *LT125ThinkingMind* (Morfidi et al., 2010), (iv) *eAccess2Learn* (Sampson & Zervas, 2010), (v) *Math Explorer* (Seo & Woo, 2010), (vi) *MudahKiu* (Siti Zaharah & Nor Azan, 2011), (vii) *eBIM* (Savita & Nur Athirah, 2011), (viii) AC for VI learners (Nurulnadwan et al., 2011), (ix) *MEL-SindD* (Rahmah & Tengku Nazatul, 2012), and (x) Digital Storytelling for Remedial Students (Rahmah et al., 2012).

i) *Auslan Children*

Auslan Children by Ellis (2009) is a multimedia application, built to assist hearing-impaired children in learning Australian sign language. According to the study, this prototype consists of three components which are learning theories, modules, and multimedia elements. The modules of *Auslan Children* were designed by absorbing multiple intelligence (MI) theory and constructivist theory to cater the Australian hearing-impaired children with multiple skills similar to normal children. Therefore, as exhibited in Figure 2.19 the AC was built by inserting a signed song, a memory game, an interactive storybook, a series of questions, and the most importantly is vocabulary instruction.

Figure 2.19: Snapshots of Auslan Children (Ellis, 2009)

All of these modules were develop by integrating text, image, audio, and video to support the multimedia presentation. On the other hand, the developed prototype also includes character to be a magnet for children to facilitate them in learning activities. Although this prototype is point to disabled children and resulted that majority of that children enjoyed learning *Auslan Children*, it does not enable the low vision learners to join the learning activities because the visualization aspects do not match with low vision needs.

ii) *Komputer Saya*

Komputer Saya is an AC designed for slow learners (Norfarhana et al., 2010). As illustrated in Figure 2.20, seven components were incorporated in the *Komputer Saya* which is technology, learning theory, approach, level of learners, holistic development, interactivity, and technique. Meanwhile, Cognitivism, behaviorism, and constructivism act as the root in the development of *Komputer Saya*.

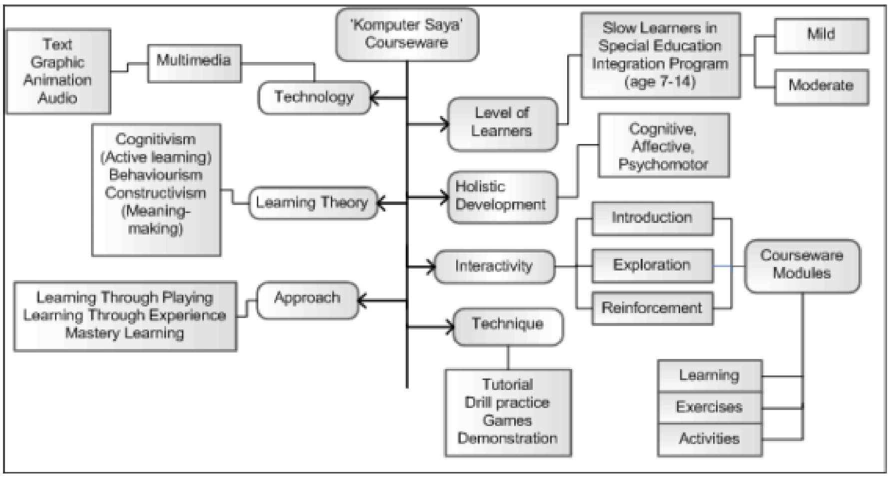


Figure 2.20: ID Model of Komputer Saya (Norfarhana et al., 2010)

Besides, to attract the learners participating in each of the learning activities, three learning approaches are adopted which are learning through playing, learning through experience, and mastery learning. On the other hand, cognitive, affective, and psychomotor aspects appear in *Komputer Saya* for their holistic development. It is important to develop the thinking skills of slow learners who also have limited cognitive abilities. As usual, texts, graphics, audio, and animations are exploited to match with the needs of slow learners (Figure 2.21).

Figure 2.21: Snapshots of Komputer Saya

Conclusively, the design model of this AC is comprehensive, according to their second study (Norfarhana, Wan Fatimah, & Emelia Akashah, 2012) the evaluation of the prototype have yielded to positive results. It was proven that the design model is applicable to develop AC for slow learners. However, the visual and audible aspects are still not fulfilling the needs of low vision learners.

iii) *LT125ThinkingMind*

LT125ThinkingMind by Morfidi et al. (2010) is an application developed to support the needs of children with severe learning disabilities particularly in learning pre-mathematical concepts such as position of objects, directionality, and object classification. The interface was designed differently for the use of educator and student as shown in Figure 2.22. There is no discussion about the component, learning theory or learning approach in the model. However, the model deals with cognitive processes (i.e. recognize an object, sort objects, and classify objects by colors, sizes, or positions).

Figure 2.22: Snapshots of Interface for: a) teacher b) student (Morfidi et al., 2010)

This indicates that the study has adapted cognitive theory, which is important for the children with severe learning disabilities. Apart from that, it is very crucial to educate the teachers about the effectiveness of the model. Thus, the study considers the teachers' perspectives. Overall, a mathematical courseware could improve the children mental development. However, without considering the aspects of visual, audible, and interactive features it means nothing to low vision learners.

iv) *eAccess2Learn*

By considering the accessibility issues in web-based educational system, Sampson and Zervas (2010) come out with the *eAccess2Learn* framework (Figure 2.23) which adopts the current Learning Technology Specifications and Web Accessibility Standard. This framework is quite complicated to understand. The main aim of *eAccess2Learn* framework is to provide tools and services that support the design and development of accessible eTraining resources and courses to be used among different disabled user group.

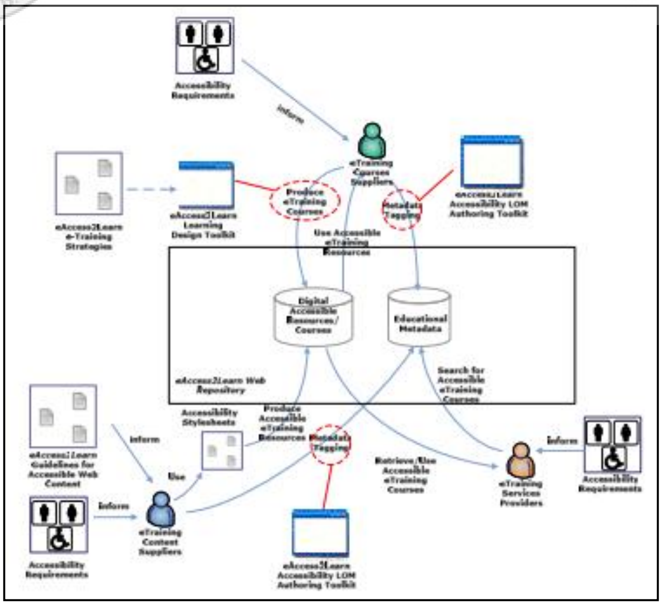
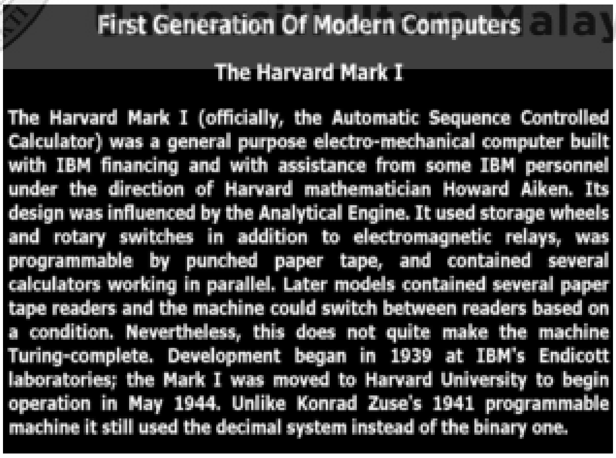


Figure 2.23: eAcces2LearnFramework (Sampson & Zervas, 2010)

Briefly, the tools and services in *eAccess2Learn* framework include (i) *eAccess2Learn* learning design toolkit for designing eTraining course templates and eTraining courses, (ii) *eAccess2Learn* guidelines and style sheets for developing accessible web-based training content, (iii) *eAccess2Learn* accessible learning objects metadata authoring toolkit, and (iv) *eAccess2Learn* web repository. Among these four, this study concerns on the guidelines of developing accessible web-based training content. More specifically, this service includes a set of W3C Web Content Guidelines 1.0 and a set of Cascading Style Sheets (CSS) for HTML-based content. In addition, these two sets of guidelines would transform the presentation of HTML elements such as text size, background and foreground color of the existing eTraining resources to be understandable and navigable by low vision, color blind, and motor disabled people. The example of it is depicted in Figure 2.24.


First Generation Of Modern Computers

The Harvard Mark I

The Harvard Mark I (officially, the Automatic Sequence Controlled Calculator) was a general purpose electro-mechanical computer built with IBM financing and with assistance from some IBM personnel under the direction of Harvard mathematician Howard Aiken. Its design was influenced by the Analytical Engine. It used storage wheels and rotary switches in addition to electromagnetic relays, was programmable by punched paper tape, and contained several calculators working in parallel. Later models contained several paper tape readers and the machine could switch between readers based on a condition. Nevertheless, this does not quite make the machine Turing-complete. Development began in 1939 at IBM's Endicott laboratories; the Mark I was moved to Harvard University to begin operation in May 1944. Unlike Konrad Zuse's 1941 programmable machine it still used the decimal system instead of the binary one.

Figure 2.24: HTML Content with eAccess2Learn Style Sheet for Low Vision People

In summary, the analyzed framework has potential to further extend in providing eTraining resource and course that match with the learner accessibility preferences.

However, the presented framework is more to web-based educational system which highly contrast with the needs of low vision children in Malaysia. Furthermore, it is applicable for those (low vision, color blind and motor disabled) who need an access for training resources and courses.

v) *Math Explorer*

Seo and Woo (2010) introduced *Math Explorer* for early elementary students with learning disabilities (LD) after identifying the critical user interface design features of computer-assisted instruction (CAI) programs in mathematics. Cognitive development is important for students with LD. Therefore, by analyzing the previous research, this model adapts four steps of cognitive (i.e. *reading* (step 1), *finding* (step 2), *drawing* (step 3), and *computing* (step 4)) and three steps of meta-cognitive strategies (i.e. *do activity*, *ask activity*, and *check activity*) in *Math Explorer*. Besides cognitive development, the more important part in producing this model is the user interface design features which are embedded into *Math Explorer*. The identified user interface design features and guidelines are listed as follow (Table 2.15):

Table 2.15: Interface Design Guidelines of Math Explorer

• Instruction-driven interface
○ Controlling the amount of mathematics instruction in *Math Explorer* ○ Using visual representations, animations, and graphics in *Math Explorer*
• Manifest structure interface
○ Having simplicity and consistency in *Math Explorer* ○ Selecting appropriate fonts and colors in *Math Explorer* ○ Highlighting and color-coding texts in *Math Explorer*
• Adaptive interaction interface
○ Providing interactive and ability/effort feedback in *Math Explorer* ○ Having adaptive multimedia in *Math Explorer*

In response to that, some of the guidelines are appropriate to be embedded in developing the Conceptual Design Model of AC4LV, such as the use of animated character to foster the students' motivation and attention. This guidelines is appropriate for children but for students with low vision the character must be created carefully to avoid them confused with the desired information (Nurulnadwan et al., 2011). Furthermore, based on the prototype the selected colors are also inappropriate for low vision learners since the contrast of foreground and background color is highly lacking (Figure 2.25). Consequently, *Math Explorer* still requires a large modification to suite low vision learners.

Figure 2.25: Snapshots of Math Explorer

vi) *MudahKiu*

MudahKiu is a framework of AC developed by Siti Zaharah and Nor Azan (2011) special for children with hearing-impaired to help them learn independently. Referring to Figure 2.26, the framework was developed incorporating nine components, which are (i) universal design principles, (ii) ID model, (iii) user interface design, (iv) teaching and learning technique, (v) approach of literacy teaching, (vi) learning activities, (vii) multimedia elements, (viii) interactivity, and (ix) navigation.

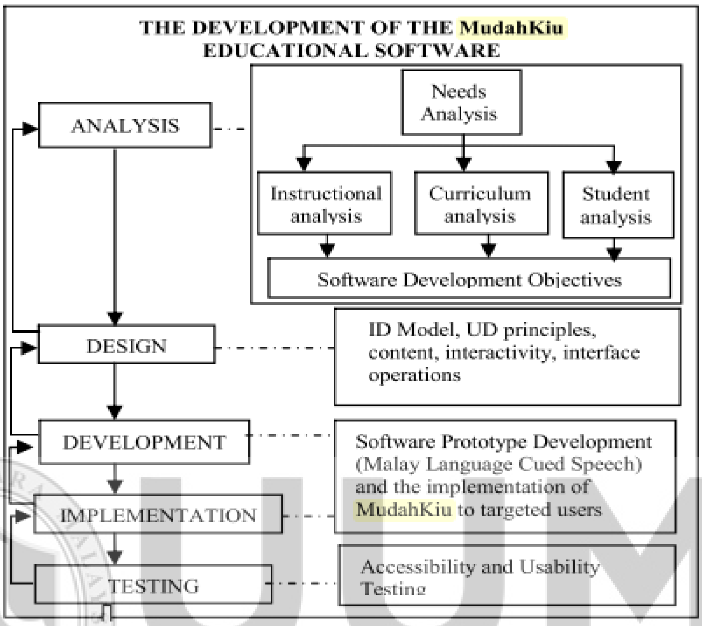


Figure 2.26: Framework of MudahKiu (Siti Zaharah & Nor Azan, 2011)

Based on the analysis, the prototype of *MudahKiu* is still in planning, however based on the developed framework it still requires more specific and structured design so that the developer would not confuse which part they need to focus. Nevertheless, the framework of *MudahKiu* is highly contrast with the needs of low vision learners since it was developed special for hearing-impaired children.

vii) *eBIM*

Figure 2.27 depicts a Malay sign language courseware called *eBIM*, a prototype of AC project by Savita and Nur Athirah (2011). It specializes for hearing-impaired children in Malaysia. There is a little discussion on the main components of the prototype, either in terms of learning approach or learning theory embedded in the AC.

Figure 2.27: Snapshots of Malay Sign Language Courseware (eBIM)

However, based on the screen shots in Figure 2.27 it can be conclude that static graphics and animations have been utilized to attract the young deaf children utilizing the courseware. On the other hand, 3D character has been created to show the alphabet sign where the student can pause, stop, and rewind the show. There is also a search engine function provided in the AC that allows the students to search the Malay word stored in database.

Overall, *eBIM* seems interesting in terms of its functions; however there is no enough discussion in terms of the components which then make this model seems similar to other courseware model that are designed for deaf people. Additionally, the analyses on the empirical evidence provided in evaluation part are also found prosaic, which then show that this model does not impact positively to the user. Also, the interface design features such as in terms of formatting style and text, combination of colors between the desired information and the background were found highly poor for the use of low vision learners.

viii) AC for VI learners

AC for VI learners has been explored by Nurulnadwan et al. (2011). Figure 2.28 depicts the screen shots of the model. Although it is special designed for VI learners, it was found that there is no illustrative and structured conceptual design model presented in the study. Additionally, discussions on specific component to form the prototype as well as learning theory, learning approach, and instructional strategies, are also highly poor. On the other hand, the model stresses on characteristics on developing the prototype of AC for VI learners which are divided into (i) audio, (ii) formatting style and text, (iii) graphics and animations, and (iv) general interaction.

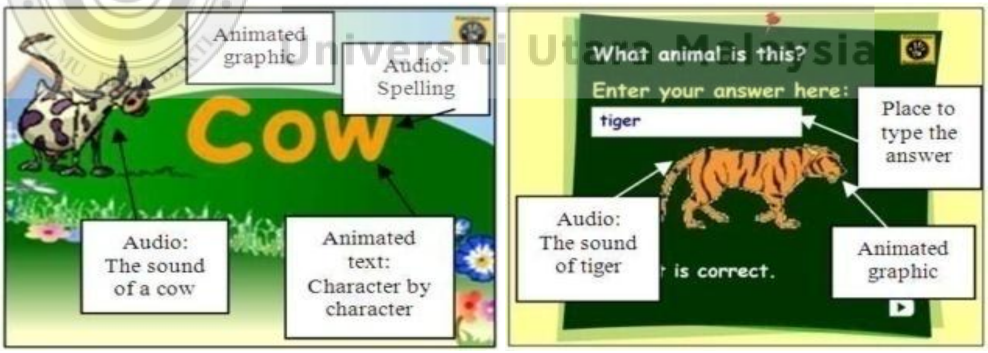


Figure 2.28: Snapshot of AC for VI Learners

Although this courseware highlights the VI learners as the main user, it still requires much more works particularly in terms of components such as ID model, approaches, and theories. Also, the evaluation could be further carried out.

ix) *MEL-SindD*

The scaffolding concept is reinforced in the courseware called *MEL-SindD* to assist the down syndrome (DS) children in learning activities. Rahmah and Tengku Nazatul (2012) introduced three types of scaffolding models which are designed to support the DS children in using the *MEL-SindD.* The models are (i) scaffolding models to explore the courseware module, (ii) scaffolding models to hear and read stories, and (iii) scaffolding models using sub-modules to explore the minds. Example of one of the scaffolding models is as represented in Figure 2.29.

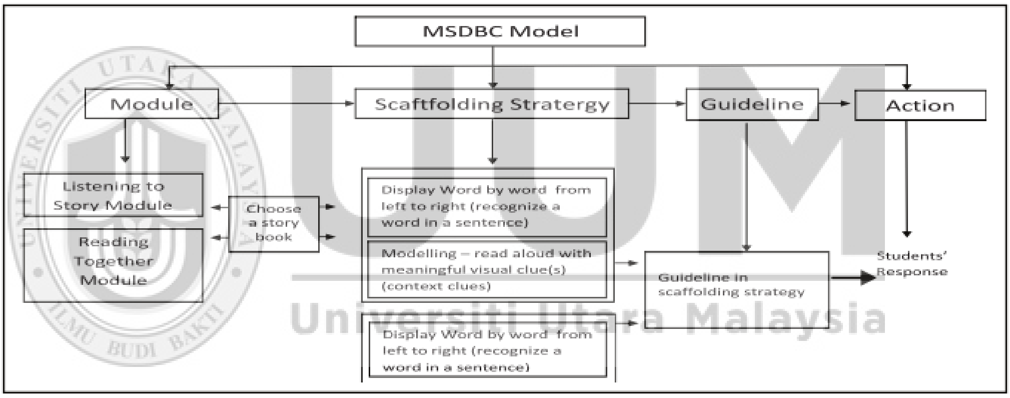


Figure 2.29: Scaffolding Models to Hear and Read Stories (Rahmah & Tengku Nazatul, 2012)

The basic elements contained in each of the scaffolding models are screen/module/sub-module, scaffolding strategy, guideline, and action. The important element is scaffolding strategy which refers to a form of assistance to support the learners to perform the tasks. There is no learning approach or theories applied in this model. The characteristics of the content are also not well-discussed, which automatically means this model is irrelevant to be applied for developing an AC4LV learners.

x) Digital Storytelling for Remedial Students

The framework of digital storytelling for remedial students is proposed by Rahmah et al. (2012) with the aim to identify the background color that present affection to remedial students in reading environment via storytelling approach. This framework has been developed based on previous studies by analyzing the user characteristic in relation with affective engineering, color psychology, and digital storytelling. As shown in Figure 2.30, there are several components that surround the framework.

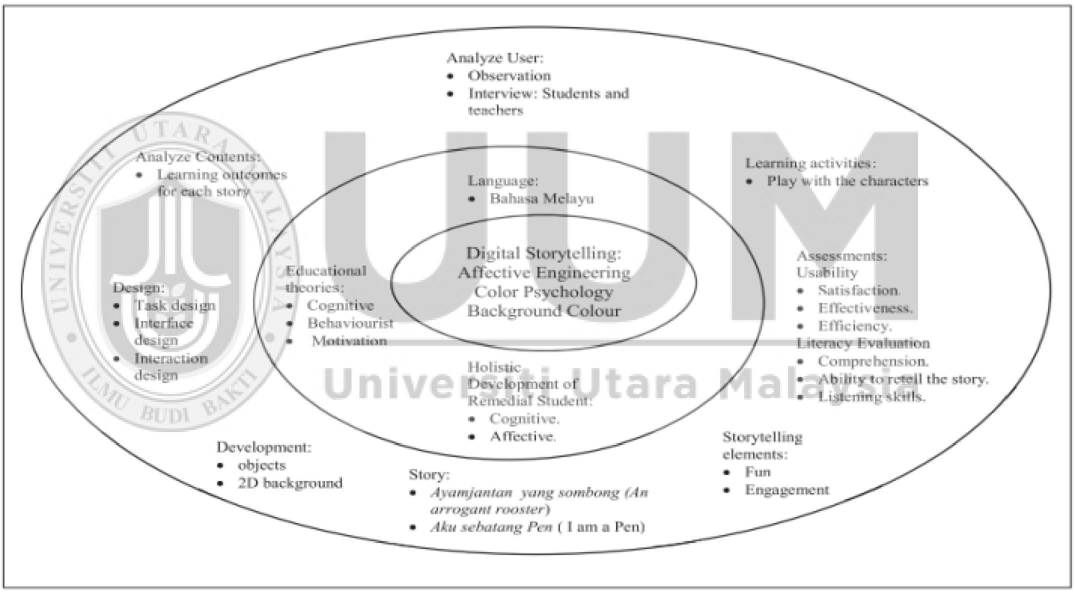


Figure 2.30: Digital Storytelling Framework for Remedial Student (Rahmah et al., 2012)

It includes educational theories (i.e. cognitive, behaviorist, and motivation), holistic development (i.e. cognitive and affective), storytelling elements (i.e. fun and engagement), development (objects and 2D background), design (i.e. task design, interface design, interaction design), and learning activities (i.e. play with the characters). This is an interesting framework, in which the remedial students' motivation and feeling were researched based on their color psychology. Meanwhile, language, educational theories, and holistic development are the key aspects in designing the framework.

Although this framework serves as the guideline and reference for the developer to develop digital storytelling applications and for teachers in teaching remedial students, still the framework ignores the low vision learners to be a part from them.

2.12.3 Implications of Reviews and Critiques on Existing Conceptual Design Model (TC and AC) to the Study

The previous literatures suggest that the development of conceptual design model of TC as well as AC should include ID model, learning theories, and learning approaches as the basic components. It would be unreasonable to ignore these three basic components in an endeavor to create any learning application (Syamsul Bahrin, 2011). On top of that, applicable learning approach is really important to motivate and attract the learners especially children in making sure they participate in using the courseware.

Moreover, the reviews and critiques in Section 2.12.1 and 2.12.2 clarify that all the reviewed models have come out with certain guidelines to ensure it matches with their target learners. However, it was found highly lacking that the conceptual design models or prototypes address the low vision learners to be the main user. Only, two models draw attention to VI learners, yet there are still much more to be filled in producing a Conceptual Design Model of AC4LV. The content aspects are also poorly emphasized for the needs of low vision learners especially in terms of information accessibility, navigationability, and pleasurability.

Hence, it ought to be noted that this is the research gap that should be the focal point of this study. In accordance, next section discusses on the existing ID models and the implication to this study.

2.13 Instructional Design Model

Since this study is intended to propose an instructional material, this section discusses on the ID models that relate with the development of courseware. Accordingly, three ID models were selected namely (i) ADDIE model, (ii) Dick, Carey, and Carey model, and (iii) ARCS model.

2.13.1 ADDIE Model

ADDIE model is the most common model utilized for creating instructional materials such as courseware. Historically ADDIE model was originally developed by Florida State University to be applied in instructional system development (ISD) program called military interservice training. ADDIE is an acronym for a five-phase framework which are (a) analysis, (b) design, (c) development, (d) implementation, and (e) evaluation. It requires the iteration process as depicted in Figure 2.31. The elaboration for each phases follow next.

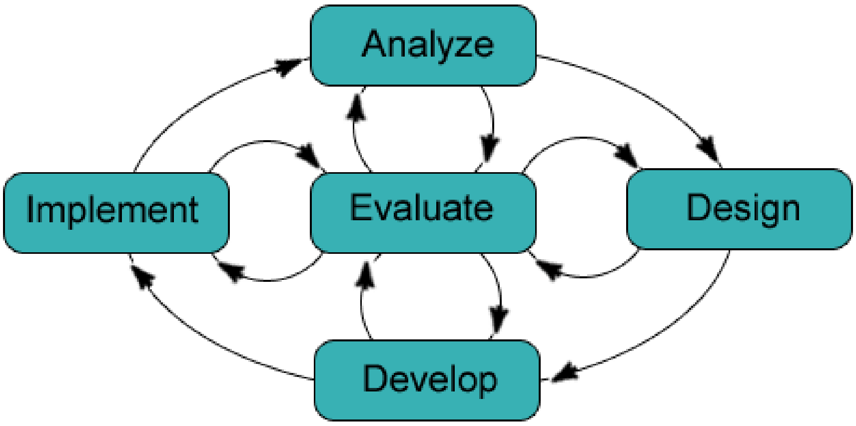


Figure 2.31: ADDIE Model

i) Analysis

Analysis refers to gathering information from primary and secondary source regarding the learning issues, target learners, learners requirement, learning objectives, and learning outcomes, as well as the timelines of the project. All the gathered information will be analyzed and classified to match it with the desired content.

ii) Design

In this phase, the designer begins to create the instructional application. By utilizing the gathered information from phase one, the designer decides on how the outcome of the content is. Such activities involve in this phase are blueprint, sketching, designing storyboard, and prototyping.

iii) Development

All the outcomes from the previous phases are assembled to create the actual product of the learning content.

iv) Implementation

Having completed the development, the actual product is then distributed to the target users to determine whether it is working as intended or applicable to be used.

v) Evaluation

The final phase is evaluation, to ensure the effectiveness of the product. The evaluation consists of two parts which are formative assessment and summative assessment. The formative assessment means the designer able to assess the project elements at every phase. Meanwhile, the summative assessment means the evaluation is conducted at the end of content being implemented in view of the fact that ADDIE is an iteration process.

2.13.2 Dick, Carey, and Carey Model

The model proposed by Dick, Carey, and Carey (1996) is also known as "The Dick and Carey Systems Approach Model". This model focuses on the interrelationship among the context, content, learning, and instruction. It presents ten components that work as a set of guidelines for novice instructional designers to develop instructional systems such as web-based educational system. All the components in this model are carried out in parallel iteratively rather than linearly. Figure 2.32 illustrates the model followed with the descriptions of each of the components.

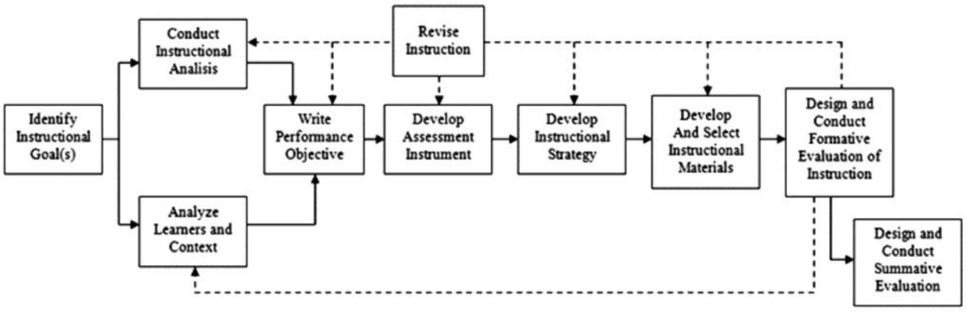


Figure 2.32: Dick, Carey, and Carey Instructional Design Model

i) Identify the Instructional Goals

The goal of the instructional should be the expected outcome that the learner will acquire at the end of the instruction. It should describe the skill, knowledge or attitude that will be acquired by the learner.

ii) Conduct Instructional Analysis

This purpose of this component is to identify the skill, knowledge, or attitude in achieving the identified goal. In particular the instructional designer should analyze the ability of the learner in performing a certain task.

iii) Analyze Learners and Context

Going deeper, at this step the characteristics of the learner including prior skills, prior experience, and basic demographic have to be identified.

iv) Write Performance Objective

Through the previous step the specific objectives of instruction will be generated. The objective should include the description of behavior, condition and criteria. This will guide the instructor to perform the next step.

v) Develop Assessment Instruments

The assessment instruments will be developed for the purpose of entry behavior testing, pre-testing, and post-testing. It is important to gain the initial findings from the learner in learning new skills. The instrument will also be useful in evaluating the actual instructional system itself.

vi) Develop Instructional Strategy

This step is carried out with the purpose to identify the instructional activities, content, learner participation, and assessment of the instructional system. The activities should be associated with the specified objective.

vii) Develop and Select Instructional Materials

All media materials required in developing the instructional system will be selected and assembled. Other than media selection, strategy development and production are also performed at this stage.

viii) Develop and Construct Formative Evaluation of Instruction

At this step the instructional designer will attempt to identify any area of the instructional system that needs for improvement with the target to provide effective learning materials for the learners.

ix) Design and Conduct Summative Evaluation

Summative evaluation is conducted to know the effectiveness of the whole instructional system through the students' performance after using the instructional system.

x) Revise Instruction

The final step means the instructional system will be reviewed in detecting any errors or ineffective activities that occur during the previous step. All the errors will be corrected until the product is perfect and ready to be used.

2.13.3 ARCS Model of Motivational Design

Based on the previous study, it is irrefutable that motivation is really important in learning process especially for children. Thus, the ARCS model of motivation has been created by John Keller by analyzing the previous research to add-on the learning activities with motivation (Keller, 2000). As depicted in Figure 2.33, John Keller proposed four components that underlie the model which are (a) attention, (b) relevance, (c) confidence, and (d) satisfaction (Keller, 2000).

Figure 2.33: ARCS Model of Motivational Design

a) Attention

The most important part in learning is grabbing attention because it initiates the learners' motivation to get interested with the topic and spend their time to explore and keep focus on the learning.

b) Relevance

Appropriate relevancies by stating established language and familiar examples will keep the learner motivated to continue the learning program. Also, the students must feel the learning activities are relevant with the objective and have benefits. If relevance is not conveyed, the learner will throw away what they have learnt before.

c) Confidence

To succeed in the learning program, the student must have confidence in their self. The confidence can be built through a method for expecting their probability of success such as syllabus of the subject, assignment, tutorial, as well as grading policy. It can be given regularly so that the students will put effort to succeed, thus increase their confidence level.

d) Satisfaction

Finally, to keep up the learners in motivated mood, they must obtain some types of satisfaction or reward based on their learning experience. The reward can be in the form of entertainment or in the sense of achievement such as high score or passing in the test might be rewarded with a certificate.

2.13.4 Implications of ID Model to the Study

The adaptation of ID model is important since this study is related to instructional design material. Based on the above discussion it is concluded that most of the models share the similar phases in proposing the instructional materials, which are divided into analysis, design, development, implementation, and testing. Although there are some of the ID models (i.e. Dick, Carey, and Carey model) include detailed phases, the main steps are still similar. More importantly, iterative process is required to ensure the final instructional materials meet the user requirement. On the other hand, motivational model are also required as part of the component of instructional materials. Thus, this study suggests those ID models for the non-technical or novice developers as the references for them in developing the AC4LV besides the development process recommended by this study (discussed detail in Chapter 4 and 5).

2.14 Learning Theories in AC4LV

Learning is an epistemology issue in view of the fact that it concerns with the nature and scope of knowledge which leads to questions such as what knowledge is, how it is acquired, and who the subject is (Guney & Al, 2012). In answering those questions, it requires an in-depth research which interrelates with learning theories. Learning theories have previously been discussed by Greek philosophers, Socrates, Plato, and Aristotle before stating the era of digital age (Pange, Lekka, & Toki, 2010). It is known that, during the last decades learning theories were only applied in conventional teaching and learning.

Recently, in the era of digital age, educators work hard in attempting to absorb diverse learning theories into the concept and process of learning that they introduce (Pange et al., 2010). Previous studies from the reviews and critiques that has been carried out in the previous section have proven that the learning theories not only applied in conventional teaching and learning but also in the new concepts that are intergrated together with new educational technologies. As a result, various instructional approaches and strategies have appeared from different theoretical perspectives (Pange et al., 2010), as well as empirical evidences that provide positive feedbacks (Thurlings, Vermeulen, Bastiaens, & Stijnen, 2013) have driven it into practice (Pange et al., 2010).

Not all learning theories are closed to instructional approaches and appropriate with this study. So, based on their principles (i) constructivism (Pange et al., 2010; Wu, Chiou, Kao, Alex Hu, & Huang, 2012) and (ii) connectivism were found suitable to be adapted in this study. Also, (iii) multimedia learning theory and (iv) multiple intelligence (MI) theory are embedded to discover multimedia and children development aspects. For that reason, these prevailing learning theories that constitute the learning process through AC4LV are discussed in the next subsection.

2.14.1 Constructivism Theory

Constructivism requires "the learner to construct their own knowledge" (Boghossian, 2006, p. 714) rather than acquiring it (Guney & Al, 2012), which means it focuses on "constructing, creating, inventing, and developing the knowledge" (Büyükduman

& Şirin, 2010, p.55) rather than transmitting the knowledge (Obikwelu & Read, 2012). Although there are many types of constructivism theories such as social development by Vygotsky in 1962, Problem-based Learning (PBL) developed in 1960's, and actor-network theory developed by Latour in 1987 (Wu et al., 2012), still all of them share similar foundation that to what extend the learners are actively participating in seeking for meaningful knowledge (Boghossian, 2006). According to this theory, the starting point of learning is through the pre-existing knowledge (Pugsley, 2011; Thurlings et al., 2013) and experience (Guney & Al, 2012).

The above constructivism analysis can be concluded into three major hypothesis which also have been agreed by many constructivist creators (Büyükduman & Şirin, 2010).

- Learning is the active formation of knowledge which acquired through prior experience and environment contact.

- Knowledge is build by the learner itself through their own experience and existing knowledge to find out a meaningful context.

- Meaningful knowledge is closely with experience. So the learner would practice that knowledge in their life.

This paradigm is accepted as the successful learning process (Syamsul Bahrin, 2011) because it is natural and applicable to be applied in accordance with the technology advancement (Büyükduman & Şirin, 2010). Another advantage of this theory is it is able to generate the learner to be explorative which is good for mental development particularly for PWDs (Dube, Ahearn, Lionello-DeNolf, & McIlvane, 2009).

In relation to this study, the constructivist theory impacts the AC4LV through the meaningful learning content, interesting learning activities, and interesting experience of interaction.

2.14.2 Connectivism Theory

Connectivism which was introduced by a Canada scholar named George Siemens in 2004 (Wei & Zhou, 2011) is a learning theory for the digital age which believes that knowledge is exists in the world rather than the control of an individual (Mechlova & Malcik, 2012). It is a theory that reflects on how people live, how people communicate, and how people learn. The concept of connectivism is learning is the process of creating connections and developing a network. It means network that contains nodes and connections is a central metaphor for learning. A node is anything that can be connected to another node within a network. Such examples of nodes are organization, information, data, feelings, and images. The connection allows people to learn more and more than the current state of existing knowledge (Mechlova & Malcik, 2012). This means learning is not only as internal and individualistic activity but it has become a social activity (Youjing & Wujing, 2011). The eight principles of connectivism theory are (Wei & Zhou, 2011; Youjing & Wujing, 2011; Mechlova & Malcik, 2012):

- Learning and knowledge rests in diversity of opinions.

- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate up-to-date knowledge) is the intent of all connectivist learning theories.
- Decision-making is a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. A right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.

Positive features from connectivism theory influence the learning process to look at a specific context which could take them to a more sophisticated level parallel to digital age to date (Mechlova & Malcik, 2012). In regards to this study, all the contents in the AC4LV that represented in the form of texts, audio, graphics, and animations could be as nodes that connected to each other in delivering the knowledge to the low vision learners. Also, feelings that triggered along the period of learning through the AC4LV could generate social interaction among the low vision learners.

2.14.3 Multimedia Learning Theory

Through well-designed multimedia content (words, pictures, illustrations, animation, and narration) students could build their mental development to learn more deeply compared to traditional mode of communication which involves words alone (Mayer, 2003). So, Mayer and his friends have investigated the nature and effects of multimedia presentation to human being (Doolittle, 2002; Mayer & Moreno, 2003; Mayer, 2008; Mayer, 2010). From that they come out with thirteen principles together with the sample example of practical application (Table 2.16).

Table 2.16: Principles of Multimedia Learning Theory

Principles	Examples of Practical Applications
Multimedia Principle: Students learn better from words and pictures rather than words alone.	Combination of block of text with still image or animation on a screen is more efficient rather that oral text or graphic alone.
Spatial Contiguity Principle: Student learns better when the combination of words and pictures on the page or screen are presented near rather than far from each other.	Placing the text under the image is sufficient. However placing the text within image is more effective.
Temporal Contiguity Principle: Student learns better when combination of words and pictures that presented simultaneously rather than successively.	When presenting text and image they should be presented simultaneously, but when presenting animation and narration the use of them is more coincide meaningfully.
Coherence Principle: Students learns better when extraneous words, pictures, sounds are excluded rather than included.	Multimedia presentations should be focus, clear and concise. Presentations that add extraneous information such as the sound of bell or whistle with the reason to increase the student interest is actually impede the student learning and focus.
Modality Principle: Student learns better from animation and narration rather than animation and on-screen text	The use of words should be presented as spoken words or using auditory, rather than present as written text to accompany the graphics.
Redundancy Principle: Student learn better from animation and narration rather than animation, narration and on-screen text.	The multimedia presentations that involve combination of words and pictures should present text either in written form, or in auditory form, but not in both on a screen.

Individuals Difference Principle: Design effects are stronger for low-knowledge learners rather than for high knowledge learners and for high spatial learners rather than low spatial learners.	Example of low-knowledge learners is novice learners and high spatial learners are for visually style learners. Well-structured multimedia presentations should be created to be more accessible.
Signaling Principle: Student learn better when cues that highlight the organization of the essential material are added.	Providing cues to the learner on how to organize the materials.
Segmenting Principle: Student learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit.	The modules or exercise provided are present sequentially and logically from easy to hard. Allows the user to control the presentation.
Pre-training Principle: Student learns more deeply when they receive pre-training in the names and characteristics of key components.	Create low level exercise/problem solving to the learners before they can proceed to the larger and more complicated exercise.
Personalization Principle: Student learns better from a multimedia presentation when the words are in conversational style rather than in formal style.	Example of conventional style text is Comic Sans.
Voice Principle: Student learn better when the words in a multimedia message are spoken by a friendly human voice rather than a machine voice	Create a teacher character in multimedia presentation.
Image Principle: Student does not necessarily learn more deeply from a multimedia presentation when the speaker's image is on the screen rather than not on the screen.	Use a voice of teacher character. No image of teacher is presented.

Each of the principle can be considered in combination as AC4LV content. Chapter 5 details this connection. Example of works that adapt the multimedia learning principles is Wan Ahmad Jaafar, Siti Nor Jannah, and Mohamed Zamri (2012) which adapted several principles of multimedia learning in their work called persuasive multimedia application to raise stress awareness among the secondary school students. Another works is Churchill (2011), which has been discussed in previous section. He has proposed a conceptual model to design learning materials for small screen application. Similarly, Domagk, Schwartz, and Plass (2010) also utilized multimedia learning principles in designing an integrated model of multimedia interactivity called INTERACT. The aim of this model is to clarify the concept of interactivity and further act as a reference to other studies in developing interactive multimedia presentation. There are four components underlying this model which are user, learning environment, system of connection and concepts to make up the interactivity. This shows the importance of concerning the multimedia aspect in designing multimedia learning content to make it useful to the intended user.

In the context of this study, all principles are applicable to be applied in AC4LV at a time since AC4LV is multimedia learning content application. However, the connection must be carefully applied since the intended users are low vision learners in order to make it useful in terms of information accessibility, navigationability, and pleasurability.

2.14.4 Multiple Intelligence (MI) Theory

The theory of MI was proposed by Howard Gardner in 1983 and further updated in 1993 and 2000. MI theory has produced a great implication to the world of education (Niroo, Nejhad, & Haghani, 2012; Li, Ma, & Ma, 2012). This can be seen when many educational institution including pre-schools and elementary schools have utilized this approach as their philosophy. In fact, it is not just a philosophy but all the nine intelligence put emphasis on the learning content and its intra relation (Niroo et al., 2012). On top of that, the MI theory enables the educators to develop their repertoire of methods, equipments, and approach beyond those that are commonly used in the conventional teaching (Zatul Amilah et al., 2011).

Accordingly this could develop the children to be confident with their natural abilities.

In conjunction, several projects have been found applying MI theory into their applications. As an example Bushro & Halimah (2008) proposed MI-Maths for learning mathematics. Another work is the development of educational game based on MI theory by Li et al., (2012). Both of these application utilize the MI theory to develop the mathematics learning content that matches with the students' preference particularly in verbal linguistic, logical mathematical, and visual spatial.

In relation with that, the development of AC4LV also considers the nine MI theory (Table 2.17) for the reason that it is important to reveal the implicit intelligence and ability of low vision children in attempt to make AC4LV is useful.

Table 2.17: MI Theory

Intelligence	Description
Verbal-Linguistic Intelligence	The ability to learn languages in spoken and written, and the capacity to use that language to accomplish certain goals.
Mathematical-Logical Intelligence	The ability to analyze problems logically, carries out mathematical operations, and investigates issues scientifically.
Visual-Spatial Intelligence	The ability to recognize and manipulate patterns of wide space as well as patterns of more confined areas.
Intrapersonal Intelligence	The ability to understand oneself, to have an effective working of oneself including one's own desire, fears and ability to use such information effectively in regulating one's own life.
Bodily-Kinesthetic Intelligence	The ability to use one's whole body or parts of the body to solve problems.
Interpersonal	The ability to understand the intentions, motivations and desires of other people and ability to work effectively with others.
Naturalist Intelligence	The ability to recognize and classifies of numerous species of flora and fauna of his or her environment.
Musical-Rhythmic	The ability to have skills in performance, composition musical patterns and appreciation of musical patterns.
Existential	The ability to have sensitivity to existence surrounded complex issues and curiosity to ask deep questions.

2.14.5 Implications of Learning Theories to the Study

Developing the instructional materials requires this study to embed learning theories during the development process. Constructivism and connectivism are the two established learning theories that act as the root of learning environment in this digital age. Since this study was proposed a kind of multimedia-based learning application so it is important to consider the multimedia learning theory as the approach to attract the low vision learners. Meanwhile, MI theory is a perfect theory for the development of children ability due to the main subject of this study is low vision children. More importantly, both of these theories are adapted to make the AC4LV useful particularly in terms of information accessibility, navigationability, and pleasurability. Although these four learning theories have their own hypotheses and principles, not all of them are inserted into the development of proposed model. They are selected based on applicability, which particularly relate to low vision learners. The detailed connections of learning theories with the proposed model are discussed in Chapter 5.

2.15 Learning Approach in AC4LV

The implication of innovation in learning system and the advancement in technology have revealed several learning approaches that emerge either as totally new theories or mixed with other established theories (Pange et al., 2010). The learning approaches that have been selected to adapt in this study are emerged from the theories as discussed previously which are (i) mastery learning approach, (ii) problem-based learning, (iii) active learning approach, and (iv) self-paced learning approach.

2.15.1 Mastery Learning Approach

The importance of learning through courseware is to what extend the learner could grasp the presented knowledge, not on to what extent the sophistication of the courseware is. It means nothing if the courseware seems to be sophisticated but is unable to provide enough comprehensible to the learners. Hence, this study uses the mastery learning approach in attempt to assist the low vision learners' understanding the learning content as well as providing applicable multimedia elements for them.

The idea of mastery learning approach has been initiated for more than 80 years (Norazzila, Tengku Norainun, & Mohd Shahir, 2010). Impressed from the idea originated by John Carroll in 1963, Benjamin Bloom then started inaugurating the concept that is known as Mastery Learning in 1968 (Sheng & Lifeng, 2012). Caroll (1989) claims that all learners have the potential to learn any given subject, but they have to take certain amount of time to complete tasks. The theory hypothesizes that each individual has different intellectual abilities and it can be seen in their achievement outcome (Elenchothy, Rohani, Mokhtar, & Aminuddin, 2010). This means that this approach is applicable to be adapted to anyone and beneficial for learners at different levels of aptitude (Norazilla et al., 2010). The challenge of this approach is that implementing instructional strategies and providing enough time in making sure all learners able to achieve similar level of learning (Bloom, 1981; Levine, 1985).

Following are basic elements of the mastery learning approach as suggested by Bloom and stated in (Warren, 2012):

- Clearly stated the objective of the course.

- The syllabus is divided into small chapters in which each chapter has its own objective.

- Identify the learning materials and instructional strategies including teaching, practice exercise, formative evaluation, re-teaching, reinforcement, and summative evaluation.

- Each chapter is preceded with a brief diagnostic tests, or formative assessments.

- Utilize the results of formative test as additional instruction, or do correction activity in class in helping the learners to overcome the problem.

- Learning time must be adjusted to fit the level of aptitude, which means no student is allowed to proceed to the new chapter until master in basic pre-requisite chapter.

On top of that, the use of mastery learning approach has been found in works such as the design and development of courseware for slow learners called *Komputer Saya* project by Norfarhana et al. (2010) and the design and development of multimedia courseware namely Li2D proposed by Zuraini and Wan Fatimah (2011). Both of them have been discussed in detail in the previous section.

In relation to this study, mastery learning approach is embedded in AC4LV by applies appropriate instructional strategies and teaching and learning techniques. Also, no specific time are allocated to them in learning and doing activities in AC4LV. This is to ensure they can grasp the knowledge without any pressure and have pleasurability in learning.

2.15.2 Problem-based Learning (PBL)

PBL is a student-centered approach, in which students learn through experience and realistic problem solving (Allen, Donham, & Bernhardt, 2011). It is an instructional method that originates from medical education and has become increasingly popular across disciplines at multiple levels of education (Hung, Jonassen, & Liu, 2008; Jolly & Jacob, 2012). The basic characteristics of PBL is (i) the use of problem as the starting point of learning process, (ii) small group collaboration, (iii) flexible guidance of instructor, (iv) limited number of lectures, (v) student-initiated learning, and (vi) ample-time for self-study (Hmelo-Silver, 2004; Sockalingam, Rotgans, & Schmidt, 2010).

Meanwhile, the goals of PBL is to help the students to develop their (i) flexible knowledge, (ii) effective problem-solving skills, (iii) self-directed learning skills, (iv) effective collaboration skills, and (v) intrinsic motivation (Hmelo-Silver, 2004). This implies that instructors or teachers have to act as facilitators rather than providing knowledge (Hmelo-Silver, 2004) to achieve those goals. Through the problem-solving and other characteristics of PBL, it train the students to become active learners and responsible to their learning (Schmidt, Rotgans, & Yew, 2011). In accordance, it enables the students to understand the subject deeply (Jolly & Jacob, 2012).

PBL embraces on good principle of teaching and learning, in which it (i) promotes student-directed learning, (ii) promotes active and in-depth learning, (iii) taps into existing knowledge of student, (iii) supports reflection on teaching and learning process, (iv) develops mutually respectful learning skills, (v) involves well-timed feedback, and (vi) supports the self-assessment and peer-assessment of students (Kiley, Mullins, Peterson, & Rogers, 2000).

In this study, by embedding the PBL approach in AC4LV, it could educate the low vision learners to be more independent, self-motivated, producing interesting work, and become a challenging person (Kiley et al., 2000). Further, Chapter 5 discusses the connections of Conceptual Design Model of AC4LV with PBL approach in detail.

2.15.3 Active Learning Approach

The term ‘active learning’ is defined as anything that “involves students in doing things and thinking about what they are doing” (Bonwell & Eison, 1991, p.2). It refers to instructional strategy that encourages students to participate and think actively on what they are doing particularly in learning (Bonwell & Eison, 1991). This means that, students not only listen to formal lecturing or presentation, but also after listening they have to be more that than such as read, talk, write, discuss, reflects, or engaged with problem solving (Chickering & Gamson, 1999). It is a process that compels the students to think and give opinion on the presented knowledge that they gain through listening (Bakır, 2011). Within this context, the students have to (i) listen purely, (ii) develop abilities to understand the knowledge, (iii) make analysis and synthesis, and (iv) evaluate the knowledge which can be done through problem solving exercises, informal small group discussions, class game, lab activities, simulations, role-playing, or reaction to video (Auster, 2006). At each step, students are engaged physically and psychologically with activities for them to process the knowledge (Bakır, 2011). The activities prepared by the instructor are named as active learning technique (Kimonen & Nevalainen, 2005). It provides students to develop higher levels of scientific understanding compared to traditional learning approach (Cooperstein & Kocevar-Weidinger, 2004). More importantly, the students feel that their study is important when their opinions and involvements have significant value to themselves (Eugène, 2006). This could increase their pleasurability and motivation in learning (Ariffin, 2009).

On the other hand, with the advancement in technology, various active learning techniques can be applied to force the students to actively participate and enjoy the lesson such as learning through courseware, educational mobile game, and online discussion (Diepen, Stefanova, & Miranowicz, 2009). Active learning approach educates the learners to be more responsible to the learning process and appreciate the knowledge which benefits for them in sharing with others, think critically in problem solving, and develops various abilities and skills that demand by market today (Bakır, 2011). On top of that, active learning approach also has been applied in works carried out by Sesen and Tarhan (2010), Scott (2011), Malik and Janjua (2011), Carlson and Winquist (2011), and Kährik, Leijen, and Kivestu (2012).

In this study, active learning approach is applied in AC4LV by providing module learning through music and song, interacting using keyboard, and meaningful graphic with friendly sound (Martyn, 2007; Scott 2011). These could stimulate and give confidence to low vision learners to interact with AC4LV with or without guidance from the instructor (Martyn, 2007). More importantly, they can learn in pleasurability environment. The details connection of this approach with Conceptual Design Model of AC4LV is discussed in Chapter 5.

2.15.4 Self-paced Learning

Self-paced learning approach is an instructional method that has become popular since education world shifted from traditional method (learning in class) to Internet (Dick & Carey, 2004). It is an approach that enables the learners to proceed the learning process on their own without intermediate response from instructor (Hsieh & Cho, 2011). This means the learners are able to control the topic that they learn depending on their speed and get instant feedback (Hsieh & Cho, 2011).

In the context of this study, self-paced learning is referred to approach that is embedded in e-learning materials either computer or online learning programs, which contain the learning content and assessment mechanism for self-evaluation (Bretz & Johnson, 2000). This means student can learn anywhere (i.e. homes, resident halls, laboratories, or workplaces) and anytime at their own pace (Hsieh & Cho, 2011). As an example, Holt (2007) has set up free online games for students to learn the concepts of economic anytime and anywhere. Another example is off-the-shelf software programs such as learning language where the consumer can buy and install on their own (Cho, Cheng, & Lai, 2009). Also, self-directed e-learning programs provided by many higher institution today to facilitate their students to learn at their own initiatives (Hsieh & Cho, 2011). All these e-learning materials are consistent with contemporary learning theories that highlight on self-paced and self-directed learning (Dalgarno, 2001).

On the other hand, in designing self-paced e-learning materials, a good user interface design is important to increase the learners' motivation (Cho et al., 2009) and easy for them to used it independently. In AC4LV, this could be done by providing interesting controls, accessibility information, clear instruction, and attracting sound to catch the attention of low vision learners in ensuring they stay focus to learning content (Schmidt-Weigand, Kohnert, & Glowalla, 2010). Over and above, by adapting self-paced approach in AC4LV, it also could educate the low vision learners to decide on their own what to study, where to study, when to study, and how long to study (Dunlosky & Thiede, 1998). This aspect has significant implications to the effectiveness of their learning effort and educational achievement (Tullis & Benjamin, 2011). Chapter 5 provides detail explanation of this approach in relation to Conceptual Design Model of AC4LV.

2.15.5 Implications of Learning Approaches to this Study

Other than learning theories, learning approaches were also important in the development of instructional materials. This is to ensure the knowledge is delivered to the learners. Thus, this study involves four learning approaches that were built based on the existing theories. Mastery learning approach and PBL is important to ensure the low vision learners could grasp the knowledge as well as develop their confidence in learning through AC4LV. Meanwhile, active learning approach make the AC4LV is useful in terms of pleasurability in learning. Also, self-paced learning approach provides AC4LV with functions that easy to be used by low vision learners. As a conclusion, without adapting the learning approaches AC4LV were useless.

2.16 Evaluation on Usefulness of Courseware

Development and evaluation of courseware depends on it objectives. One of the objectives of courseware is to ensure that the developed courseware is useful to the target users. In making sure the developed courseware is useful to the target users, their needs in learning have to be identified. According to Oxford Dictionary (2014) usefulness is defined as “the quality or fact of being useful”. This definition is also inline with the study carried out by Chang and Chen (2011) that defined the usefulness is influence by the quality of the courseware, multimedia instructions, and learners’ self-efficacy. Related to quality concept usefulness also can be measured in terms of job productivity, job performance, and effectiveness on the job after using the courseware (Abdul Nasir, Syamila Zakiah, Juliana Aida, Adzira, & Abdul Aziz, 2011). The facts of making the courseware in their study useful are the features of the courseware itself (i.e. interactive). Moreover, study conducted by Mtebe and Twaakyondo (2012) investigate on the extend the animations and simulations making the difficult concept in Computer Science course easier to understand. So, to achieve the objective they evaluate on the usefulness of the animations and simulations of courseware which developed in their study. Another example of study related to usefulness is the study performed by Silius and Tervakari (2003) which evaluate the usefulness of web-based learning environment in terms of accessibility, informational quality, and subjectively pleasing. These are some of the needs that the study found through their target user.

Based on the above discussion, this study understand that usefulness of the courseware is achieved based on the identified user needs. In this study, information accessibility, navigationability, and pleasurability are the aspects that the low vision learners needs in their learning activities. Hence, the usefulness on each of the elements of AC4LV contains in information accessibility, navigationability, and pleasurability were evaluated by the low vision learners.

2.17 Summary

Courseware is known as a good platform to motivate people to learn at anytime and anywhere they want. Previous studies have shown that numerous types of courseware have been developed with their respectable objective and positive results. This includes coursewares that are purposely designed to be used by normal people and disabled people. Before starting the development of courseware the designing of conceptual design model is required. Nevertheless, the reviews and critiques of a number of conceptual design model of TC and AC model carried out in this study found that the courseware that particularly designed for low vision learners is highly lacking. Due to the lacking of courseware for low vision learners, this study refers to it as AC4LV. In a nutshell, various aspects were reviewed in this chapter including the concept of AT, inclusive design, disabilities, VI, information accessibility, navigationability, pleasurability as well as ID model, learning theories, learning approaches, and aspect of evaluation carried out in this study which is usefulness. All of these concepts are discussed deeply to reveal the current situation and their implication to this study. This finally results the identification of research focus for this study. Figure 2.34 depicts the overall overview of literature study conducted in this chapter.

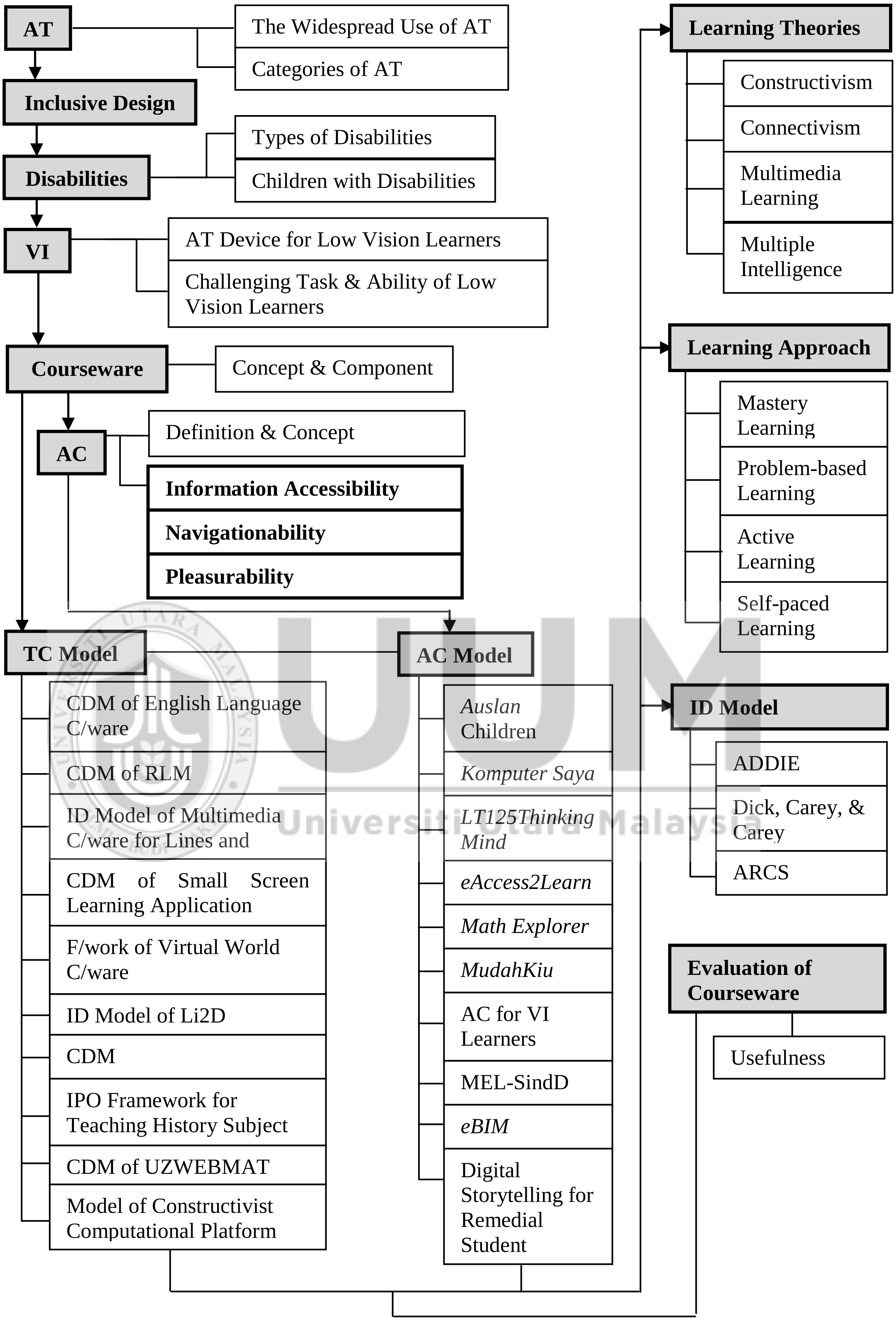


Figure 2.34: Overview of Literature Study

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter describes in particular the overall research process required to achieve all the objectives stated in Chapter 1. Iterative Triangulation Methodology is adapted for the whole research process that is based on qualitative approach. The rationale for this is described in the next section. Each phase of the methodology is coherently elaborated matching with the activities to accomplish each objective of the study.

3.2 Rational of Using Qualitative Approach

Qualitative research seeks to understand the phenomenon within a specific-context by using a naturalistic approach, in which the studies are not allowed to manipulate the phenomenon (Golafshani, 2003). In regards to this, this study concerns with the phenomenon related to low vision learners as discussed in Chapter 1. Accordingly, this study is relevant to be conducted by adopting qualitative approach because:

i) The primary subject of the study is low vision learners and they are still children. It reflects complexities in research works that need a well-structured planning and naturalistic approach in effort to understand them while participating in this study.

ii) Low vision children are special individuals, who need extra attention to be approached. Hence, their behaviors provide meaningful and valuable data. Accordingly, qualitative approach ensures the richness of data are guaranteed.

iii) This approach has also been found in works by other researchers which involve low vision people and children as their primary subjects such as Andreou and McCall (2010), Feeney (2011), Khadka et al. (2012), Atkinson and Hutchinson (2013), Hodge, Barr, Bowen, Leeven, and Knox (2013), Bertoni (2013), and Nantanoot (2013).

Consequently, in ensuring each objective is achieved various studies suggest that triangulation is the most appropriate method to be adopted. It is further discussed in the next section.

3.3 Triangulation Methodology

Triangulation methodology is a combination of multiple methods in analyzing the same phenomenon (Jack & Raturi, 2006). Cohen, Manion, and Morrison (2007) and Lambert and Loiselle (2008) point out that triangulation is an effort to work out in detail or provide a full explanation of the richness and complexity phenomenon by researching it from more than one points of view. It is a method to increase the confidence of findings through cross-checking/verification/examination of data from more than two sources to seek for regularities in the study (O'Donoghue & Punch, 2003; Lambert & Loiselle 2008; Ariffin, 2009). In particular, it refers to the utilization of multiple research methods in the same phenomenon of study which gives an in-depth and unbiased image of the researched phenomenon (Altrichter, Posch, & Somekh, 2008).

Generally, triangulation is required in qualitative research to increase the validity interpretation of the research (Zenios, 2011). However triangulation is highly required if, (i) the phenomenon of the research is controversy and sensitive therefore a more comprehensive interpretation from different perspectives is needed (as an example if the phenomenon is related with religion sentiment it is unsuitable to select Malay people only as the subject because another race also have their own religion sentiment) and (ii) the phenomenon of the research is highly complex and dynamic (as an example, drugs addiction phenomenon that involves various parties i.e. individual, family, enforcement agency)[6].

In the context of this study Iterative Triangulation Methodology (Marianne, 1998) which requires the iteration of processes are adopted. Consequently, Figure 3.1 exhibits the basis of methodology for this study.

[6] http:// www.drotspss.blogspot.com – is a research blog. The author of the blog is Dr. Othman Talib from Universiti Putra Malaysia (UPM).

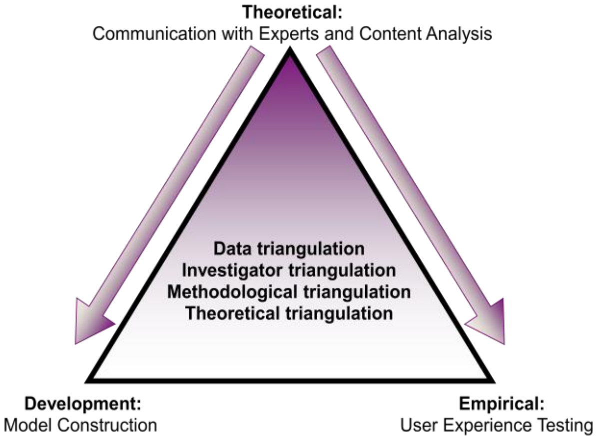


Figure 3.1: Basis of Methodology

Ammenwerth, Iller, and Mansmann (2003) proposed four basic types of triangulation. In conjunction, this study adapts the recommendation. The four types of triangulation are describes in the following list:

i) Data triangulation – the use of various data source based on different time, space, and person.

- Time – involving cross-sectional and longitudinal. This study gathers the data by using both of that technique. Cross-sectional means the data are gathered from different persons at the same time meanwhile, longitudinal means the data are gathered from the same person at different time. In this study, cross-sectional was applied by conducting the semi-structured interview in the same time with experts that consists of low vision teachers and normal teachers. Meanwhile, for longitudinal the prototype of AC4LV was tested with a group of low vision learners at different time until the results were saturated (Bowen, 2008).

- Space – this study gathers the data from low vision learners across different culture including Malay, Chinese, and Indian.

- Person – the data are gathered from experts that come from different background or organization involving teachers of special primary school and trainers from private organizations.

ii) Investigator triangulation – Particularly, only one observer and interviewer involve in observation and interview sessions to observe and record the testing phase. However, the instruments such as video camera, audio recorder, digital camera, and recording sheets were used to record both sessions. It is to increase the validity and reliability of the data and to avoid from biasness.

iii) Methodological triangulation – involving between-method and within-method in answering the research questions. Between-method means making use of different method on the same sample to check the validity such as interview and observation. Meanwhile, within-method means making use of the similar set of interview question in different times to test the reliability. In regards to this, this study applies both of the techniques. For between-method the similar group of subjects were observed and interviewed. Meanwhile, within-method implicates that pilot test are conducted to the subjects before the actual testing is run to check the reliability of the semi-structured interview question.

iv) Theoretical triangulation – the use of various theories and hypothesis to clarify the same phenomenon from different perspectives. This implicates that, multiple learning theories and learning approaches are incorporated. Further, Chapter 2 describes the theories and approaches.

3.4 Rational of Using Iterative Triangulation Methodology

As discussed with the example in previous section, this study is applicable to be accomplished by adopting the Iterative Triangulation Methodology and the following paragraph highlights the rational of using this methodology.

i) To overcome the weaknesses or intrinsic biasness that comes from complex and dynamic qualitative data if only depending on single method, single observer, and single theory.

ii) To provide meaningful and comprehensive explanations of the findings from qualitative data by using an in-depth cross different methods.

iii) To increase the credibility, validity, and reliability of the findings (Iacono, Brown, & Holtham, 2011).

iv) The Iterative Triangulation Methodology has also been found in other studies such as Orji (2007), Ariffin (2009), Iacono, Brown, and Holtham (2011), and Din et al. (2012).

v) It caters well all of research phases and provides research outcomes that are relevant to the expectation of this study.

Consequently, the next section explains the overall research process in detail based on the illustration of research methods.

3.5 Phase in Methodology

Based on the above elaboration, this study involves three parts which are theoretical, development, and evaluation. All of them require iterations of processes. Accordingly, systematic tasks were planned for achieving the research objectives (Dwolatzky, Kennedy, & Owens, 2002). Thus, design science approach (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Vaishnavi & Kuechler, 2007) which consists of five phases (i) awareness of problem, (ii) suggestion, (iii) construction, (iv) evaluation, and (v) conclusion were employed in this study. Therefore, the following paragraph lists the rational of using design science approach:

i) Design science approach provides a systematic process in order to create effective artifacs (Siti Mahfuzah, 2011).

ii) As highlighted by March and Smith (1995) design science approach consists of two basic activities which are build and develop. Building is "the process of constructing an artifact for specific purpose". Meanwhile, evaluation is "the process of determining how well the artifact performs". In relation to this study, Conceptual Design Model of AC4LV was constructed as the artifact and evaluated through user experience testing.

iii) In making the successful artifacts the use of design science approach is important to be applied (Peffers et al., 2007)

iv) In obtaining knowledge and understanding the domain of the problem, design science approach that involves the development and application of the designed artifact is applicable to be adapted (Hevner, March, Park, & Ram, 2004).

All the listed reasons overlap with the outcomes of this study, which make the design science approach applicable to be applied in this study.

Hence, to achieve the design research objective, three aspects of Iterative Triangulation Methodology which are (i) theoretical study, (ii) development, and (iii) empirical are triangulated (Norshuhada & Shahizan, 2010). This means each of the processes involve in this study mostly implemented iteratively and all phases interacted with each other along the period of study. This connection is outline illustratively in Figure 3.2. The main focus of this study is on the development of the Conceptual Design Model of AC4LV learners. Thus, to accomplish the objectives a sequence of steps involved but they are not executed in sequence all the time as this study requires the iteration process. The implementation of the activities results the research artifacts as exhibited in the outcome column.

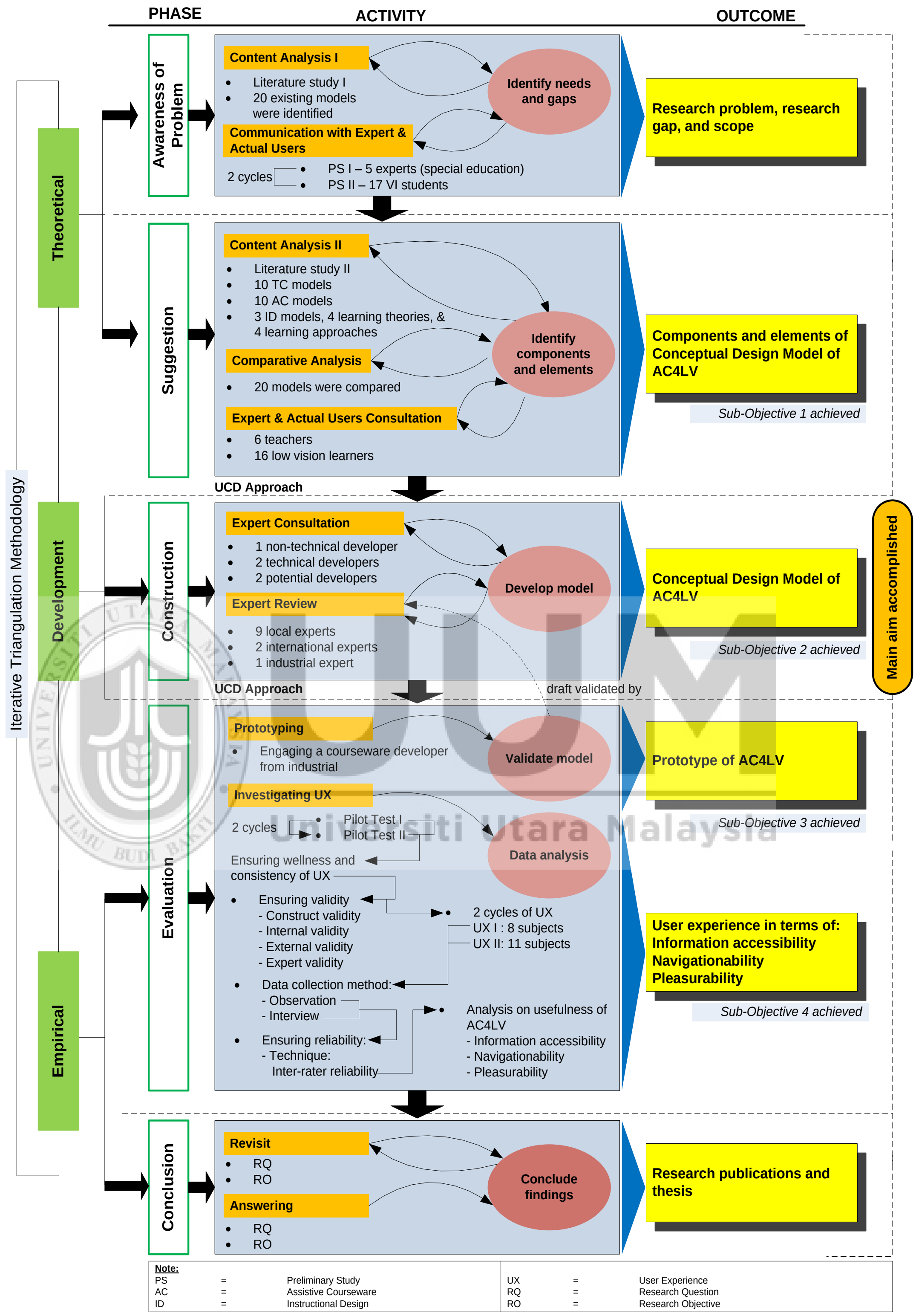
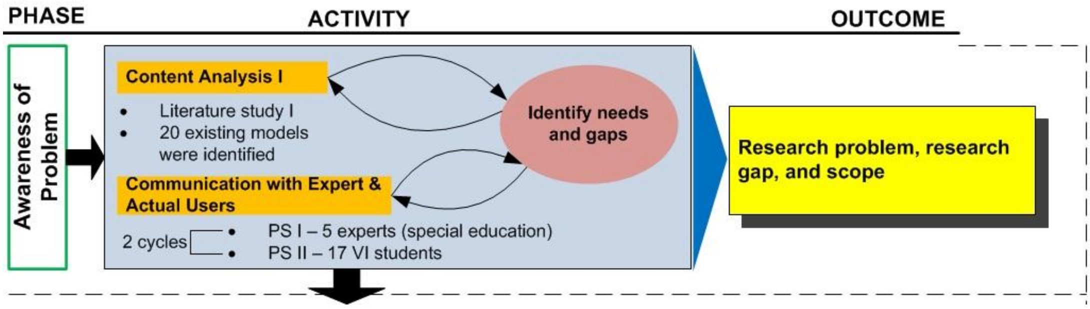


Figure 3.2: Phases in the Research Process

3.5.1 Phase 1: Awareness of Problem

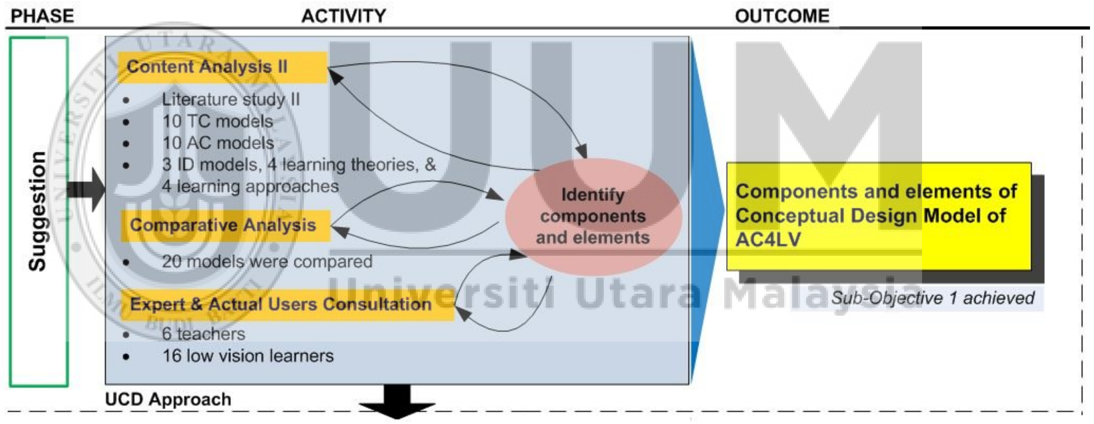


In understanding the concept related to this study, content analysis and communication with expert and actual users are required to confirm the outcomes of the first objective. In this phase, the issues to be researched are defined through elicitation from literatures and two cycles of preliminary investigation. Several facts from current articles and actual data have established the research problems which then lead this study to conduct the preliminary investigation. With the established key issues resulted from literature study and preliminary investigation, it then guides to the formulation of research gaps, objectives, and scopes as discussed previously in Chapter 1.

3.5.1.1 Content Analysis I and Communication with Expert and Actual Users

Content analysis I have been carried out through elicitation of literatures. A comprehensive and systematic literature search was performed in seeking for information and facts from various sources including books, articles in journals and proceedings of international and national conference, and newspapers. At this stage, 20 existing models of TC and AC were identified. The key information and facts gathered from these sources are outlined in the form of table and flow chart. This helps in understanding the problems to be solved. Based on the gathered key issues, two sessions of interviews were conducted with the objective to identify availability and needs of a Conceptual Design Model of AC4LV (*preliminary study I*). Besides, in developing the research target, an initial experimental testing was also carried out with the objective to understand the VI learners' motivation in learning through AC (*preliminary study II*). Both findings of this initial study are discussed in detail in Chapter 1.

3.5.2 Phase 2: Suggestion



Having identified the research problem, gap, and scope this study move on to the second phase which is suggestion. In the second phase, content analysis II, comparative analysis, and expert and actual users consultation were utilized in accomplishing the first objective.

3.5.2.1 Content Analysis II

Content analysis is a process of extracting knowledge about the proposed study. In this study the content can be obtained from various forms of sources including text, audio, video and other elements (Ariffin, 2009; Syamsul Bahrin, 2011). The main aim of the content analysis II is to gather the concept and theories in proposing Conceptual Design Model of AC4LV learners. In achieving the objective, this study decides that interview, literature review, peer review, and expert review are appropriate in literature study II. The elements of the proposed model as well as the design principles of AC4LV was also identified through comprehensive review on 10 existing TC model, 10 existing AC model, four learning theories, and four learning approaches. This process then continues to a more systematic stage which is called as comparative analysis.

3.5.2.2 Comparative Analysis

Every conceptual design model has different special elements based on the application to be developed (Ariffin, 2009). This study adopts the technique applied by Ariffin (2009), Syamsul Bahrin (2011), and Siti Mahfuzah (2011) in identifying the main components and elements from the existing models. This study has explored, compared, and analyzed two types of models which are TC model and AC model (10 for each types of model). Each of the models has been illustrated in figures. Then, the components and elements of the models are extracted in tables. The results of comparative analysis from these 20 existing models as discussed in Chapter 4 were compiled and utilized as the input in determining the main elements of the Conceptual Design Model of AC4LV. All the gathered elements were compiled prior to move to expert consultation stage.

3.5.2.3 Expert and Actual Users Consultation

To confirm the determined elements, the findings gathered previously were compiled and actual users were involved, in which this method is called User-centered Design approach (UCD). This stage refers the actual users to low vision learners. Meanwhile, experts are teachers among schools that provide special programmes for VI children.

i) UCD Approach

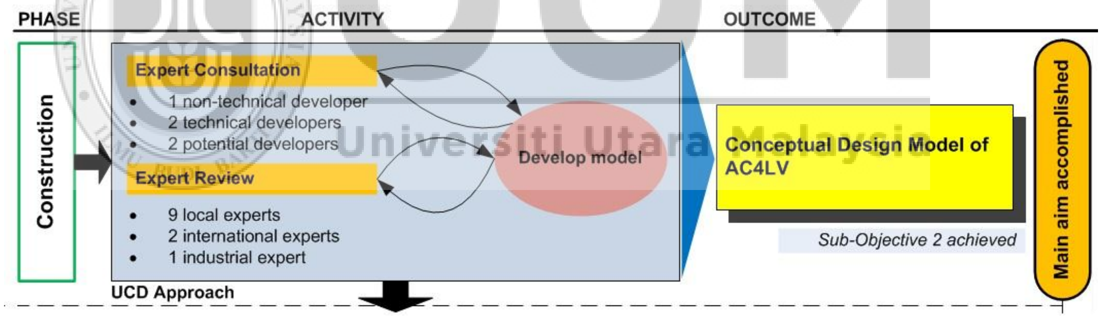
In general, UCD approach is the process in which the requirements and limitations of end users of the product are given a comprehensive concentration at each level of the process. The gathered findings and comments from the users then are used to make the decisions on the design and development of the product. In conjunction, Table 3.1 list six key principles described by ISO standard to ensure the design is user-centered.

Table 3.1: Six Key Principles of UCD

No.	Items
1.	The design is based on clear understanding of users, tasks, and environments.
2.	Users are involved all the way through the design and development stage and process.
3.	The design is determined and developed by user-centered evaluation.
4.	The process is iterative.
5.	The design addresses the whole user experience.
6.	The design team includes multidisciplinary skills and perspectives.

At this stage, the actual users were involved in the process of determining the elements of the Conceptual Design Model of AC4LV. A piece of form was prepared to them with the list of findings. Then, the teachers commented for each of the listed elements. Based on the comments, interview and discussion was excuted simultaneously. Meanwhile, face-to-face informal conventional interview (discussed in the next section) was conducted with the low vision learners so that they feel more comfortable to give comments on their preferred elements. At this stage, extensive attention is important to ensure that the gathered elements could fulfill the user needs.

3.5.3 Phase 3: Construction



The construction process is one of the challenging parts because it leads to the main contribution of this study which is the Conceptual Design Model of AC4LV. The construction of the Conceptual Design Model of AC4LV is based on the previous phases. The gathered elements in the previous phase together with the components are integrated to form the model. This requires an iterative process. Similarly, the UCD approach was utilized to ensure that the proposed model meets the user requirements. This stage is called expert consultation which is discussed next.

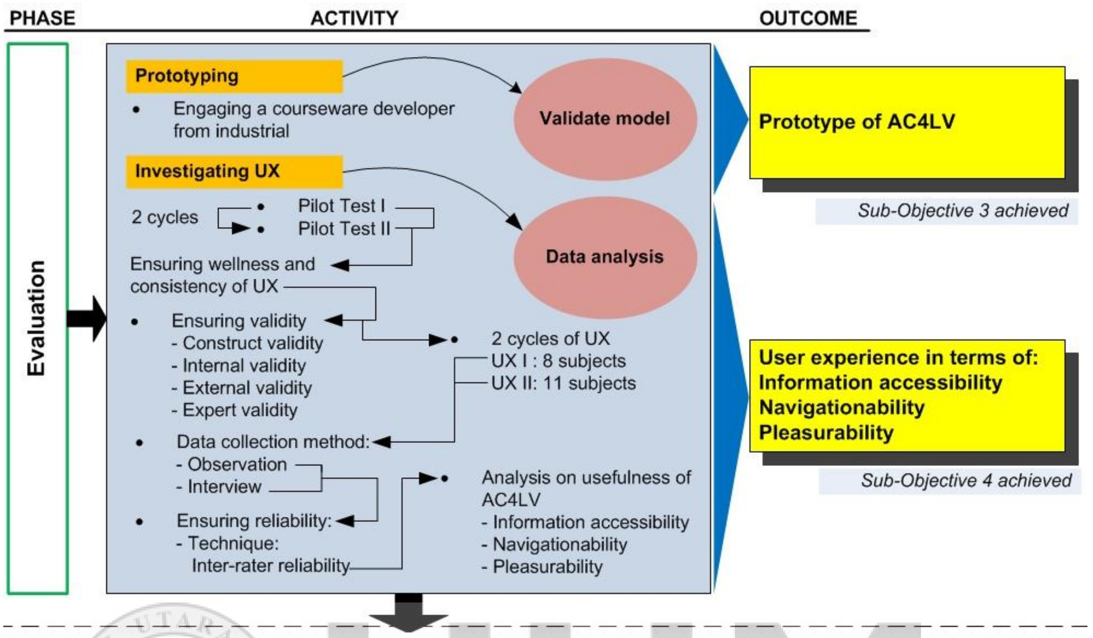
3.5.3.1 Expert Consultation

At this stage, the users of the proposed model are courseware developers. As developers, the proposed Conceptual Design Model of AC4LV should help them as guidelines and reference in designing and developing the AC4LV. The developers involved at this stage including non-technical, technical, and potential/novice developers. Their comments regarding the technical parts are really useful in the contruction process. Having completed the construction process, the developed model is then ready to move to expert review stage as discussed in the next point.

3.5.3.2 Expert Review

Expert review is a significant way to improve the quality of the work. In this study expert review involves academicians of local and international universities who have been at least five years of experience in their fields. They comprise of nine local experts, two international experts, and one industrial expert also from overseas, in which Chapter 4 further details their profiles. At this stage, they look into the proposed elements, design principles, terms used, and the logical of the connections and flows of all of the components. They also ensure that the proposed model is readable. A piece of instrument was provided for them to review the proposed model and annotate helpful comments that would improve the design of the proposed model. In particular, emailing services has been utilized as the communication medium. Having justified all the comments from the experts, this study come out with reviewed Conceptual Design Model of AC4LV which ready for prototyping as discussed in the evaluation phase.

3.5.4 Phase 4: Evaluation



Evaluation is the crucial part in order to ensure the proposed model is useful. There are different types of approaches in evaluating and validating the research outcomes (Vaishnavi & Kuechler, 2007; Ariffin, 2009; Syamsul Bahrin, 2011; Siti Mahfuzah, 2011). Most of the studies also suggest that the selection of evaluation methods must match appropriately with the research outcomes. In conjunction, the following lists discuss the sampling, strategies, and instruments involved in this study.

3.5.4.1 Sampling and Sample Size

The subjects in this study were selected by utilizing purposive sampling as it focus on particular characteristics of a population which means the subjects are homogeneous (Teddlie & Yu, 2007). The particular characteristics focuses in this study are the subjects were low vision learners from standard three to six with the average age nine to 12. The focus of purposive sampling is the sample being studied is not representative of the population, but the sample being selected which enable the study to answer the research question (Battaglia, 2011).

Qualitative study only require a few data records (Sabrina, 2012) which is inline with Miles's and Huberman's contention that the most useful generalizations of qualitative studies are analytic not sample-to-population (Miles & Huberman, 1994). Also, there are no firm guidelines for sample size in qualitative study (Patton, 2002). In this study, the sample is composed six subjects in *pilot test I*, eight subjects in *pilot test II*, eight subjects in *user experience I*, and 11 subjects in *user experience II*. The sample size has provided sufficient data to respond to the research question, although the quantity is limited. As noted by Patton (2002) "qualitative inquiry typically focuses in depth on relatively small samples, even single cases (n=1), selected purposely".

3.5.4.2 Prototyping

It is very hard to evaluate and validate the conceptual design model without translating them into a working prototype. In fact, there are also several previous works that applied this technique in their evaluation and validation process such as Ariffin (2009), Siti Mahfuzah (2011), and Efendioğlu (2012). This study engages a courseware developer from industry to prototype the Conceptual Design Model of AC4LV. Prototypes could be built in two types; low-fidelity prototypes and high-fidelity prototypes in which both of them have different properties and uses. Low-fidelity prototypes could be built in the form of paper, cardboards, or any materials to indicate the design direction. These include visuals, colors, menus, and controls' locations but not detail navigation and interaction. Low-fidelity prototypes are very useful in the early design stage of gathering requirements and analysis. In contrast, high-fidelity prototypes refer to fully operational prototypes which mean it is fully interactive and the users could interact with it as the real product (Alethea, 2009). Two methods underlying the prototype development are throwaway prototyping and evolutionary prototyping. According to Davis (1992) throwaway prototyping is discarded after the desired information is obtained compared to evolutionary prototyping is refined continuously until it evolves into a final product. This study uses the semi-working prototypes by applying evolutionary method. On the other hand, low-fidelity prototypes were performed (storyboarding using hand sketching) prior to develop the high-fidelity prototypes for evaluation. Having successfully prototyped the proposed model, it indicates that the proposed model is validate and useful to the developer. Further detail of the prototyping process is discussed in Chapter 5.

3.5.4.3 Investigating User Experience

This study involves studying the usefulness of the prototype in terms of (i) information accessibility, (ii) navigationability, and (iii) pleasurability as stated in Chapter 1. The next subsection explains the strategies and instruments that have been utilized in conducting the user experience testing in detail.

3.5.4.4 Pilot Test

Pilot test has been conducted before the actual user experience testing is implemented. It is important in qualitative research to ensure that the observation and interview sessions conducted in the actual experimental testing are well prepared and the prepared questions are reliable. This explains that the pilot test would assist this study to check for error, limitation, or other drawbacks in the designed questions and observation preparation. This allows this study to make any necessary modifications or refinements before running the actual user experience testing. The pilot test should involve subjects that have similar interest with those to participate in the actual testing. To ensure that, this study requires two cycles of pilot test in which the subjects are low vision learners from Integration Primary School of Jabi (Visually-impaired) (pilot test I) and Special Education Primary School of Alma (pilot test II). After ensuring that the designed question and the prepared observation have no error, then the actual user experience testing was conducted. Prior to start the user experience testing, it is important for this study to ensure the validity of the research findings which discussed next.

3.5.4.5 Ensuring Validity

This study ensure the validity of the research findings through (i) construct validity, (ii) internal validity, (iii) external validity, and (iv) expert validity which discussed in detail in Chapter 6.

3.5.4.6 User Experience Testing

The next part of the empirical study is the user experience testing. This study emphasized on the user experience testing in order to evaluate the usefulness of the proposed model rather than the effectiveness of the prototype as the proposed model was designed to tackle the low vision learners as the end user. The evaluation was conducted to the low vision learners using the translated proposed model which is the prototype of AC4LV. It was evaluated based on three dimensions which are (i) information accessibility, (ii) navigationability, and (iii) pleasurability. These three dimensions are selected based on the needs of the low vision learners that have been clarified in Chapter 1 and 2. So, the purpose of evaluation is to seek whether all the elements provided in the AC4LV is useful to the low vision learners in terms of those three aspects. Therefore, based on the rationale of using qualitative approach as discussed in the previous section this study decides to apply observation and interview as the methods in gathering data during the user experience testing. In addition, other techniques (Table 3.2) of the usefulness evaluation method (Hartson, Andre, & Williges, 2003) were also applied which could provide richer data on top of the empirical data.

Table 3.2: Usefulness Evaluation Method

No.	Evaluation Method	Type of Evaluation	Relevant Stages	Description
1.	Think-aloud protocol	Testing	Design, coding, testing, and release of application	The subjects are encouraged to express their feelings during the test session. It can be seen through their behaviors. This method is less expensive and the results are close to the user experience.
2.	Focus groups	Inquiry	Testing and release of application	A group of users is selected to involve in the discussion that guided by a moderator. The subjects can express a lot of ideas about the developed application.
3.	Interviews	Inquiry	Design, coding, testing, and release of application	The subjects are interviewed to find out their experience and expectations while using the prototype. It is good to obtain detail information.
4.	Observation	Testing	Design, coding, testing, and release of application	The subjects' behavior are being seen and heard by the observer during the test session. All the gathered information will be recorded by manually or digitally

In conjunction to the discussions in previous paragraphs, two cycles of user experience testing was carried out. The rationale for this are as discussed in Chapter 6. The user experience testing has been conducted in a computer lab that is equipped with computers, headphones, and speakers. The subjects have been assigned to sit next to their peers as in their routine classes. Before starting the user experience testing, the prototypes were installed to each of the computer. So, they feel comfortable to interact with the prototypes on their own. This is important because their behavior provide valuable data during the observation.

3.5.4.7 Data Collection Method

This study collected the data in two method; observation and interview. They are discussed next.

i) Observation

Observation is a technique of obtaining data by witnessing and listening to the behavior or events, and annotating physical characteristics in the natural setting (Driscoll, 2011). The types of observation are depending on the research question itself (Cross, 2007). Commonly there are two types of observation techniques and both of these techniques can be utilized in two different manners as discussed in Table 3.3:

Table 3.3: Observation Techniques

Observation techniques	Elaboration
Participant observation	Participant observation is a common practice used in ethnographic research (Luo, 2011). In these type of observation, the researcher participate actively in interacting with the subjects and become part of the group or community (Cooper, Lewis, & Urquhart, 2004; Driscoll, 2011). This may require the researcher to live or work in that area for a period of time (Cooper et al., 2004; Driscoll, 2011). This type of observation assumes that the researcher will be accepted as the member of the group or community to be researched and the subjects aware that they are being observed (Taylor-powell & Steele, 1996; Cooper et al., 2004). Usually the researcher is the observer itself (Taylor-powell & Steele, 1996; Cooper et al., 2004).
Non-participant Observation	Non-participant or unobtrusive observation means the observer act as the eavesdropper (Cooper et al., 2004; Driscoll, 2011). In other words, the researcher were not interact with the subjects and the observation were conducted without the subjects' knowledge (Cooper et al., 2004; Driscoll, 2011). The researcher become as the observer to record the observation (Cooper et al., 2004; Driscoll, 2011). Usually, this techniques is used by psychologists to observe the children or animal behavior (Cross, 2007).

In the context of this study, non-participant observation was applied. The testing session was conducted in natural setting as in their routine class. When the prototypes are played to them, the observation was recorded through the recording sheets, camera video, and photographs. This study discussed two setting of observation in which the details are provided in Table 3.4.

Table 3.4: Observation Setting

Observation setting	Elaboration
Unstructured observation	Unstructured observation is informal approach which is not depending on pre-specified coding systems (Mulhall, 2003). Cohen et al. (2007) and University of Strathclyde (2013) note that there are four types of unstructured observation which are ethnography or participant observation, naturalistic observation, narrative methods, and critical incidents. In these four types of observation, the researcher were enter into the community with some general ideas, but has not decided specifically on what to be observed (Mulhall, 2003). This four approaches share that the unstructured observation is unfocused and holistic, which means the observer attempt to record as much as possible about the subjects in order to discover the research themes (Mulhall, 2003). In accordance, the observer or researcher not have to prepare checklists or coding schemes, but the researcher should report it in narrative styles on things relevant to the research question (Mulhall, 2003).
Structured observation	Structured observation is a systematic investigation, in which particular types of behavior are looked for and counted (Phellas, Bloch, & Seale, 2011). The focus of the observation should be determined systematically before the observation is conducted (Phellas et al., 2011). It is implemented in natural or laboratory setting (Phellas et al., 2011). Structured observation provides a consistent information and numerical summary of the observation (Allday, Duhon, Blackburn-Ellis, & Van Dycke, 2010).

In this study, structured observation was utilized. A structured checklist form that contains evaluation attributes are provided to the observers. The setting of the observation in terms of subjects, time, and place are prepared before conducting the observation. Instead of checklist form, it is important to determine the method that applied by the observer during the observation implementation. Thus, the next point discussed an appropriate observation method that utilized in this study.

a) Think-aloud Protocol

As shown in Table 3.2, think-aloud protocol is one of the methods used to gather data in user experience testing. According to Kuusela and Paul (2000) and Maaike and Menno (2003), think-aloud protocol consists of two different experimental procedures which are (i) concurrent think-aloud protocol (the data are collected during the test session), and (ii) retrospective think-aloud protocol (the data are gathered after the test session). This study applied both of the protocol in which the data are collected during the observation and after the test sessions by interviewing the subjects. The setting procedure are (i) the prototypes were introduced to them by playing it on each of the computer, and (iii) the subjects were encouraged to speak aloud all of their ideas about the prototypes while using it to understand their inner feelings. This means it involves the subjects to state everything on what they see, think, and feel as they go through the prototypes. The main purpose of this method is to capture explicit data during the test sessions. Besides, this protocol allows this study to witness the user reactions about the prototype before continuing to the next stage. Data were collected by taking notes over the subjects' comments and their body languages without trying to interrupt and interpret their actions and words. Instead of taking notes manually, video, audio, and screen recordings is also useful to record the test session. It could assist this study to analyze the data afterward. Thus, the next point discusses on the types of instruments that has been used during the test sessions.

b) Observation Instrument

To provide a useful and credible evaluation, the observations were documented. Currently there are numerous instruments that can be used to record the observation, but it depends on how the researcher prepares the instruments in effort to make the observation data be grasped systematically. Sometimes it can be record on the spot but to be safe and to avoid from thrown off the valuable data, this study provides the observation instrument as described in Table 3.5:

Table 3.5: Observation Instrument

Instrument	Description
Recording sheets or checklist	It is a printed form to record the observation in a YES/NO option, and in a rating scale. Checklist is useful to record specific items or attributes. In this study checklists were used to record the attributes that indicate the usefulness of the prototype. It also provides space for the observer to note anything that they see or heard during the observation. It is prepared structurally so that it is easier for the observer to tick and note the observation perfectly. Moreover, the testing involves two sessions and two locations. So it is important for this study to provide a systematic and structured form in grasping richer data.
Video recording	Video recordings is important in observation as it enables the researcher to analyze the data in detail afterward especially on the user reactions and emotions while using the prototypes. It also could assist the researcher if there is something important point missing or unrecorded in the recording sheets. This study used camera video to record the whole process of the observation.
Audio recording	As the think-aloud protocol is depend on the thoughts verbalized by the subjects, therefore audio recordings is also important as the video recordings. The audio were recorded parallel to video recordings by using the same equipment.
Screen recording	Other than video, photograph is also the important material in analyzing the observation data. Thus, this study used the digital camera to capture the meaningful moment during the observation. Screen recording is very useful to illustrate the evaluation report.

ii) Interview

Another type of data collection method that utilized in this study is interview. It is a method that could provide exhaustive information regarding the subjects' experiences and perspective pertaining to the research topic. Interview is different from other data collection method in which it enables the researcher to be more flexible and explorative. It is an effective method in a study that acquires the subjective understanding from the subjects' point of view, where they can explain using their own words.

To acquire rich and meaningful data with qualitative investigation, various forms of interview design can be developed. For the purpose of this study four common types of interview design are possible to involve which are (i) informal conversational interview, (ii) general interview guide approach, (iii) standardized open-ended interview, and (iv) closed-fixed respond interview (Turner, 2010). They are described in Table 3.6.

Table 3.6: Types of Interview

Types of Interview	Description
Informal Conversational Interview	It is an informal conversational approach which is also called unstructured interview, in which the questions are addressed spontaneously (Turner, 2010). The types of question are open and the interviewer attempts to adapt as much as possible into the context of the subjects (Zhang & Wildemuth, 2009). Also, the researcher does not prepare any specific question, particularly the study depends on the interaction with the subjects to guide the interview process (Kajornboon, 2005). This type of interview provides more flexibility between the researcher and the subjects to interact with each other (Corbin & Morse, 2003). Nevertheless, most of the studies view this type of interview as unstable or unreliable because of the provided questions is inconsistent (Roulston, DeMarrais, & Lewis, 2003; Dicicco-Bloom & Crabtree, 2006; Zhang & Wildemuth, 2009). The study possibly face difficulties to code the data when come to the analyzing process (Corbin & Morse, 2003). The flexibility of answer resulted from the interview process is critical to understand (Cohen et al., 2007).
General Interview Guide Approach	This category of interview is more structured compared to informal conversational interview (Turner, 2010). It intends to gather similar general ideas of information from each of the subjects (Turner, 2010). However, it still provides flexibility to the researcher in asking questions (Harrel & Bradley, 2009). This means that the general interview guide approach is more focus but it still offers a degree of freedom to the interviewer in obtaining the information from the subjects (Schatz, 2009). For this type of interview, the researcher has to structure a set of questions but the question can be adapted and customized as the interview process is running in order to explore more information from the subjects (Leech, 2006). This type of question is also called pre-constructed questions or semi-structured interview (Pathak & Intratat, 2012). It also enables the researcher to ask question using their own unique styles depending on the field of study and who the subjects are (Dicicco-Bloom & Crabtree, 2006).
Standardized Open-ended Interview	In the standardized open-ended interview, (also called structured interview) the researcher have to prepare a set of structured questions (Turner, 2010). During the interview, the interviewer extremely follows the structure of the questions (Turner, 2010). The same set of question is asked to all subjects (Phellas et al., 2011). However the term open-ended means the subjects are able to fully express as detail information as they desire, in which the answer is usually based on their experiences (Rapley, 2001). This approach provides richer qualitative data but it is quite hard for the researcher to extract the narrative transcript to the similar themes or codes (van der Zee, Bakker, & Bakker, 2002) . However, involving a number of subjects in the interview process could reduce from biases of study (van der Zee et al., 2002).
Closed Fixed-respond Interview	In studies that utilize closed fixed-respond interview, all subjects are asked the same set of questions (Leader & Thompson, 1999). Options are provided for them to choose the answer (Turner, 2010). This type of interview is suitable to those researchers who are not practice to conduct the interview which also called structured interview (Fontana & Frey, 1994).

In responds to the above discussions, this study applied general interview guide approach. It implicates that, a set of structured interview questions were prepared before the interview. However, the questions were customized during the interview sessions to suit with the subjects' responses. As the subjects for this study are low vision children, this study needs to conduct the interview with appropriate approaches. The interview was conducted after the subjects view the prototypes. The same set of questions was asked to the similar group of subjects those participating in observation. Hence, this also requires this study to explore on the psychology and communication aspects of special needs students on how to get close to them in effort to obtain meaningful data that could answer the research questions and achieve the research objective.

a) Interview Instruments

The interview session was recorded in a form of audio files. This requires this study to prepare an audio recording apparatus. This facilitates this study to analyze the content of the interview afterward. The next point discusses the techniques that have been utilized in analyzing the qualitative data gathered from the previous phases.

3.5.4.8 Analysis on User Experience of AC4LV

Empirical evidences from the previous phase were justified through analysis of findings. The analysis techniques that have been utilized were discussed in the following points.

i) Coding and Analyzing Interview Data

In analyzing the data from the interviews, the audio files were transcribed verbatim. Also, the observation data were recorded as transcripts. Each of the transcripts were reviewed and coded comprehensively to highlight the views and perceptions of the low vision learners regarding the usefulness of the prototype. Qualitative data analysis software (named as ATLAS.TI) has been used to carry out the data management, coding, and analysis. Words and phrases that have been obtained from the transcripts were used to link similar statements among the subjects. A database consisting of texts with its associated codes were created using the ATLAS.TI. The software assists in organizing and retrieving the portions of the text that has been linked to the common codes. Then, it displays the systematic relationships between the coded texts. By utilizing the search function, all the related ideas can be detected including the strand data. This process facilitates the exploration of the data patterns and the conceptualization of the findings.

The text data that has been obtained from the ATLAS.TI database were grouped, organized, and then read to explore the key findings, and themes (Khadka et al., 2012). In qualifying any topics as a theme, two criteria must be fulfill: (i) at least two subjects from a group of participants have to make substantive comments on that topic, and (ii) at least one subject from two different groups have to discuss the same topic (Walsh, Irwin, Meier, Varni, & DeWalt, 2008). Both of these criteria have to be satisfied to be agreed as a theme (Walsh et al., 2008). There are two approaches to code the gathered data as discussed in the next point.

a) Emergent Coding and Priori Coding

Coding is the process of organizing, sorting, and segmenting the data (Cohen et al., 2007). There are two approaches of coding in qualitative study, which are named as emergent coding and priori coding (Othman, 2013). Emergent coding refers to the codes that are produced after reading and examining the transcripts (Othman, 2013). On a contrary, priori coding refers to the codes that were initially developed in the study based on previous theories or research questions (Othman, 2013). Both of the coding process also can be performed simultaneously (Othman, 2013) as applied in this study. Having coded all the transcripts, it is important to ensure the validity and reliability of the data prior to analyze it which discussed next.

ii) Validity and Reliability of Qualitative Data

Coding is like a life for the qualitative research. For that reason, it is important to ensure the code that has been identified in the previous stage is validated and reliable to be used for analyzing the findings. Besides, this could increase the confidence of findings. Therefore, as suggested by Punch (2002), Golafshani (2003), and Mulhall (2003), two steps of validation and reliability has been implemented in this study which are:

a) Expert Validation

At this stage, expert validation form has been prepared as the instrument to validate the theme, code, quotations, or occurrances. The form was divided into four columns (theme, code, quotation, and expert comments). As sampled in Figure 3.3. Two experts in qualitative research of HCI and multimedia education have been invited to involve in expert validation stage. Both of the experts checks and comments either the quotations/occurrances is match with the theme and code.

Theme		Code	Quotations/Occurrances		Expert Comment
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
6.			6.		

Figure 3.3: Sample of Expert Validation Form for Validity of Data

b) Inter-rater Reliability

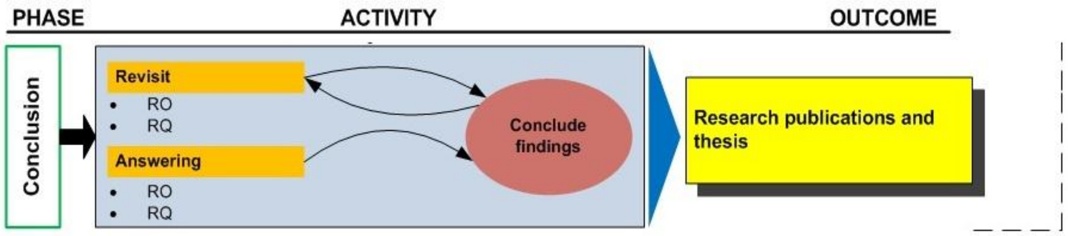
The next step is inter-rater reliability. Having made appropriate corrections based on the comments by the two experts, the data that represented in the form of number were inserted into a statistical package to test the reliability. This data were run and the output is refer to Kappa Statistics from Family Medicine 2005 (Viera & Garrett, 2005) as shown in Table 3.7. This provides evidence that this study have validate and check the reliability of the theme, code, and the quotations/occurrances carry out in the previous stage.

Table 3.7: Kappa Statistics

Kappa Statistics	Strength of Agreement
<0	Less than chance agreement
0.01 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 0.99	Almost perfect agreement

After going through all the above process, the data were analyzed and reported in Chapter 6. All the image and illustrations gathered in the previous phase were inserted to support the analysis.

3.5.5 Phase 5: Conclusion



In the final phase, all the findings gathered in each of the previous phases were concluded through revisit and answering all the research questions and research objective. Finally, this study comes out with full thesis and several publications as the contribution to the body of knowledge and theory.

3.6 Summary

In a nutshell, this chapter deals with the research methods that have been adapted in this study. With the rational that has been discussed, Iterative Triangulation Methodology has been selected to be utilized throughout this study which involves three major parts; theoretical, development, and evaluation. All of the parts require the iterations processes which have to be implemented systematically in effort to achieve the stated objectives. Thus, five phases from design science research which are (i) awareness of problem, (ii) suggestion, (iii) development, (iv) evaluation, and

(v) conclusion were adapted. Each of the phases has been described in detail with the activities carried out throughout this study.

Details on the development of Conceptual Design Model of AC4LV are described in Chapter 4.

CHAPTER FOUR

CONSTRUCTION OF CONCEPTUAL DESIGN MODEL OF AC4LV

4.1 Overview

This chapter describes the processes in constructing the Conceptual Design Model of AC4LV. Generally, the methods used in developing the proposed model include content analysis II, comparative analysis, and expert and actual users consultation. Also, the expert reviews in validating the proposed model are elaborated. The relationship between the techniques and their objectives is illustrated in Figure 4.1.

Method	Objective	Outcome
Content Analysis II	• To analyze and critique the previous models that are related to the Conceptual Design Model of AC4LV. • To identify the elements and design principles for the Conceptual Design Model of AC4LV.	• Justification of 20 previous conceptual design models of TC and AC. • Elements and design principles for the Conceptual Design Models of AC4LV based on previous studies.
Comparative Analysis	• To identify and analyze the generic components, elements, and design principles for the Conceptual Design Model of AC4LV.	• Components, elements, and design principles of the Conceptual Design Model of AC4LV based on analyzed models.
Expert and Actual Users Consultation	• To confirm the gathered components, elements, and design principles of the Conceptual Design Model of AC4LV.	• Proposed components, elements, and design principles of the Conceptual Design Model AC4LV.
Expert Review	• To review and validate the Conceptual Design Model of AC4LV.	• Reviewed and validated Conceptual Design Model of AC4LV.

Figure 4.1: Summary of Activities in Constructing the Conceptual Design Model of AC4LV

Conceptual Design Model of AC4LV extends the ideas of the existing conceptual design model of TCs and ACs. Most of the ideas are used as the basis in constructing the proposed model as they share similar format. However, it has to be stressed that the content of AC4LV is different with the existing models because it addresses assistive characteristics. As discussed in Chapter 1, most of the existing coursewares mean too little to low vision learners because the contents are designed not supporting their needs. So, based on the existing guidelines, and learning theories and approaches as discussed in Chapter 2, this study has discovered appropriate elements in the Conceptual Design Model of AC4LV. Those elements are necessary to cater the needs of low vision learners in learning, which have been identified through analyzing the contents in literatures, comparative analysis, and supported with expert and actual user consultation through UCD approach. Their characteristics are detailed in Figure 4.2. Also, the criteria of selecting them in UCD are justified in Table 4.1.

Table 4.1: Criteria and Justification of Participants in UCD Cycles in the Contruction of Conceptual Design Model of AC4LV

Users	Criteria	Justification
Low vision learners	Their school level are from standard three to standard six with the average age nine to 12 years old.	Low vision learners are the target users of AC4LV. They are introduced to ICT subjects start from standard three. Involving them is important to find out the specific elements and design principles of the proposed model which could fulfill their needs in learning activities.
Teachers	They have been teaching low vision learners for at least five years experience.	With five years experience of teaching low vision learners could increase the confidence of this study to seek and confirm the needs of low vision learners in their learning activities.
Developers	They have experience involve in the development of learning applications for at least 3 years.	The developers' participation is important to confirm on the technical part of the proposed model (i.e. process and navigation).
Academicians/ Researchers	Their criteria are as discussed in Section 4.6.	Their participation is to review, comment, and validate the proposed model.

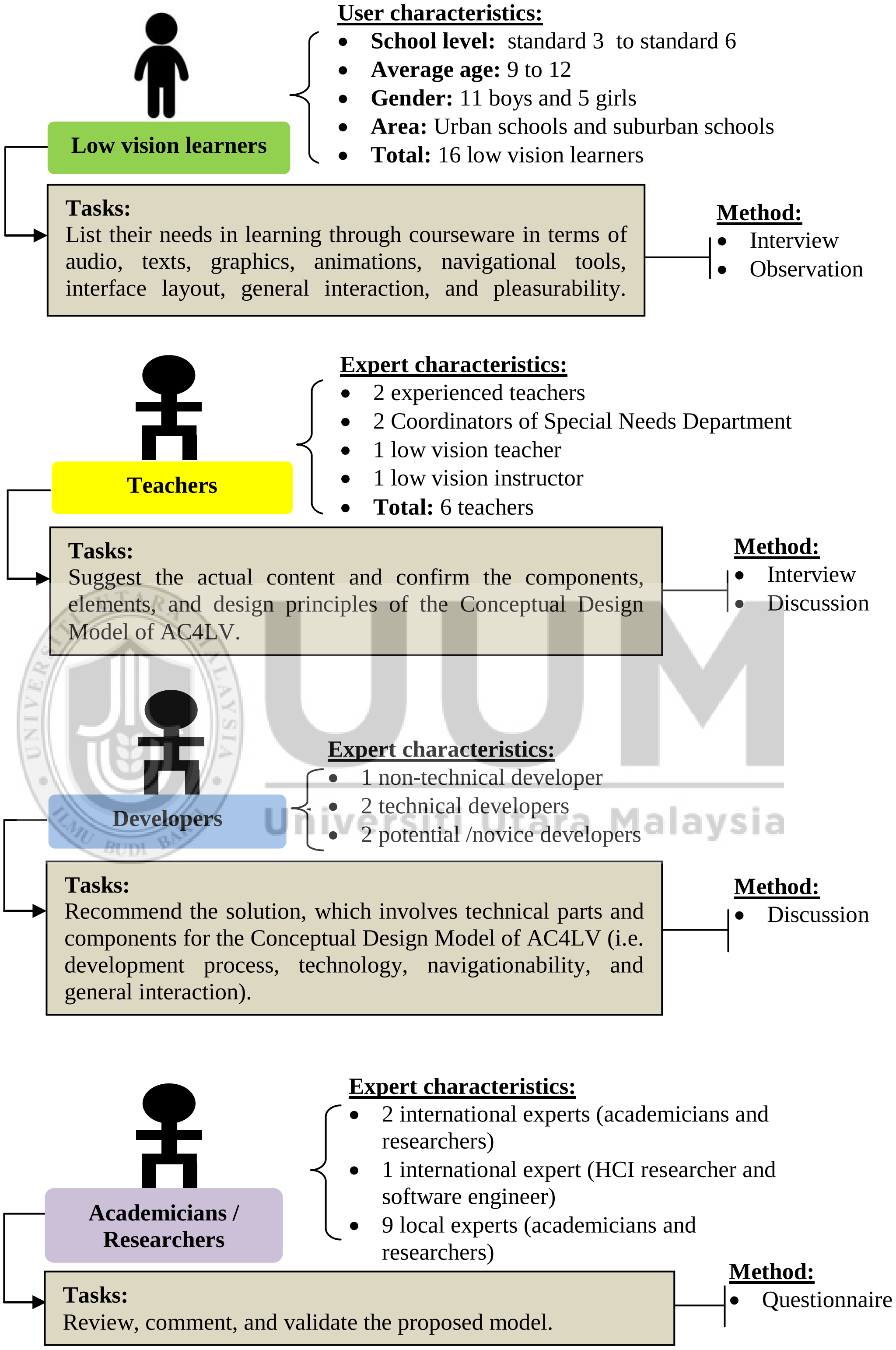


Figure 4.2: Summary of the Participants in UCD Cycles in the Construction of the Conceptual Design Model of AC4LV

Conceptual Design Model of AC4LV focuses on ensuring that learning applications support to information accessibility, navigationability, and pleasurability as needed by low vision learners. Accordingly, it leads to the idea of determining the elements of Conceptual Design Model of AC4LV, which are then applied in content design.

In short, the proposed AC4LV Conceptual Design Model gives particular attention to delivering contents, which serve the needs of low vision learners. This is called as assistive content. In the remaining sections, the Conceptual Design Model of AC4LV is elaborated deeply.

4.2 Component of the Proposed Model

Prior to proposing the Conceptual Design Model of AC4LV, a comparative analysis of the existing conceptual design models was conducted. Altogether, 20 existing conceptual design models (i.e. 10 for each TC and AC) from previous studies were selected. They were selected as part of this study on the basis that they are inline with this study. To simplify the discussion in this chapter, both of them are named as model.

In Chapter 2, these selected models have been discussed and analyzed deeply including their limitations, in seeking the research gap. Consequently this section compares them with the objective to identify their generic component in developing the Conceptual Design Model of AC4LV. They were selected to be compared based on justifications detailed in Table 4.2.

Table 4.2: Justification for Selecting Models

No.	TC	Justification
1.	Mazyrah et al. (2008)	This model is selected because it highlights the details regarding the courseware component.
2.	Ariffin (2009)	It is selected for the reason of elucidation because the design model is almost perfect. Also, this study considers the learning theories and approach applied in the model.
3.	Syazwan and Wan Fatimah (2010)	It is targeted for learners with visual problems in learning mathematics, which is related with this study.
4.	Churchill (2011)	This model recommends specific design guidelines, in which some of them are appropriate to be adapted in this study.
5.	Nik Siti Hanifah et al. (2010; 2011)	This model represents basic components in designing a courseware.
6.	Zuraini and Wan Fatimah (2011)	Description of the content in this model is comprehensive in terms of learning theory, interface guidelines, and development process.
7.	Efendioğlu (2012)	The design of this model is quite technical, but it stresses on courseware structure and guidelines of multimedia elements that a courseware should have.
8.	Rossafri (2012)	Generic components of courseware are clearly presented in this model.
9.	Özyurt et al. (2013)	This is one of the latest models that provide learning contents based on individual learning style. This relates with this study when VI learners are more to audible and kinesthetic style.
10.	Garcia and Pacheco (2013)	This model is tailored for young children at primary level. It stresses on pedagogical aspect, which is one of the factors interests this study.
	AC	**Justification**
1.	Ellis (2009)	Multiple characters provided in this model motivate this study to refer to it as guidance in developing characters for AC4LV.
2.	Norfarhana et al. (2010; 2012)	Learning theories and approaches adapted in this model were found related with this study. Also, the presentation of such components is of interest.
3.	Morfidi et al. (2010)	This model emphasizes on interface layout, which is important to be considered in this study.
4.	Sampson and Zervas (2010)	This model suggests specific guidelines in terms of text, size, and color for low vision learners, which is almost tailored to this study.
5.	Seo and Woo (2010)	This model comes out with specific interface design guidelines of learning mathematics for early elementary school children, which is really important to be considered in this study.
6.	Siti Zaharah and Nor Azan (2011)	This is one of the models that analyzes their user needs prior to proposing their conceptual design model. This factor influences this study to consider that aspect.
7.	Savita and Nur Athirah (2011)	This model provides interesting features in terms of its function, which inspires this study in designing the content of AC4LV.
8.	Nurulnadwan et al. (2011)	Developed specifically for VI learners and proposes specific guidelines for developing AC for VI learners.
9.	Rahmah and Tengku Nazatul (2012)	Supports the disabled children in learning through courseware by providing scaffolding strategy in making sure the subjects could grasp the knowledge.
10.	Rahmah et al. (2012)	This model draws attention to the usage of colors in attracting remedial students to learn via storytelling approach. This is one of the important elements in designing AC4LV. Furthermore, the presentation of the model is detailed and easy to understand.

With reference to Table 4.2, a number of unique reasons make all of the models significant to be selected for discussion in this study. Some of the models interest this study through their specific design guidelines, some with their learning theories and approaches, some with their comprehensible presentation, some with the logical structure, and some with the contents. It has to be stressed again that, this comparative analysis was carried out to discover generic components. This means that the selection of components in the proposed model also considers suggestions from users and experts through UCD approach.

Accordingly in determining the generic components for the proposed model, Table 4.3 and Table 4.4 plot the similarities and differences of each of the selected conceptual design models for TC and AC and categorized them in terms of their generic components. This analysis is important to ensure the proposed model is constructed based on the established root. First, the generic components for both models were analyzed. The analysis was done line by line through the model illustration, snapshots of the prototype, and their elaboration. Then, the generic components across all models are recorded as shown in the following tables.

Table 4.3: Comparative Analysis of Generic Components for TC

Generic component	1	2	3	4	5	6	7	8	9	10	Total
Structural component	√	√	√	√	√	√	√		√	√	9
Content composition	√	√	√	√	√	√	√	√	√	√	10
Design guidelines	√		√	√		√	√		√	√	7
Learning theories	√	√	√	√		√	√	√		√	8
Learning approach	√	√	√			√	√		√		6
Development process	√	√	√			√		√	√	√	7
ID model	√		√		√	√		√			5
Technology	√	√	√	√	√	√	√	√	√	√	10

Note. 1-10 is referred to TC

Table 4.4: Comparative Analysis of Generic Components for AC

Generic component	1	2	3	4	5	6	7	8	9	10	Total
Structural component	√	√			√		√	√	√	√	7
Content composition	√	√	√	√	√	√	√	√	√	√	10
Design guidelines	√		√	√	√	√	√	√	√	√	9
Learning theories	√	√	√							√	4
Learning approach		√								√	2
Development process		√		√	√	√	√	√		√	7
ID model		√			√	√			√	√	5
Technology	√	√	√	√	√	√	√	√	√	√	10

Note. 1-10 is referred to AC

After analyzing all the models, it has to be summarized to represent the generic components for both types of models. This is to confirm which component would be selected in constructing the proposed model. It is exhibited in Table 4.5 in which the classification of components follows the rules in Table 4.6.

Table 4.5: Summary of Generic Component of Existing Models

Generic component	TC	AC
Structural component	**M**	**M**
Content composition	**A**	**A**
Design guidelines	**M**	**M**
Learning theories	**M**	**M**
Learning approach	**M**	**F**
Development process	**M**	**M**
ID Model	**M**	**M**
Technology	**A**	**A**

Table 4.6: Indicator for Categories of Component

Indicator	Description	Condition
A	All models apply	<u>All</u> models apply
M	Majority of models apply	There are <u>four</u> models applying
F	Few models apply	There are between <u>one</u> to <u>three</u> models applying
X	Not applied in any model	There is <u>no</u> model applying

The results of the above summarization are used as the guidance in constructing the generic components for the Conceptual Design Model of AC4LV. Accordingly, Table 4.7 provides the proposed generic components of existing models followed by Figure 4.3 showing the conditions in determining compulsory and recommended components.

Table 4.7: Generic Component of Existing Models

Generic component	**AC4LV**
Structural component	◙
Content composition	◙
Design guidelines	◙
Learning theories	◙
Learning approach	◙
Development process	◙
ID Model	◙
Technology	◙

Condition 1: The component is compulsory ◙ to apply when there is any **A** OR there is at least one **M** with no **X** in the row.

Condition 2: The component is recommended ○ when there is only **F** and **X** in the row.

Figure 4.3: Conditions for Classification

The results in Table 4.7, indicate that all the eight components are compulsory to be included in the Conceptual Design Model of AC4LV. It can be seen that all of them are commonly contained in the existing models. As most of the courseware shares the similar format, so it is compulsory to have the structural component to formulate the structure of AC4LV.

AC4LV is a type of educational content application that stresses on the information accessibility and navigationability. Hence, it is compulsory to include content composition component. Also, most of the existing models have their own specific design guidelines to cater their target learners. However, the design guidelines are merely close to content, which means content are designed based on the design guidelines. As the content of AC4LV has specific elements, this study decides to include it in the content composition component.

Besides, it is necessary to include instructional design as a generic component since AC4LV is also considered as a type of instructional aid. In this case, the developer may also refer to other (as discussed in Chapter 2) ID models as guidance while developing AC4LV. Additionally, learning theories and approaches are pedagogical aspects that must be referred to as the basis to tackle the low vision learners in learning. So, it is compulsory to include both of them in the proposed model.

Chapter 1 states that the main aim of this study is to propose a conceptual design model that acts as guidance for those who have interest in developing AC4LV. They can be technical or non-technical people. This includes novice or potential developers. The main important aspect in developing the AC4LV is the content design itself. Therefore, this study does not concern on the steps involved in the development process. As a result, the methodology to be used in developing AC4LV is up to the users' preference. However, they have to follow the proposed elements and design principles provided in content composition component. As a result, this study decides the development process as "recommended to apply". Accordingly,

Table 4.8 lists the proposed generic component of AC4LV. It is represented in an illustrative model in Figure 4.4.

Table 4.8: Proposed Generic Component of AC4LV

Generic component	AC4LV
Structural component	◙
Content composition	◙
Learning theories	◙
Learning approach	◙
Development process	○
ID Model	◙
Technology	◙

Description of symbols	
◙	Compulsory to apply
○	Recommended to apply

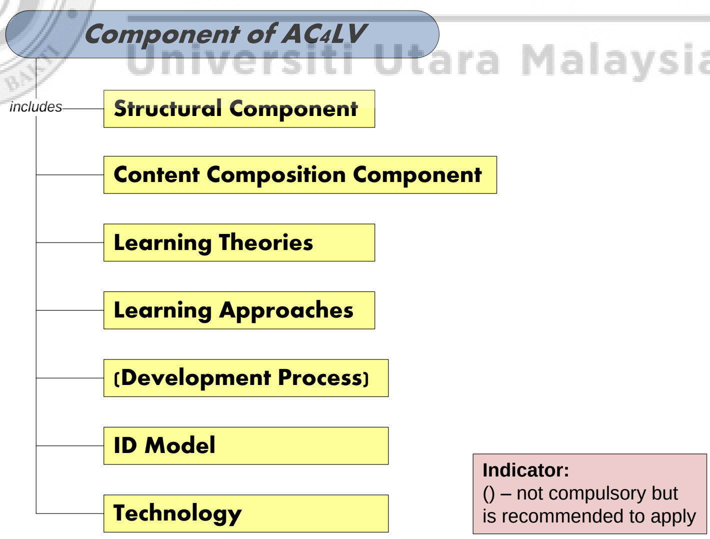


Figure 4.4: Proposed Model for Generic Component of AC4LV

4.2.1 Structural Component

To confirm the learners possibly achieve a highly effective learning, a courseware should be structured properly. This means starting from the opening until the ending of a courseware, it must be organized in a consistent and coherent manner (Efendioğlu, 2012). In short, the whole presentation of the content must make sense with the learners. In regards to that, based on the existing models, most of them suggest that structural component should have three segments. They are (i) opening segment that contains only information about the subject (not the actual subject content), (ii) content segment which contains the actual contents, and (iii) closing segment to indicate that the presentation is approaching to the end. These three segments are further detailed as outlined in Table 4.9.

Table 4.9: Details of Structural Components

Segment	Component	Details
Opening segment	Welcome	Simple welcoming speech.
	Title	Title of the course or subject.
	Verso	Meta-information of the course (i.e. publication year, synopsis).
	Development team	List of individuals or organizations that involve in making the courseware.
Content segment	Lesson objective	Objectives of the course that the learners will achieve after learning the lesson. It also can be learning outcome.
	Section separators	Separator between segments (i.e. unit, chapter).
Closing segment	Review lesson	As a sign of course end (i.e. revision, summary of course).
	Thanking remarks	The appreciation to the learner for learning with courseware.
	Acknowledgment	Provide acknowledgement to the content contributors.

In relation with AC4LV, the structural components of the existing models were compared and analyzed. Snapshots of the prototype and model illustration were highly useful to interpret the structural components. The findings are as tabulated in

Table 4.10 and Table 4.11. Meanwhile, they are summarized in Table 4.12 using the rules in Table 4.6.

Table 4.10: Structural Component of TC

Segment	Component	1	2	3	4	5	6	7	8	9	10	Total
Opening segment	Welcome						√	√				2
	Title		√		√		√					3
	Verso		√	√								2
	Development team		√									1
Content segment	Lesson objective	√	√	√		√	√	√				6
	Section separators	√	√	√	√	√	√	√		√		8
Closing segment	Review lesson							√			√	2
	Thanking remarks		√									1
	Acknowledgment		√									1

Note. 1-10 is referred to TC

Table 4.11: Structural Component of AC

Segment	Component	1	2	3	4	5	6	7	8	9	10	Total
Opening segment	Welcome					√			√			2
	Title					√			√			2
	Verso		√									1
	Development team								√			1
Content segment	Lesson objective		√			√					√	3
	Section separators	√	√			√		√	√	√	√	7
Closing segment	Review lesson					√						1
	Thanking remarks								√			1
	Acknowledgment								√			1

Note. 1-10 is referred to AC

Table 4.12: Summary of Structural Component in the Existing Models

Segment	Component	TC	AC
Opening segment	Welcome	F	F
	Title	F	F
	Verso	F	F
	Development team	F	F
Content segment	Lesson objective	M	F
	Section separators	M	M
Closing segment	Review lesson	F	F
	Thanking remarks	F	F
	Acknowledgment	F	F

Description of symbols			
A	All models apply	**F**	Few models apply
M	Majority of models apply	**X**	Not applied in any model

The structural components of AC4LV were derived from the summary in Table 4.12, and provided in Table 4.13 based on the same conditions as in the generic components (see Figure 4.3).

Table 4.13: AC4LV Structural Component based on Analyzed Models

Segment	Component	AC4LV
Opening segment	Welcome	○
	Title	○
	Verso	○
	Development team	○
Content segment	Lesson objective	◙
	Section separators	◙
Closing segment	Review lesson	○
	Thanking remarks	○
	Acknowledgment	○

Description of symbols	
◙	Compulsory to apply
○	Recommended to apply

Based on the analysis, this study decides to maintain all the structural components (as listed in Table 4.13) as they share similar format. However, the output of the comparative analysis alone is insufficient to determine the structural components of AC4LV as there are only two existing models attending to low vision learners. Thus, opinions from the teachers and low vision learners are important for this study since they have in-depth experience on this matter. In accordance, UCD approach (Figure

4.5) was utilized in acquiring suggestions from teachers and low vision learners to determine the structural component of AC4LV.

Figure 4.5: UCD Approach (Having Discussion with Teacher)

The structural components of AC4LV in Table 4.13 are reviewed for amendment to suit with the needs of low vision learners. In the discussion with them, it is much important to catch the learners' attention with simple welcoming speech in the opening segment. This is to ensure that the learners alert with the starting scene while the AC4LV plays to them. Therefore, welcome speech in the opening segment should be compulsory. Besides, they also recommend that the scene for development team is appropriate to move to closing segment. This is to avoid them from facing overload information before getting into the actual content. This agrees with reducing cognitive load by Andharini and Ari (2012) and Yang, Leung, Yue, and Deng (2013) especially for low vision learners. This explains that the AC has to utilize more audio to catch the information appears on the screen.

In addition, comments from teachers also suggest that review lesson is compulsory for AC4LV as low vision learners are slow in grasping knowledge through visual.

So, by providing a summary of the lesson, this could enhance their understanding of the subject as well as ensuring that the learning outcome is achieved. Also, thanking remarks is as important as the welcoming speech, to indicate that the AC4LV is approaching the end of the course. However, the existing models do not suggest it as compulsory. Hence, having considered the recommendations by the low vision learners and the teachers, the components in Table 4.13 is revised into a list with more compulsory items in Table 4.14.

Table 4.14: Proposed Structural Component of AC4LV

Segment	Component	AC4LV
Opening segment	Welcome	◙
	Title	◙
	Verso	○
Content segment	Lesson objective	◙
	Section separators	◙
Closing segment	Review lesson	◙
	Thanking remarks	◙
	Development team	○
	Acknowledgment	○

Description of symbols	
◙	Compulsory to apply
○	Recommended to apply

From the proposed components in Table 4.14, the model of AC4LV structure could be obtained and illustrated in Figure 4.6.

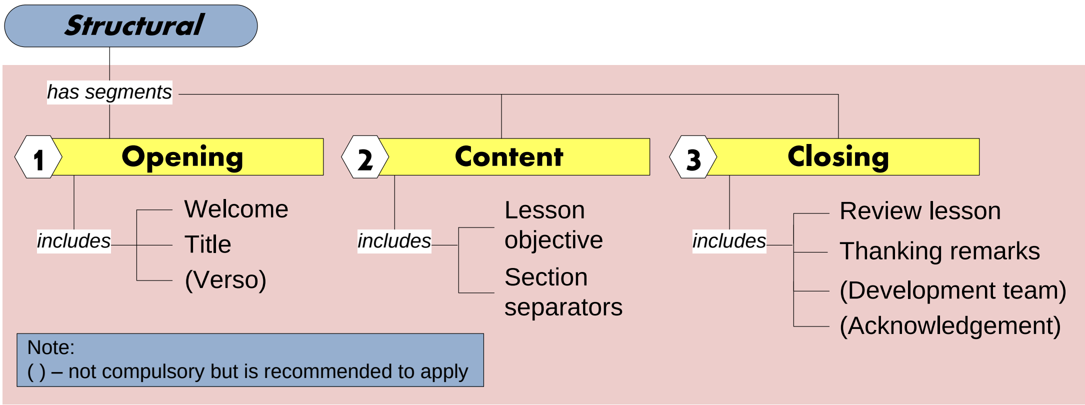


Figure 4.6: Proposed Model for Structural Components of AC4LV

4.2.2 Content Composition Component

Composing content for AC4LV needs sufficient efforts since this study focuses on fulfilling the needs of low vision learners. With that, the content must be directed to information accessibility, navigationability, and pleasurability as discussed in Chapter 1. Similar with determining the structural components, this study made use of 20 existing models as the basis to determine the content composition component of AC4LV.

Pedagogical issues as well as learning theories and approaches as discussed in Chapter 2 also influence the process of constructing the content composition. Generally, the components are divided into two main categories which are (i) pedagogical approach and (ii) human entities. In developing a quality courseware, both of these categories are considered necessary. This means a courseware should have pedagogical strategy similar to teachers (Efendioğlu, 2012). In ensuring the quality, this study believes that human entities play an important role to express the pedagogical aspects in the courseware. In view of that, learning theories, learning approaches, and literatures on courseware component as discussed in Chapter 2 act as the basis to put across the pedagogical aspects in content delivery.

4.2.2.1 Pedagogical Approach

Based on the existing models, this study divides the pedagogical approach into five sub-categories; (a) multimedia elements, (b) presentation styles, (c) teaching and learning techniques, (d) content delivery strategies, and (e) conduction styles. The idea to propose these five sub-categories is influenced by a comparative analysis, findings, and suggestions from previous studies, which is also inline with the learning theories and approaches as discussed in Chapter 2.

i) **Multimedia elements:** The selection of multimedia elements as one of the pedagogic component is inspired by the principles of multimedia learning theory (Mayer, 2003) and MI theory (Gardner & Hatch, 1989). Most of the existing models categorize it into audio, visual, and interface layout. Visual is defined as any information that is visible on the screen. This includes real objects, images, texts, graphics, animations, and video. Audio and visual can be utilized in a single mode or combination of more than one modes. However, the use of them must be well-organized to confirm the learning objective could be achieved. This also includes the design of interface layout.

ii) **Presentation styles:** Besides multimedia elements, pedagogical aspect also really emphasizes on presentations styles. This is to ensure the knowledge is successfully delivered to the learners. Usually, presentation styles have relationship with human entities, which refers to the way the instructor delivers knowledge and information. Creative presentation styles could attract the learners to stay focus on the lessons. However, presentation styles must be tailored to user needs and level of learners. Most of the existing models classify lecturing, instruction-based, and demonstration as the categories of presentation styles. The selection of them is also influenced by constructivism theory.

iii) **Teaching and learning technique:** Through courseware, many teaching and learning techniques are able to be applied including storytelling, simulations, game-based learning, blended learning, auditory explanation, tutorial/exercise/activity-based, and RLM. All these techniques are gathered from the existing models and most of them are applied based on the learning styles as well as fulfilling the needs of the target user.

iv) **Content delivery strategies:** Formally, any learning activity should start with briefing, followed by objective, then actual content, and ending with closing segment. This is also applied in most of the existing models. Accordingly, this study adopts these delivery strategies as they share similar format.

v) **Conduction styles:** Conduction style refers to the flow of the courseware is presented. It is divided into separated scenes and non-separated scenes. From the analysis, majority of the existing models that apply separated style also include navigational buttons to facilitate the users in navigating the courseware. Besides, transitions are required when the contents are separated based on topics.

4.2.2.2 Human Entities

Human entities are categorized into actor and interaction.

i) **Actor:** Actor refers to people who act with the courseware. It includes instructor and learners. Instructor can either be seen instructor, unseen instructor, or characters. They are people who teach, give instructions, motivate, or entertain the learners in using the courseware. Seen instructor means they are able to be seen on the screen either in the form of real images, or graphics and animations. In contrast, unseen instructor means only their voice appears in the courseware. Characters also use peoples' voice but usually they are not created as human (i.e. superhero, puppet, or cartoon). Meanwhile, learner refers to the actual users of the courseware, who are not acting in the courseware.

ii) **Interaction:** The way the learners' response through the courseware is called interaction. It is divided into self-interaction and social interaction. Self-interaction means the interaction between the learners with the courseware such as clicking the navigational buttons to move to the next topic or inserting text through keyboard in doing the exercise. On a contrary, social interaction refers to interaction between learners with the environment such as peers, teachers, parents, group of community practice, and tools around them while using the courseware. It includes sharing their feelings, motivation, discussions, or asking questions. These also are among discussions in many learning approaches including PBL, active learning, and self-paced learning.

On top of the discussions in the previous paragraphs, Table 4.15 provides further detailed explanation on the content composition component in the context of this study.

Table 4.15: Details on Content Composition Component

Components			Details
Pedagogical approach	Multimedia elements	Audio	All audio effects (i.e. animal sound, sound effects, dialogue, narration, explanation, and question).
		Visual:	Information that can be seen on the screen.
		• Real objects	Representing real object with real photo (i.e. fish, plant).
		• Images	The depictions of two or three dimensional pictures that have similar appearance to real subjects (i.e. waterfall view).
		• Texts	Texts (i.e. titles, labels).
		• Graphics	Must be composed with special characteristics to make it useful to the target learners.
		• Animations	Suitable to explain complex concepts.
		• Video	A recording of moving visual image.
		Interface layout	The design and arrangement of visual elements appear on the screen.
	Presentation styles	Lecturing	Instructor talks to the learners. It can be teacher's voice or sometimes run with the help of funny characters to attract users' attention especially children.
		Instruction-based	In the form of command-base. Usually contained in practical-based contents (i.e. exercise, activity, quiz, mini-test).
		Demonstration	Display the process or steps to increase the user understanding. Usually contained in RLM (i.e. demonstration on how to make VCD) .
	Teaching and learning technique	Storytelling	Conveying the course in the form of narration with words and images or graphics.
		Simulations	The imitations of the operations that occur in real-world process or system. It benefits to train by experience on how the information should be used in real life (i.e. training at the hospital).
		Game-based learning	Learning through games that have specific learning outcomes.
		Blended learning	Combine multiple types of learning environments.
		Auditory explanation	The use of audio to explain everything that appear on the screen (i.e. the use of teachers' voice to explain complex concepts).
		Tutorial/Exercise/Act	Contains questions and answers to enhance students' understanding. Also can be in

		ivity-based	the form of games and instruction-based.
		RLM	Unplanned learning concept but has certain specific learning outcomes. Occur in spontaneous environment. Ensuring learning activities fun and entertaining. (i.e. learning through reality TV concept).
	Content delivery strategies	Briefing	Overview of the learning content.
		Objectives of the course	The expected outcomes that the learning would achieve from the course.
		Content	The main part where the actual contents are delivered.
		Closing	The ending part of the course (i.e. summary of the course content).
	Conduction style	Separated	The separators between each of the segment (i.e. unit, topics, chapter).
		Non-separated	Conveying the course continuously from start to finish with no transition (i.e. demonstration, storytelling).
		Navigational buttons	Provides button for users to navigate the courseware.
		Transitions	Required in displaying the scene.
Human entities	Actor	Instructor	People or only the voice who act in the courseware.
		• Seen instructor	Actor who teach the learner. This actor appears on the screen.
		• Unseen instructor	Actor who only speaks, no appearance on the screen.
		• Character	Actor in the form of a character, to attract learners' attention. Sometimes, also acts as instructor (i.e. superhero, puppet, and cartoon).
		Learner	People who learn through the courseware.
	Interaction	Self-interaction	The interaction of user with the courseware.
		Social interaction	The interaction of user with the environment and (i.e. time, place, and tools) peers or the group of community practice.

Having described the terminologies, results of the comparative analysis are detailed in Table 4.16 and Table 4.17.

Table 4.16: Comparative Analysis on Content Composition Component for TC

Components			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Pedagogical approach	Multimedia elements	Audio	√	√	√		√	√	√	√	√	√	9
		Visual:											
		• Real Objects		√									1
		• Images		√	√					√	√		4
		• Texts	√	√	√	√		√	√	√		√	8
		• Graphics	√	√		√		√		√		√	6
		• Animations	√		√		√	√	√		√		6
		• Video			√				√	√			3
		Interface layout			√	√		√	√		√		5
	Presentation styles	Lecturing						√		√			2
		Instruction-based			√						√	√	3
		Demonstration		√			√						2
	Teaching and learning technique	Storytelling	√										1
		Simulations	√				√	√	√				4
		Game-based learning			√		√	√				√	4
		Blended learning						√					1
		Auditory explanation			√				√		√		3
		Tutorial/Exercise/ Activity-based	√		√	√	√	√	√	√	√	√	9
		RLM		√									
	Content delivery strategies	Briefing		√	√		√						3
		Objectives of the course	√	√	√		√	√	√				6
		Content	√	√	√	√	√	√	√	√	√	√	10
		Closing		√									1
	Conduction style	Separated	√	√	√		√	√	√		√	√	8
		Non-separated				√				√			2
		Navigational button	√		√			√	√				4
		Transitions		√	√	√		√					4
Human entities	Actor	Instructor:											
		• Seen instructor		√				√	√				3
		• Unseen instructor	√		√								2
		• Characters	√										1
		Learner	√	√	√	√	√	√	√	√	√	√	10
	Interaction	Self-interaction	√	√	√	√	√	√	√	√	√	√	10
		Social interaction		√					√	√		√	4

Note. 1-10 is referred to TC

Table 4.17: Comparative Analysis on Content Composition Component for AC

Components			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Pedagogical approach	Multimedia elements	Audio	√	√	√	√	√	√		√	√	√	9
		Visual:											
		• Real Objects											0
		• Images	√										1
		• Texts	√	√		√	√	√	√	√		√	8
		• Graphics		√	√		√	√	√	√	√	√	8
		• Animations		√			√	√	√	√	√		6
		• Video	√						√				2
		Interface layout			√		√	√				√	4
	Presentation styles	Lecturing								√		√	2
		Instruction-based	√		√		√	√	√		√		6
		Demonstration	√	√				√	√				4
	Teaching and learning technique	Storytelling	√								√	√	3
		Simulations											0
		Game-based learning	√	√									2
		Blended learning											0
		Auditory explanation	√			√				√			2
		Tutorial/Exercise/ Activity-based	√	√	√		√	√	√		√		7
		RLM											0
	Content delivery strategies	Briefing								√			1
		Objectives of the course		√								√	2
		Content	√	√	√	√	√	√	√	√	√	√	10
		Closing					√						1
	Conduction style	Separated	√	√			√		√	√	√		6
		Non-separated											0
		Navigational button	√	√	√	√	√	√	√		√		8
		Transitions	√		√								2
Human entities	Actor	Instructor											
		• Seen instructor	√						√				2
		• Unseen instructor		√	√								2
		• Characters	√				√	√		√	√	√	6
		Learner	√	√	√	√	√	√	√	√	√	√	10
	Interaction	Self-interaction	√	√	√	√	√	√	√	√	√	√	10
		Social interaction			√					√	√		3

Note. 1-10 is referred to AC

It is very hard to illustrate the model without tabling all the gathered data. As a result, Table 4.18 summarizes the analysis of content composition component and provided in Table 4.19, based on the same rules as in classifying the structural components (see Table 4.6).

Table 4.18: Summary of Content Composition Component from Existing Models

Components			TC	AC
Pedagogical approach	Multimedia elements	Audio	A	A
		Visual:		
		• Real Objects	F	X
		• Images	M	X
		• Texts	M	M
		• Graphics	M	M
		• Animations	M	M
		• Video	F	F
		Interface layout	M	M
	Presentation styles	Lecturing	F	F
		Instruction-based	F	M
		Demonstration	F	M
	Teaching and learning technique	Storytelling	F	F
		Simulations	M	X
		Game-based learning	M	X
		Blended learning	F	X
		Auditory explanation	F	F
		Tutorial/Exercise/Activity-based	M	M
		RLM	F	X
	Content delivery strategies	Briefing	F	F
		Objectives of the course	M	F
		Content	A	A
		Closing	F	F
	Conduction style	Separated	M	M
		Non-separated	F	F
		Navigational button	M	M
		Transitions	M	F
Human entities	Actor	Instructor		
		• Seen instructor	F	F
		• Unseen instructor	F	F
		• Characters	F	M
		Learner	M	M
	Interaction	Self-interaction	M	M
		Social interaction	M	F

Description of symbols			
A	All models apply	F	Few models apply
M	Majority of models apply	X	Not applied in any model

Table 4.19: AC4LV Content Composition Component based on Analyzed Models

Components			AC4LV
Pedagogical approach	Multimedia elements	Audio	◙
		Visual:	
		• Real Objects	○
		• Images	○
		• Texts	◙
		• Graphics	◙
		• Animations	◙
		• Video	○
		Interface layout	◙
	Presentation styles	Lecturing	○
		Instruction-based	◙
		Demonstration	◙
	Teaching and learning technique	Storytelling	○
		Simulations	○
		Game-based learning	○
		Blended learning	○
		Auditory explanation	○
		Tutorial/Exercise/Activity-based	◙
		RLM	○
	Content delivery strategies	Briefing	○
		Objectives of the course	◙
		Content	◙
		Closing	○
	Conduction style	Separated	◙
		Non-separated	○
		Navigational button	◙
		Transitions	◙
Human entities	Actor	Instructor	
		• Seen instructor	○
		• Unseen instructor	○
		• Characters	○
		Learner	◙
	Interaction	Self-interaction	◙
		Social interaction	◙

Description of symbols			
◙	Compulsory to apply	○	Recommended to apply

As discussed in Chapter 1, AC4LV is specifically designed for low vision learners. Referring to comparative analysis, only two existing models cater the VI learners as their main users. This means, the result exhibited in Table 4.19 alone is insufficient to construct the content composition component of AC4LV. Again, UCD approach involved in this part, to obtain comments from teachers and actual users. Their suggestions are highly important. On top of that, the literatures on the ability of VI learners, component of courseware, design guidelines for children, information accessibility, and learning theories and approaches as discussed in Chapter 2 have strong influence on the formation of these components in AC4LV. Thus, Table 4.20 provides the proposed AC4LV content composition components after discussion with the teachers and actual users.

Table 4.20: Proposed Content Composition Components of AC4LV

Components			**AC4LV**
Pedagogical approach	AC4LV elements	Audio	◙
		Visual	
		• Texts	◙
		• Graphics	◙
		• Animations	○
		Interface layout	◙
	Presentation styles	Lecturing	○
		Instruction-based	◙
		Demonstration	◙
	Teaching and learning technique	Storytelling	○
		Simulations	○
		Game-based learning	○
		Blended learning	○
		Auditory explanation	◙
		Tutorial/Exercise/Activity-based	◙
		RLM	○
	Content delivery strategies	Briefing/Welcome	◙
		Objectives of the course	◙
		Assistive content	◙
		• Information Accessibility	◙
		• Navigationability	◙
		• Pleasurability	◙
		Closing	◙
	Conduction style	Separated	◙
		Non-separated	○
		Navigational button	◙
Human entities	Actor	Instructor	
		• Seen instructor	○
		• Unseen instructor	◙
		• Character	○
		Learner	◙
	Interaction	Self-interaction	◙
		Social interaction	◙

4.2.2.3 Justification on Content Composition Components of AC4LV

As low vision learners has restrictions in visualization, this study consider that real objects, images, and video is not recommended to apply in AC4LV. It is because these three elements visualize living things, which is very hard for the low vision learners to recognize. So, this requires more complex works from the developer to make it accessible by the low vision learners. Additionally, this study considers the non-technical skill people but have interest in developing AC4LV such as teachers and parents. Besides, children prefer to learn via graphics and animations (cartoon) compared to real pictures (Rahmah et al., 2012). Based on the above arguments, this study decides to focus on accessibility of graphics and animations rather than real objects, images, and video.

According to the preliminary study (Chapter 1), the acceptance of low vision learners on animation is not similar to sighted learners eventhough majority of the existing models prove that animation is compulsory to be applied in the courseware. However, for low vision learners, animations (2D or 3D) means nothing if that elements do not cater to their needs. For that reason, this study decides to recommend animations to be applied in AC4LV (not to make it compulsory) by referring to multimedia learning theory as the basis.

Every person has different learning styles especially for the disabled. As discussed in Chapter 1, low vision learners prefer to learn audibly. Preliminary study also indicates that VI learners depend 100% on audio to recognize everything that appears on the screen. In fact, by using auditory explanations, synchronized with visual scene, it improves the learners' perceptions and learning levels manner (Efendioğlu, 2012). As a result, this study decides that auditory explanation is compulsory as one of the teaching and learning techniques in AC4LV although existing models only recommend it.

In accordance, instructor must be provided either as a seen instructor or an unseen instructor. But for AC4LV, it prefers to employ an unseen instructor to avoid the low vision learners from facing crowded screen, which then make them feel difficult for them to recognize the desired information. Hence, this study considers unseen instructor as compulsory.

The most important part in AC4LV is content. Based on discussions with the teachers and low vision learners, the contents are reviewed for extension to make it much closer to the needs of low vision learners. This is referred to as assistive. Empirical evidences from the preliminary studies indicate that information accessibility, navigationability, and pleasurability must be designed as part of the content. However the existing models do not include them.

Based on these arguments, Table 4.20 lists the extended content composition components of AC4LV to include the assistive content which consists of information accessibility, navigationability, and pleasurability as its breakdowns. Besides, it is important for this study to have comments from the expert in Instructional Design regarding the initial concept of content composition component prior to extend the proposed model. So, the components listed in Table 4.20 were represented as the model for content composition (see Figure 4.7) and has been reviewed with an expert in Instructional Design Model Development. The expert is an Associate Professor at the University of Hong Kong; Associate Prof. Dr. Daniel Churchill. His comments are:

"*This work sounds interesting. I am not sure exactly how you are catering for low vision learners and what kind of technology you are embedding in your model. I think you have worked out something in your mind. I can say that utility of special design features might be useful. You mentioned assistive features but not much of elaboration about these in the diagram".*

(Churchill, 2013)

As given to the expert is not the complete model, so this interprets that the initial concept for the content composition model is well-understood. However, the Conceptual Design Model of AC4LV has to stress on the special needs features for low vision learners because the model for content composition only includes the main content component without emphasizing on the special needs features for low vision learners. This also interprets that the comments are inline with the first objective of this study, which is to determine the elements of Conceptual Design Model of AC4LV. By considering that comments, the conceptual design model for content composition component then extend the design by having special features for low vision learners which is called as elements and design principles of AC4LV. This also indicates that the AC4LV elements have certain implications over the assistive content. The discussions of them are provided in the next subsection.

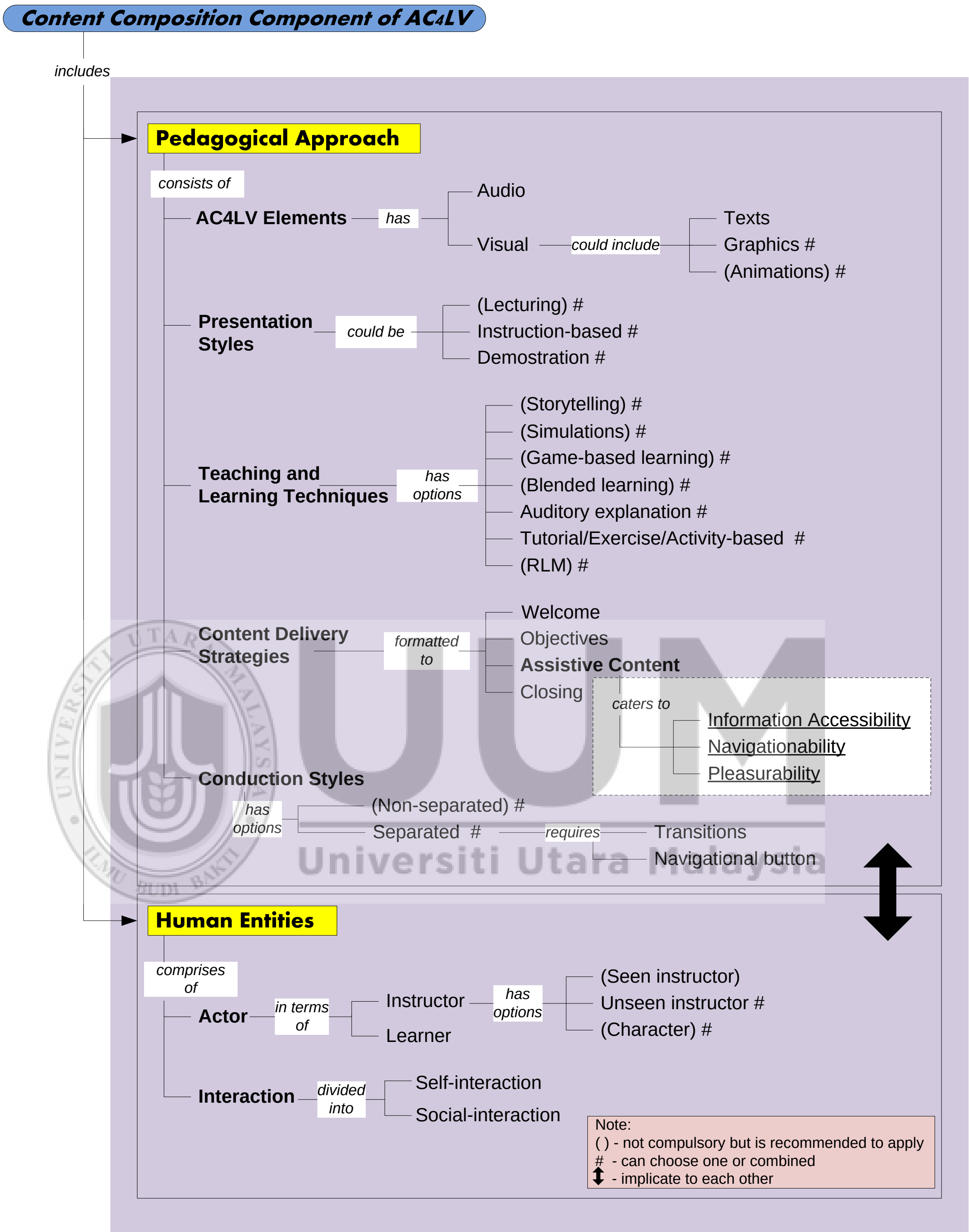


Figure 4.7: Proposed Model of Content Composition Component of AC4LV

4.2.3 Elements and Design Principles of AC4LV

The elements of AC4LV have implications over the content. Each of the provided elements is driven by certain design principles and each of the design principle has its own justification. They are constructed based on accessibility guidelines, design guidelines for children, multimedia learning theory, and reviews of literatures from previous studies as discussed in Chapter 2. It also involves expert consultation through UCD approach. Their comments are inline with early discussion on information accessibility, navigationability, and pleasurability as discussed in Chapters 1 and 2. This is important to ensure that the proposed elements are closely touching to the needs of low vision learners before developing the conceptual design model. However, not all of the proposed design principles are compulsory to apply; some of them are recommended which stated in the bracket. The proposed elements of AC4LV together with the design principles and justification are provided in Table 4.21, in which each of them has its own connection with other components of pedagogical approach and human entities.

Table 4.21: Proposed Elements and Design Principles of AC4LV

Elements	Design principles	Justification
Audio	Provide auditory explanation	Low vision learners and other types of VI depend 100% on audio to explain everything that appear on screen (Sodnik, Jakus, & Tomažič, 2011). Without auditory explanation, the visual aspect means nothing to them. It is difficult for them to recognize information presented merely in visual form. However, it must be well-organized because not all information has to provide audio.
	Provide clear pronunciation	The audio should be clear to the user. This means that the desired information must be pronounced clearly word by word especially for the instruction part (i.e. activity or exercise).
	Omit the background music	Even VI learners depend 100% on audio, but the use of background music blending with auditory explanation in actual fact make them confused. They have to think deeply

		to distinguish between background music and the actual information. So, the best solution is omit the background music.
	Use friendly voice intonation	Children including low vision learners learn better when contents, instructions, or demonstrations are spoken by a friendly human voice or teachers' voice rather than a machine voice. This is inline with voice principle (Multimedia Learning Theory) and also agreed with Efendioğlu (2012). This also avoids them from feeling bored and demotivated in learning.
	Supply sound effects	Low vision learners have restriction in visualization, which means they are less sensitive on anything displayed on screen. So, it is important to enhance their alert by supplying sound effect especially for user interaction.
	Avoid using sudden loud sounds	Low vision learners are sensitive with sounds. Disturb them with sudden loud sound possibly make them shocked and confused on what happens on screen. As an example, automatic background sound is startling and unexpected. In some cases users' speakers were not set at appropriate volume. If possible, audio should start low and increasing gradually.
	(Use multiple types of voice over)	As suggested by the teachers, multiple types of voice over could assist the low vision learners to enhance their understanding in explaining the complex concepts.
Formatting Texts and Styles	Use sans-serif font face	Low vision learners face difficulties to read if otherwise. Difficulties means they have to put high efforts in reading serif font faces, which then lead them to getting tired (their eyes) and finally give up with the lesson. Therefore, avoid using serif font faces.
	Use the biggest font size	Low vision learners face difficulties to read small font size. They have to struggle and normally get eye strain after some reading. This will put them in frustrated condition. Therefore, the preferences font size is at least 18 point.
	Create good contrast color between foreground and background	Low vision learners are different than normal people in color perception. It is very tough for them to differentiate combination of less contrasted colors. Therefore, font color and background color must be highly contrasted. As example, they are unable to distinguish between blue and red because the color is less contrast for them. Combination of black and white is an example of good pair of them.
	Use only regular and bold typeface	Avoid using italic, irregular, fancy, or any decorative typeface because the low vision learners normally spend extra time and effort trying to figure out the characters. So, regular and bold typeface is a perfect choice. In addition, the fonts must be highlighted or outlined to catch the attention of users.
	Place text only on solid background	Avoid placing text on any background image either it is animate or static. The low vision learners are unable to grasp the information presented on it. This is also usually taking them into an unmotivated condition.
	Use simple and conventional style text	Low vision learners learn better when the words are presented in conventional style rather than formal style. This is aligned with personalization principle in Multimedia Learning Theory.
	Use single font	Using multiple font styles especially on one screen may

	styles	overload their mind. Single font style is adequate.
	Avoid using superfluous text	Do not add extra, redundant, unnecessary, or too much text especially on one screen. This is complicated for them to classify the desired information.
	Avoid creating text only version	Text only version requires low vision learners to concentrate on reading. This is a struggling task for them in learning. So, avoid creating text-only version so that they feel released in learning. In fact, multimedia principle (Multimedia Learning Theory) also suggests that students learn better from words and graphics rather than words alone.
	Use text concisely	Display only concise text. If need a long description, provide it in auditory explanation. This avoids them from quickly feel tired and bored in learning.
	Use understandable terms	AC4LV is designed for low vision children. Using technical terms either to be displayed or in audio form may cause them incomprehensible and blur. So, avoid using terms that they are not familiar with.
	Avoid using rollover text	The level of sensitivity among low vision learners in visual form is not similar with normal users. It is difficult for them to distinguish between desired information with rollover text. So, it is better to avoid using rollover text to convey information.
	Avoid using animated text	Animated text should be avoided. It may cause the users confused and feel difficult to grasp the information especially if the animated text moves too fast.
Graphics	Provide clear graphics	The graphics must be clear enough in terms of shape and combination of colors. Use only two or maximum three colors for one attribute. It is recommended to outline the shapes of graphics with contrast colors.
	Provide biggest size of graphics	The low vision learners attend to the biggest element first followed with the smaller ones. So, the most important information should be made the biggest.
	Provide good contrast color between graphics and background	Combination of attributes and background must be highly contrasted. Low vision learners are unable to compare the combination of colors that look almost similar such as red and orange or green and blue. Black is a good example for background while white and yellow is for the attributes.
	Use meaningful graphics	Provides only meaningful graphics. Avoid adding extra unusable graphics as screen decorative element. It means nothing for low vision learners. Additionally, it also looks crowded for them.
	Minimize the use of graphics	Low vision learners are unable to absorb information like normal people. Too much graphics on one screen are crowded for them. Normally, they pay attention to information they intend to. So, three attributes of graphics on one screen is the maximum for them.
Animations	Follow the same rules of graphics and texts	Use animations for graphics and texts when only necessary.
	Provide animated character as attraction	Children like animated characters such as puppet and cartoon because the use of them can enhance their learning motivation. This also has been proven by previous studies. However, it must be well-organized as suggested in imaging principle (Multimedia Learning Theory).
	Only animate the	Do not animate every information at the same time. It is

	desired information	difficult for low vision learners to focus on the desired information.
	Avoid too much animation	Only animate when it is necessary. Avoid animating the graphics for all the time.
	Avoid fast animation	Provide slow movement of animation. So, the low vision learners have time to capture the information.
Transitions	Create texts and graphics transition from one direction.	Avoid texts and graphics transition from multiple directions. It is important since the low vision learners are able to focus on a single direction at a time.
	Avoid fast movement of transition	As low vision learners have problem to capture fast animated information, so they also face the similar problems with transition. So, provide slow movement of transition would give time for them to capture the information transit on the screen.
Navigational button	Design button to look clickable	For low vision learners, buttons must be designed to look clickable so they are able to recognize the buttons. This includes in terms of shape and the usage of colors, even though the button function through the keyboard.
	Minimize the number of button	Provide button only when it is required.
	Avoid using blinking button	Blinking button will disturb the users' focus. It is not appropriate for low vision learners.
	Avoid using image as button	Low vision learners have less ability to differentiate between images and button. So, avoid utilizing image-based button.
	Avoid using text only as button	It is complicated for low vision learners to differentiate between button and desired information if the text is also created as button. So, combination of shape and text is appropriate for them.
	Use hybrid and linear navigational style	Hybrid and linear navigational style is important to support navigation among modules and next-to-next task sequence within modules. In AC4LV, both types of navigational style should be supported with audio explanation. This could assits the low vision learners to know where there are and where to go.
Interface layout	Divide the screen area logically	Clear and consistent screen area is important for users to navigate in the application. Logically for AC4LV it should be divided into menu area and content area.
	Minimize the number of screen area.	The best number of screen area for low vision learners is two or maximum three main sections.
	Place texts under the graphics	For low vision learners, placing text under the graphics is more effective compared to placing text within the graphics. This contrasts the spatial contiguity principle (Multimedia Learning Theory) because low vision learners are incapable to discern texts that are placed close with the graphics.
	Place menu area on the left side	It is highly recommended to place the menu area on the left side of the screen area. It is because, if the AC4LV is played on the large monitor screen and the menu area is placed at the top, it is very uncomfortable for the learners to access it. Also, if the menu area is place at the bottom this will disturb the content part. Meanwhile, center and right side is suitable for content area.
	Design for full screen presentation	The overall design of AC4LV must cover full screen presentation. It is not recommended for the designers to

		design other than this as it will cause more difficulties for low vision learners to concentrate on learning.
	Design for a single screen	It is highly recommended for the designers to place the desired information for not more than one screen. This is easier for low vision learners to learn from the screen.
	Having simplicity and consistency	The good interface layout for AC4LV should be simple and consistent from start to end. Having simplicity and consistency will keep users stay focus on the learning activities. This is the way the courseware becomes user friendly with the user.
	Avoid unnecessary decorative elements	Decorative elements do not make sense to low vision learners. So, avoiding it is the best decision.
	Avoid scrolling screen	Scrolling screen is inappropriate for AC. It requires more works from the disabled users to get the information.
General interaction	Provide explicit instructions	Even though instruction is provided in auditory form, they have to be simple and explicit, not in long sentences. In addition, the intonation to pronounce the instructions must be well-controlled to make it not too fast or not too slow. This is important for low vision learners to perform their task correctly after getting the instructions.
	Provide repeatable function	Repeatable functions must be provided, which allow the low vision learners to repeat the instruction or the lesson. This is to avoid them misunderstand the instructions or the lesson.
	Provide close function	Most of the low vision learners especially children have lack of knowledge on technical function, so providing suitable close function displayed on the screen eases for them to exit the AC4LV.
	Provide previous and next function	With the restrictions in visualization the low vision learners face difficulties in grasping the presented content, so providing "previous" and "next" functions is important to help them revise the learning content when necessary.
	Keyboard-based interaction	Previous studies indicate that most of the VI learners require 100% keyboard-based interaction. For that reason, most of them are not able to utilize mouse to interact with the courseware. It is difficult for them to point the cursor to the desired information especially for the severe low vision. So, keyboard-based interaction is necessary.
	(Mouse-based interaction as optional)	Creating mouse-based interaction is optional. It is designed for low vision learners that able to interact with courseware using mouse. Usually they are in moderate category. However, they still require biggest cursor to point and navigate the courseware.

Having detailed the elements in Table 4.21, Figure 4.8 exhibits the relationship among the elements with information accessibility, navigationability, and pleasurability.

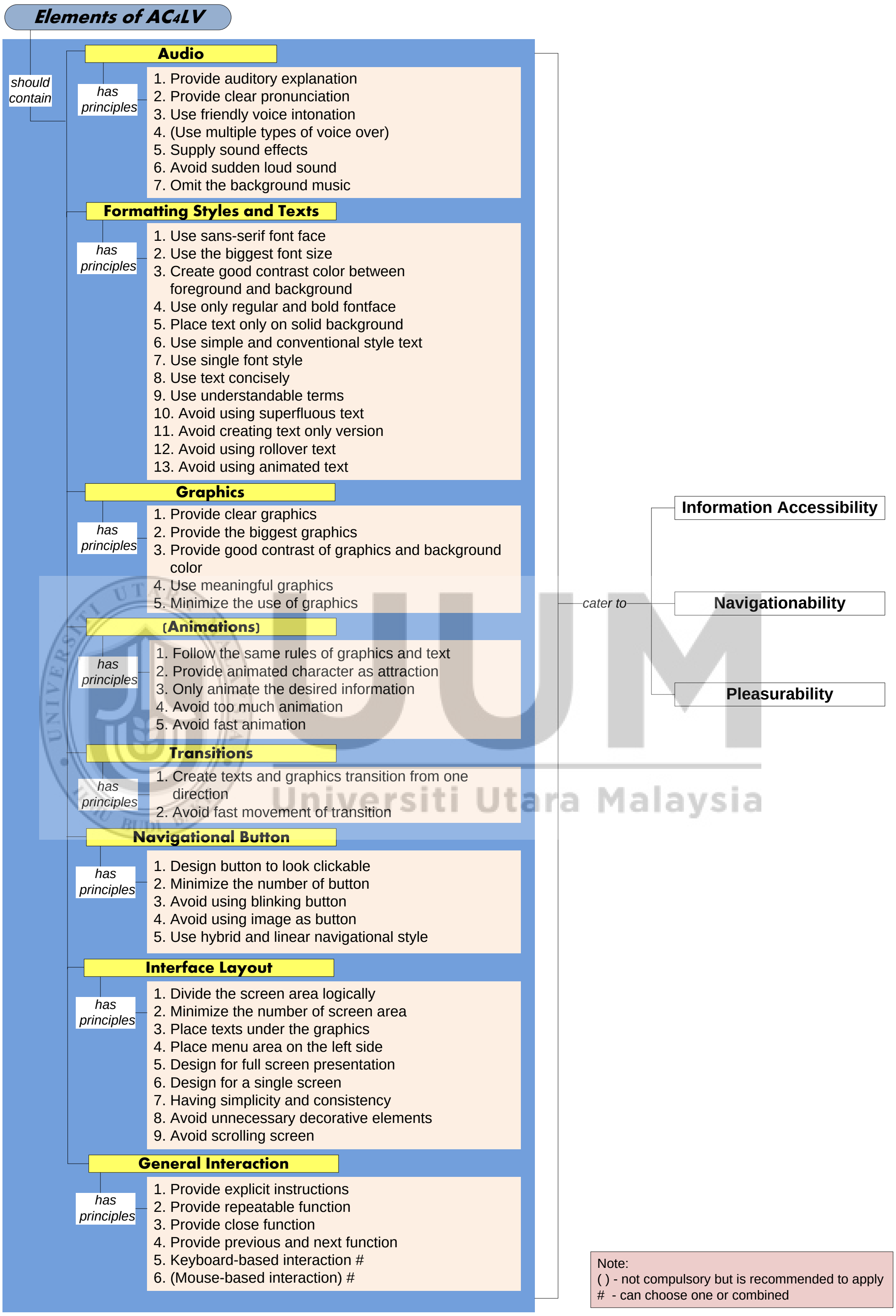


Figure 4.8: Proposed Elements of AC4LV with Design Principles

4.2.4 Explanation on Content Composition Component of AC4LV

This paragraph and the subsequence ones explain the diagram in Figure 4.7. As discussed before, content composition component of AC4LV is divided into pedagogical approach and human entities, which is similar to other existing model as they share similar format. However, the inner part of pedagogical approach and human entities differentiate AC4LV from the existing models. They are designed to cater the needs of low vision learners in learning, which involves information accessibility, navigationability, and pleasurability. Further, the following paragraphs explain them.

4.2.4.1 Pedagogical approach

Pedagogical approach of AC4LV is broken down into AC4LV elements, presentation styles, teaching and learning techniques, content delivery strategies, and conduction styles. There are approaches to tackle when preparing the learning content to suit with the learning needs of low vision learners. In fact, they are constructed based on learning theories and approaches which are discussed in detail in Chapter 5.

i) **AC4LV elements:** AC4LV elements are broken down into audio, formatting styles and texts, graphics, animations, transitions, navigational button, interface layout, and general interaction. In designing AC4LV, audio is compulsory. This is inline with teaching and learning techniques applied in AC4LV, which is auditory explanation. Eventhough low vision learners highly depend on audio, it is also suggested that visual elements are used. In visual, animations are highly recommended to use. However, it has to suit the course context. Other elements which are texts and graphics are compulsory. It is highly recommended that texts and graphics either static or animated are used together on a screen as suggested by principle of multimedia learning theory. This is supported by other design guidelines which also recommend to avoid texts-only version. However, it is not necessary that all these three visual elements are utilized in one AC4LV. Besides, interface layout is highly important in designing the AC4LV. This study found that most of the listed design principles in Table 4.21 are compulsory to apply in making AC4LV accessible, navigable, and pleasurable to low vision learners. Meanwhile, element of transitions and navigational button are correlated with conduction styles, and general interaction have connotation to human entities. So, they are appropriate to discuss next.

ii) Presentation styles: Content of AC4LV can be presented in three styles: lecturing, instruction-based, and demonstration. The types of instructor in AC4LV have implication over the presentation styles. It was found that at least unseen instructor is compulsory to be applied. In AC4LV, lecturing is highly recommended to use, where the instructor speaks to the learner. However, the instructor's image is not recommended. But it was found that the use of characters is highly recommended as AC4LV is designed for low vision children. It is suggested that the characters should use teachers' voice or friendly human voice to convey the information as well as enhancing learners' motivation. Unseen instructor is applicable to be used for instruction-based and demonstration. In the AC4LV, instruction-based and demonstration are applied in “activity” part. Both of them are compulsory to ensure the low vision learners are able to perform the provided tasks. Also, the AC4LV allows them to repeat the instructions and demonstration if they are unable to grasp for the first time.

iii) **Teaching and learning techniques:** It is recommended that teaching and learning techniques are appropriate to be applied in AC4LV. It can be in the form of storytelling, simulations, gamed-based learning, blended learning, or RLM. However, the use of them must be well-researched since they have their own characteristics to suit with low vision characteristics. In this study, activity and auditory explanation are compulsory. The used of activity are inline with suggestions by a number of learning approaches such as mastery learning approach, PBL, and active learning. Also, auditory explanation cannot be avoided when it comes to VI learning context.

iv) **Content delivery strategies:** AC4LV follows the similar strategies as applied in classroom teaching. It starts with welcoming speech, followed by the objective of the topic, the actual content, and finally the closing. The actual content of AC4LV is designed to be assistive, which means it contains characteristics that could assist the low vision learners in learning through courseware.

In AC4LV, content are delivered in the form of audio, texts, graphics, and animations. They are designed by following the design principles as justified in Table 4.21. Although the main elements of AC4LV look similar with those in the existing courseware, but the design principles underlying the main elements make the AC4LV different from other courseware. The assistive content means the content is accessible by low vision learners; they make the AC4LV easy to use by the learners and the learners' pleasure while using the AC4LV. This assistive content can only be achieved through the proposed elements. It is supported by the learning theories and approaches which their connections are discussed detail in Chapter 5.

Lastly, the AC4LV should have the closing part. It is compulsory for low vision learners to have a summary of the course and thanking remarks at the closing segment ensuring that they are always engaged with the content.

v) **Conduction styles:** In AC4LV, the content could be delivered in continuous or separate form. If the content is long which contain multiple level of lessons and topics, it is compulsory to design it separately. So, this requires transitions scenes to introduce the new subtopics and obviously must be delivered in audio form. Also, separated means the AC4LV must have navigational button. This allows the users to navigate the courseware in their own manner. If the content is focusing only on one discussion then it is not separated.

4.2.4.2 Human Entities

Human entities in AC4LV consist of actor as discussed in presentation styles and interaction. Interaction is divided into self-interaction and social interaction. Both of them are compulsory. Concepts of abilities of VI learners are used as the basis to propose the self-interaction in AC4LV. They are slow in mouse-based interaction but they have high ability in using keyboard. Findings from UCD approach also reveal that they are able to memorize all the keys in keyboard. Meanwhile, social interaction is proposed by utilizing MI theory as the basis. This is important in ensuring AC4LV not covering the learning contexts individually but allow them to have their social life with environment.

4.2.5 Learning Theories and Approaches

The selection of learning theories and approaches as the component of Conceptual Design Model of AC4LV is based on the content analysis which has been carried out through comprehensive searching, reading, and reviewing the past studies. As reviewed in Chapter 2, four learning theories and four learning approaches; constructivism, connectivism, multimedia learning theory, MI theory, mastery learning, PBL, active learning, and self-paced learning were utilized in determining the elements of Conceptual Design Model of AC4LV. They are also used as the guidance in construcing the design principles of AC4LV.

4.2.6 Development Process

Structural and content composition component were derived from comparative analysis of existing TC and AC models. In contrast, the development process of developing the AC4LV has been determined through reviewing the previous ID models as discussed in Chapter 2. In which some of the steps contain in the previous ID models has influence the steps in the development process of AC4LV. Also, co-operation from the external parties (i.e. non-technical developer, technical developer, and potential developer) give a lot of ideas in constructing the steps and flows of the development process of AC4LV (UCD approach). Overall, the development process of AC4LV contains three main phases; (i) preproduction, (ii) production, and (iii) post production. In which, each of the phase have it own steps which could be executed iteratively until the AC4LV is ready for packaging. The elaboration of each of the activity is discussed detail in Chapter 5. The development process proposed in this study is recommended to apply as the developer may also refer to the other ID models as discussed in the next section.

4.2.7 Instructional Design Model

ID Model has been selected as one of the component of the Conceptual Design Model of AC4LV as AC4LV is also a type of instructional aid. The selection of ID models was also based exhaustive review as discussed in Chapter 2. Instead of the development process recommended in this study, the developer may also refer to the ID models as suggested in this study in developing the AC4LV. In which, the developer have two options of ID models; ADDIE or Dick, Carey, and Carey model.

However, either they utilized the development process recommended by this study or suggested ID models, the development of AC4LV must be embedded with ARCS model which important to support each of the elements contain in the AC4LV.

4.2.8 Technology

Technology means the platform to run the AC4LV. In this study, desktop is the best platform for low vision learners to use the AC4LV as in school they already expose to personal computer since standard three. In which, the AC4LV could be run by playing VCD or DVD or it could be downloaded via Internet.

4.3 The Proposed Conceptual Design Model of AC4LV

Generally, the proposed Conceptual Design Model of AC4LV (Figure 4.9) consists of seven generic components which are (i) structural, (ii) content composition, (iii) learning theories, (iv) learning approaches, (v) development process, (vi) ID models, and (vii) technology. Structural component which consists of three segments: (i) opening, (ii) content, and (iii) closing illustrates the entire formation of AC4LV. Inside the structural component is content composition component, that further details all the component contained in the opening, content, and closing segments. There are (i) pedagogical approaches and (ii) human entities. Both of them implicate each other in ensuring the AC4LV caters the information accessibility, navigationability, and pleasurability aspects. These three aspects guarantee that the content of the courseware achieve the objective to be assistive. To guarantee that, the design of AC4LV must refer to the proposed elements and design principles which are constructed based on content analysis, comparative analysis, expert and actual users consultation (UCD), learning theories, and learning approaches. Among learning theories that act as the guide in constructing the design principles of AC4LV are constructivism, connectivism, multimedia learning theory, and MI theory. Also, mastery learning approach, PBL, active learning, and self-paced learning are the learning approaches that influence the content design of AC4LV. To develop the AC4LV, the developers are recommended to refer to the three-phase activity recommended in the development process components. As the developer has to refer to ID models in developing the AC4LV, so the proposed model suggests two options of ID models which are ADDIE, and Dick, Carey, and Carey (discussed in Chapter 2). By applying anyone of the suggested model, the development of AC4LV has to be supported with ARCS model (discussed in Chapter 2). Finishing the development process, AC4LV is packaged in the form of VCD or DVD that is able to be run on desktop or over the Internet that is able to be downloaded by interested users.

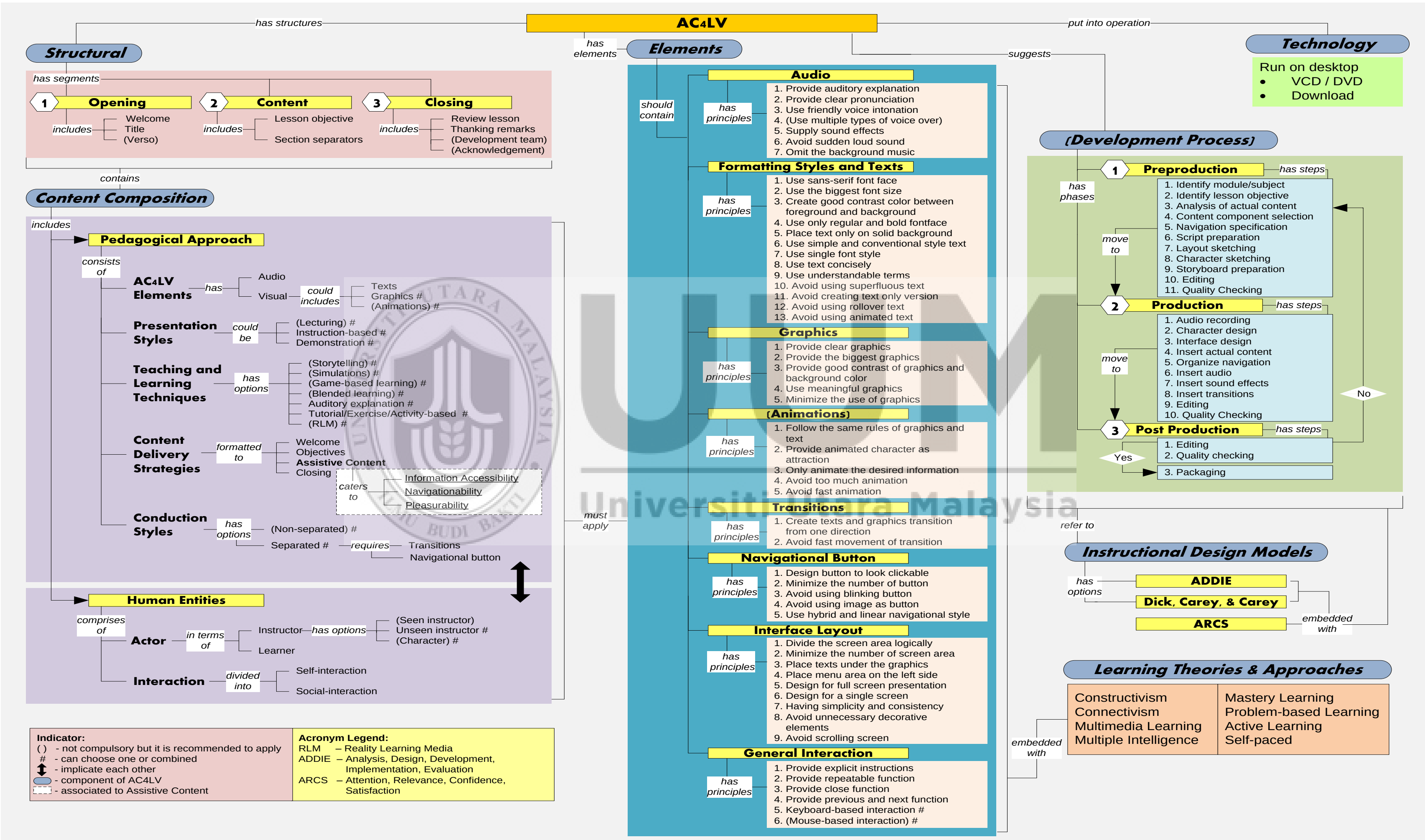


Figure 4.9: The Proposed Conceptual Design Model of AC4LV

4.4 Expert Review

Chapter 1 mentioned that, the proposed conceptual design model needs to be validated through prototyping method. This is discussed in Chapter 5. Prior to prototyping, expert review method was conducted to review and validate the proposed model. Altogether, 22 invitations (11 experts for each local and international) were sent to the identified experts via email communication. Experts involved in this review process were selected based on the following criteria:

- Have PhD qualifications either in AT or Special Educational Technology or Human Computer Interaction (HCI) or Multimedia or Instructional Design Expert or Computer Science (CS) related area **or/and**

- Have at least five years teaching background either in AT or Special Educational Technology or HCI or Multimedia or Instructional Design Expert or CS related area **and**

- Have been studying/researching either in AT or Special Educational Technology or HCI or Multimedia or Instructional Design Expert or CS related area for at least five years.

Out of the 22 experts 12 of them agreed to participate as experts. This number is sufficient as supported by Keeney and Winterfeldt (1991) and Chang, Kaasinen, and Kaipainen (2013). Hence, Table 4.22 displays the demographic profile of the experts.

Table 4.22: Demographic Profile of the Experts

Expert	Gender	Education	Field of Expertise	Experience (Year)	Affiliations
A	Female	PhD	Multimedia	20	Universiti Utara Malaysia (UUM)
B	Female	PhD	Multimedia in Education for Children	10	UUM
C	Male	PhD	Learning Application	12	UUM
D	Female	PhD	HCI	16	Universiti Teknologi Petronas (UTP)
E	Female	PhD	Educational Technology	12	Universiti Teknologi MARA (UiTM)
F	Female	PhD	Multimedia Application Accessibility	15	Universiti Kebangsaan Malaysia (UKM)
G	Male	PhD	Computers in Education	30	Universiti Tun Hussein Onn Malaysia (UTHM)
H	Male	PhD	Instructional Design	26	UKM
I	Female	PhD	Special Educational Technology	28	Universiti Sains Malaysia (USM)
J	Female	PhD / Post doctorate	AT and Universal Design	14	University of Auckland
K	Female	PhD Candidate	HCI Researcher / Software Engineer	5	University of Eastern Finland
L	Male	PhD	HCI (Visual Disabled Interface)	30	University of York

As exhibited in Table 4.22, the 12 experts represent different fields of expertise from different academic institutions including local and international. This is important for this study to have established reviews and comments. As for the educational background, two of them are professors and three are associate professors. The remaining six are PhD holders and one possesses master degrees which currently pursuing PhD at University of Eastern Finland. Expert L is from University of York, UK who is an expert in HCI particularly on visual for disabled interface and interaction. He also served as the University Adviser on Disability besides other official posts regarding disabilities. Another international expert involves is Expert J from University of Auckland, New Zealand, who is an expert in AT and Universal

Design. She is previously served as a Professional Engineer of Ontario. It is important for this study to have experts not only from academic background but also from the industry to gain input from the industrial perspectives. Accordingly, Expert K who is HCI researcher specialist in low vision user interface accessibility and software engineer for five years was approached. Reviews and comments from international experts who are expert in materials related to low vision needs are important in confirming the elements and design principles in the proposed model are tailored towards the target users. It is also because, they have advance experiences regarding AT for VI to guarantee no elements and design principles is missing. Besides, in guaranteeing appropriate learning aim, structures, theories, and approaches are well-planned, an instructional design expert who has more than 20 years experience in teaching and researching was engaged and collaborated with. Also, an expert in multimedia particularly in conceptual design model of learning content application involves to ensure the relevancy of the design, connections, and terms used in the proposed model. As Conceptual Design Model of AC4LV is related to special educational technology, having one expert in that area is important to ensure the AC4LV fulfills the target users' needs. She is Expert I who has almost 30 years experience in teaching and researching in educational technology, which are specifically designed for PWD. Among examples of her successful products are *eKodBraille* and *ePKhas*. On top of that, reviews and comments from other experience experts with their respective fields really contribute to the improvement of the proposed model.

4.4.1 Instrument and Procedure

Throughout the review process email was used as the medium of communication. First, invitation email was sent to the identified experts. A sample of the invitation emails is attached in Appendix B. Having agreed to be appointed as an expert reviewer, a consent form (Appendix C) and an official appointment letter (Appendix D) were sent to them. Having received the signed and stamped consent form, the illustration of the proposed model (Figure 4.9) together with the instrument were attached also via email. An ample time and opportunity were given to the experts to review the model and complete the questionnaire. Most of them took two to three weeks to complete all the tasks.

As mentioned, the main instrument used for expert review is questionnaire (Appendix E). The format of the questionnaire is adapted from Siti Mahfuzah (2011). It contains five questions asking about the (1) relevancy of the proposed elements contained in the components of AC4LV, (2) understanding of the design principles in each of the AC4LV elements, (3) terms used in the proposed model, (4) connections and flows of all of the components, and (5) readability of the proposed model. Experts were also asked a few demographic profile such as working experience and the highest level of education. Along with that, they were also encouraged to write their further comments in the provided instrument.

A list of the proposed components was provided in the first question in which the experts were required to verify the relevancy of the elements contained by the components (i.e. some are definitely not relevant or some may be not relevant or all are relevant). For the second question, eight elements of AC4LV were listed: audio, formatting styles and texts, graphics, animations, transitions, navigational button, interface layout, and general interaction. The experts were required to verify their understanding for each of the proposed design principles included in those elements (i.e. needs very detailed explanation or needs some explanation or is easy to understand). For questions three to five, the experts were required to validate the items by answering “yes” if they agree with the statement and “no” otherwise. Finally, based on their expertise, experience, and perception, they were expected to write their further comments from an overall point of view regarding the proposed model. The next subsection discusses the findings of the review.

4.4.2 Expert Review Findings

The gathered data were recorded in frequency and tabulated in Table 4.23 based on the questions asked in the instrument. It is also plotted in the clustered column charts (Figure 4.10, Figure 4.11, and Figure 4.12) which provide a straightforward and valuable way to illustrate the different frequency of responses.

Table 4.23: Frequency of Responses from Expert Review

Items		Frequency (*n* = *12*)		
		Some are definitely not relevant	*Some may be not relevant*	*All are relevant*
Q1:	The proposed elements in the following components are relevant			
	a) Structural			12
	b) Content Composition		3	9
	c) ID Models		3	9
	d) Learning Theories		3	9
	e) Learning Approaches	1	2	9
	f) (Development Process)		1	11
	g) Technology		2	10
Q2:	The proposed design principle in the following AC4LV elements are understood	*Need very detail explanation*	*Needs some explanation*	*Is easy to understand*
	Audio	2	2	8
	Formatting styles and texts		3	9
	Graphics		3	9
	Animations	3	2	7
	Transitions	1	5	6
	Navigational button		4	8
	Interface layout	1	4	7
	General interaction		3	9
		Yes	*No*	
Q3:	The terms are easy to understand	10	2	
Q4:	The connections and flows of all the components are logical	9	3	
Q5:	Overall, the conceptual design model is readable	12		

Note: Q = Question

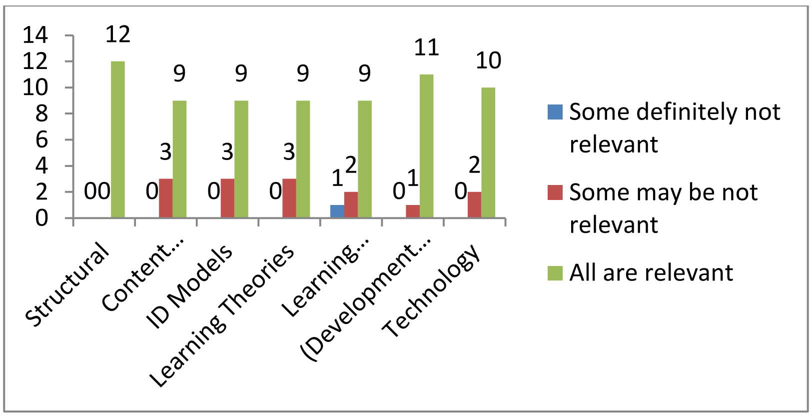


Figure 4.10: Relevancy of the Proposed Elements in the Components of AC4LV

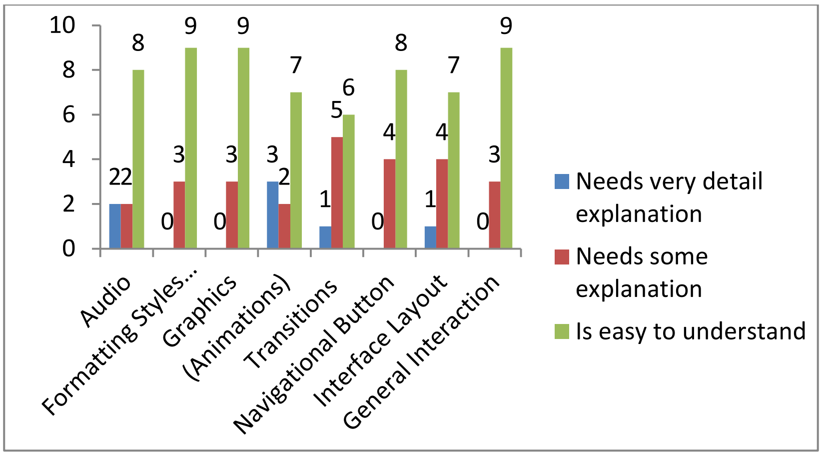


Figure 4.11: Understanding of the Proposed Design Principles in AC4LV Elements'

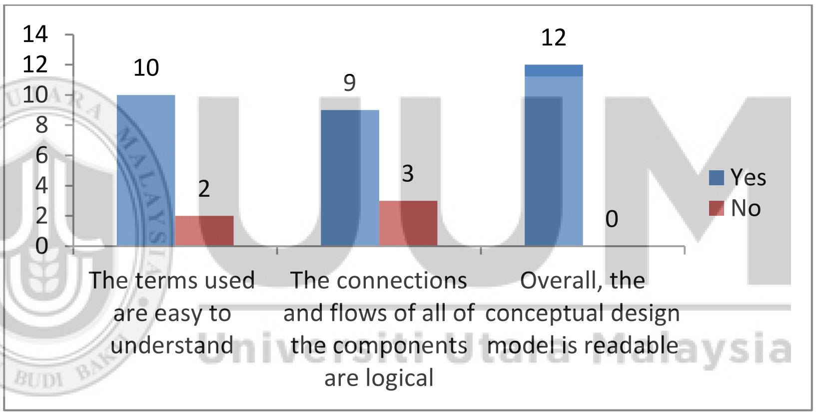


Figure 4.12: The Terms, Connections and Flows, and Readability of the Conceptual Design Model of AC4LV.

As exhibited in Table 4.23, Figure 4.10, Figure 4.11, and Figure 4.12 majority of the experts agreed that the proposed elements contained in each of the components are relevant. While, the proposed design principles for each of the elements is understandable except for some of the design principles contained in "animations", "transitions", and "interface layout", which almost half of the experts need clarification on that. Also, majority of the experts agreed that the proposed conceptual design model contains understandable terms, logical connections and flows, and it is readable. However, the reviews reveal that two of the experts need clarification on the terms “conduction style” and “assistive content”.

In addition, further comments from all of the experts were also recorded in this study as depicted in Table 4.24. In conveying the clearer meaning, some of the comments were rephrased from the original versions. The sample of comments in the figure is attached in Appendix F.

Table 4.24: Further Comments from the Expert

Experts	Comments
Expert A	(1) There are specific contents, elements, and technology for low vision learners. (2) What is the difference between elements in Content Composition and Element? (3) Assistive Content must be the focus of this conceptual model. (4) What is conduction style? (5) Please see my comments in the figure.
Expert B	(1) No title is given relating with the Conceptual Design Model of AC4LV. (2) Put into operation – technology – should provide running platform on the Internet version (discuss with supervisor). (3) Include “Yes” and “No” process in quality checking. (4) Why underline the “Assistive Content”? (5) Need to provide operation definition (OD) or conceptual definition (CD) for ID models. (6) Provide close confirmation pop up box. (7) What is the difference between Presentation Styles and Teaching and Learning Techniques? (8) How about video? (9) Only that in presentation styles?
Expert C	(1) For formatting styles and texts - needs some explanation for design principles no. 2 and 6. (2) What is the purpose of transitions? (3) Should provide logical flow, to show which component comes first.
Expert D	(1) The proposed design principle box for AC4LV elements should be leveled according to the AC4LV elements in the Content Composition box. You may want to consider (i) Audio (ii) Visual (iii) User Interface Design (iv) General Interaction as in one level. Visual has many subsets that include Graphics, Formatting Styles and Texts, Animations, Transitions, and Navigational Button. (2) How does your model support social interaction? Consider item 7. Tabletop surface interaction as an option to choose to facilitate multi-user interaction when using the courseware.
Expert E	(1) For audio - Provide volume adjustment. (2) For formatting styles and texts – design principles no. 2, the word “biggest” may be changed to “suitable”.

	(3) For graphics – design principles no. 1, the word "clear" may be changed to "high quality". (4) For graphics – design principles no. 2, the word "biggest" may be changed to "suitable size". (5) What needs to be checked in the quality checking in the pre-production phase? (6) Quality checking in the post production phase is OK because you develop and check it in the production phase.
Expert F	(1) For content, human interaction, elements – you need to show aspects/elements accessibility which should be the main difference from other models. (2) ID models – bear in mind that in practice only one ID is used to guide the designing of learning materials since each model has an underlying philosophy associated. Eventhough there will always be a bit of behaviorism used such as in giving feedback. (3) Technology – download IS NOT a technology but web is.
Expert G	(1) For content please be exact. Which learning theory is used exactly for which item, sub topic and topic? And give the rational for the answer. (2) If interactivity, how long can your system wait for the users response. (3) In the model, the user must be informed where they are at the moment. Which objectives have been met? (4) Recommend the user how to proceed if they got stuck, confuse and lost. (5) Put the contribution as clearly as possible, defend your claimed contributions. (6) References? Which bibles have you used most, least and sometimes. Why?
Expert H	(1) For learning theories you may consider adding connection. (2) Otherwise, the model is quite comprehensive.
Expert I	(1) The visual ability of people with low vision is quite diverse. Their visual acuity, visual fields and ability to see contrast varies. Therefore, it is suggested that options are provided to change the following elements: (a) Background/foreground contrast: (i.e. yellow text on black background is quite popular; white text on black background, which seems to work better than black text on white background). You can also refer to Windows Accessibility options for the different types of contrasts. (b) Text size- the biggest may not be the best. When the text is big, then the person has to scan more and that can be tiring for people with low vision. Again, it is better to provide the option to change the font size. You can refer to some websites whereby you can have the option of changing text size by just clicking on the size you want. (c) Audio- has the option to turn it off/on. (d) Graphics- graphics is actually a good element to have for low vision. People with low vision should not be deprived of graphics which is rich in information. However you need to make the graphics accessible for low vision. For example (i) graphics used need to be clear and distinct, (ii) avoid unnecessary details, provide only the relevant details to illustrate the intended point, and (iii) have the option to enlarge the graphics (zooming).
Expert J	(1) It looks like a very interesting approach. (2) For the content composition, the learning techniques could be combined. For example, a game that incorporates storytelling. (3) Technology must also include forward/backward compatibility and testing on multiple operating systems. (4) As indicated in the model, it is important to look at the auditory options - understand audification, sonification, auditory icons, and earcons. (5) Navigational button - must be placed in a location easily accessible - centre of screen, or bottom right are most common. (6) Interface layout - please ensure alternate text options are available for all images.
Expert K	(1) For audio (i) allow users to easily control the audio playback and (ii) speed short and precise.

	(2) For formatting styles and text (i) text size should be adjustable (not only just large and (ii) predefined and customizable contrast settings. (3) For graphics (i) what is big graphics (define a size, in pixels or byte) and good contrast? (4) Transitions - animated transitions or what? I did not understand. (5) You would also speak to several low vision users to get their views on the different elements
Expert L	(1) Content composition: Pedagogical approach (i) AC4LV elements – (a) has audio - What does ‘audio’ refer to here? Audio can take many forms, notably speech and non-speech (and a lot of variation within those categories), so should not this be more specific? (b) has visual - does that include video? (ii) Presentation styles (i) could be (lecturing), instruction-based, demonstration -Is it a deliberate decision to be limited to these styles? What about others, such as problem-solving? (See Learning Theories & Approaches) (iii) Content delivery strategies - Formatted to Assistive Content - I am not sure what this means in this context (iv) Conduction styles - again, I simply do not understand what is meant here. (2) Elements: (i) Formatting styles and texts – has principles avoid using rollover text - Is that not too prescriptive? *Reliance* on rollover might disadvantage some, but if the information presented is redundant, it should not disadvantage them completely – and may be of assistance to others. I am unclear as to why one section states ‘avoid using animated text’, while another says, ‘only animate the desired information’. The latter comes under the rule, ‘follow the same rules as graphics and texts’, so that appears to be a contradiction. (ii) Interface layout – (a) place menu area on the left side - why? I know of no interface guideline which prescribes this, (b) having simplicity and consistency - these are good principles – but sometimes hard to achieve, (c) avoid scrolling screen - why? Scrolling is almost inevitable; the information capacity of a single screen is limited. Would you not distinguish vertical and horizontal scrolling? Are you assuming that all presentations will be on large, desktop screens?

Based on the comments, it is concluded that majority of the experts concern on the proposed design principles as this study focus on developing a conceptual design model. As pertaining to the needs of low vision learners, most of the experts pointed out their suggestions on the design principles. However, there are also three of them need clearer explanation on some of the proposed design principles. One of the experts gave advices on clearer indications of “formatting styles and texts” and “graphics”. On top of that, three of the experts remarked on the development process, in which the “quality checking” step is quite confusing. Besides, four of the experts remark on the component “technology”. The justifications for the comments are discussed in the next section.

4.4.3 Justification on Experts' Comments

Answering the comments regarding the terms "Yes" and "No" in testing the satisfaction of "quality checking" in the component of "development process", this study admit that the terms is not suitable for indicating the satisfaction because "Yes" and "No" should be used after determining the decision. So, by referring to the rule of flow chart diagram, the illustration on that particular part is revised by replacing the word "Yes" and "No to "Satisfy" to show the satisfaction testing was executed and the word "Yes" and "No" were moved out of the decision shape to show the determined decision.

As for the remarks on the components of "technology" this study agrees that "download" is not a technology, so the word "download" is replace to "website". Considering comments from Expert D that AC4LV not only could run on desktop, but "tabletop surface" also is an option to choose to facilitate multi-user interaction when using AC4LV. This also could support social interaction among the users. Another suggestion on "technology" is "mobile devices" in which AC4LV also should be run on "laptop", "tablet" or "smartphone". All suggestions on "technology" are put as "recommended to apply".

To answer the comments and suggestions regarding flows and connections, this study admits the suggestion from Expert C to provide logical flow by putting numbering at each of the components to avoid from confusion and showing which component comes first. Also, add connections between "AC4LV elements" contain in "content composition components" and "AC4LV elements" contain in "elements".

This is as suggested by Experts A, D, and F. Having accepted their ideas, it is established that “assistive content” is the focus of Conceptual Design Model of AC4LV which should be the main difference from others model. This also answers the question by Expert L regarding “assistive content” which also has been explained in Subsection 4.4.1. About the comments on connections of “learning theories” and “learning approach” with the proposed design principles and the concerns from Expert G regarding the users’ condition while using the AC4LV, they are discussed in detail in Chapter 5.

As for the comments concerning “video” and “animations” elements, the justification are as discussed in the medium part of this chapter (see 4.4.1). About the remarks on “presentation styles”, “teaching and learning techniques”, and “conduction styles” the explanation are as discussed in Table 4.15 and Subsection 4.4.3. However, to be clearer on “conduction styles” this study decides to reword the word “non-separated” to “non-separated scene” and the word “separated” is changed to “separated scene”. This is to explain that “conduction style” is the flow of delivering the content in AC4LV which is also influenced by the “style of presentation” and the learning content itself. Also, to answer about considering “problem-solving” as one of the “presentation styles”, this study has already included it in “activity”, which embeds PBL approach. The details are discussed in Chapter 5.

Regarding the comments on “design principles” subject, majority of the experts need some explanation for the design principle “use the biggest font size” and “provide the biggest graphics". Two of the experts also comments that the biggest attribute do not mean the best for low vision learners. As a result, this study decides to change the word "biggest" to "preference". Besides, this study also counters the comments by Expert E and I about their concern on "provide clear graphic" principles. So, to be more comprehensible this study rephrases that design principles to "provide clear and distinct graphics" and include "avoid unnecessary details" as suggested by Expert I. Interestingly, Expert L also draws his attentions regarding the "avoid using rollover text", "having simplicity and consistency", "avoid scrolling screen", "avoid using animated text", "only animate the desired information", "follow the same rules as graphics and text", and "place menu area on the left side" principles. Additionally, Expert C and K need some explanation on "transitions" and Expert J voice out her apprehension on "navigational button" and "interface layout". The answer for these has been justified in Subsection 4.4.2 and Table 4.21. Thus, those commented design principles are retained. When Expert B recommends "provide close confirmation pop up box" it contradicts with the accessibility guidelines (Pernice & Nielson, 2001). Captivatingly, one of the experts (from the software engineers' point of view) also pointed out her suggestions "to allow users to easily control the audio playback". This is inline with the design principle proposed in this study which is "provide repeatable function". The explanation also has been provided in Table 4.21.

This study focuses on content application, which is designed to have assistive features to make sure that learning content is delivered to the low vision learners without forcing them to operate any technical function in getting the presented information. This is also inline with the definition of AT as discussed in Chapter 2. It has to be emphasized that assistive in AC4LV ensures that the low vision learners could stay focus on the learning content without having distress to operate the technical function. Accordingly, suggestion from experts to have “volume adjustment”, “turn audio on and off”, “customizable texts size and contrast colors”, and “customizable graphics size and colors” do not lead to the purpose of this study. As these is very easy for the low vision learners to get lost with the actual content and make them get fatigue easily (Pernice & Nielson, 2001). This technical function also requires more instructions from the instructor, which actually lead the low vision learners to suffer from ear strain and simply get bored less interested in learning (Pernice & Nielson, 2001; Suziah, Siti Nur Syazana, Mean, & Halabi, 2010). However, this study agrees with the suggestions by Expert I to decide the usage of colors for content in AC4LV rather than providing “customizable function” as discussed in detail in Chapter 5.

Having understanding the concept of “audification”, “sonification”, “auditory icons and earcons”, and “notably speech and non-speech”, as regards to the concerns by Experts J and L, it is beyond the scope of this study. “Audio” for this study is as defined in Table 4.15 and Table 4.21.

4.5 Reviewed Conceptual Design Model of AC4LV

In efforts to provide a better impression and enhancing the readability, the Conceptual Design Model of AC4LV has been revised and redesigned based on the comments from the experts as illustrated in Figure 4.13.

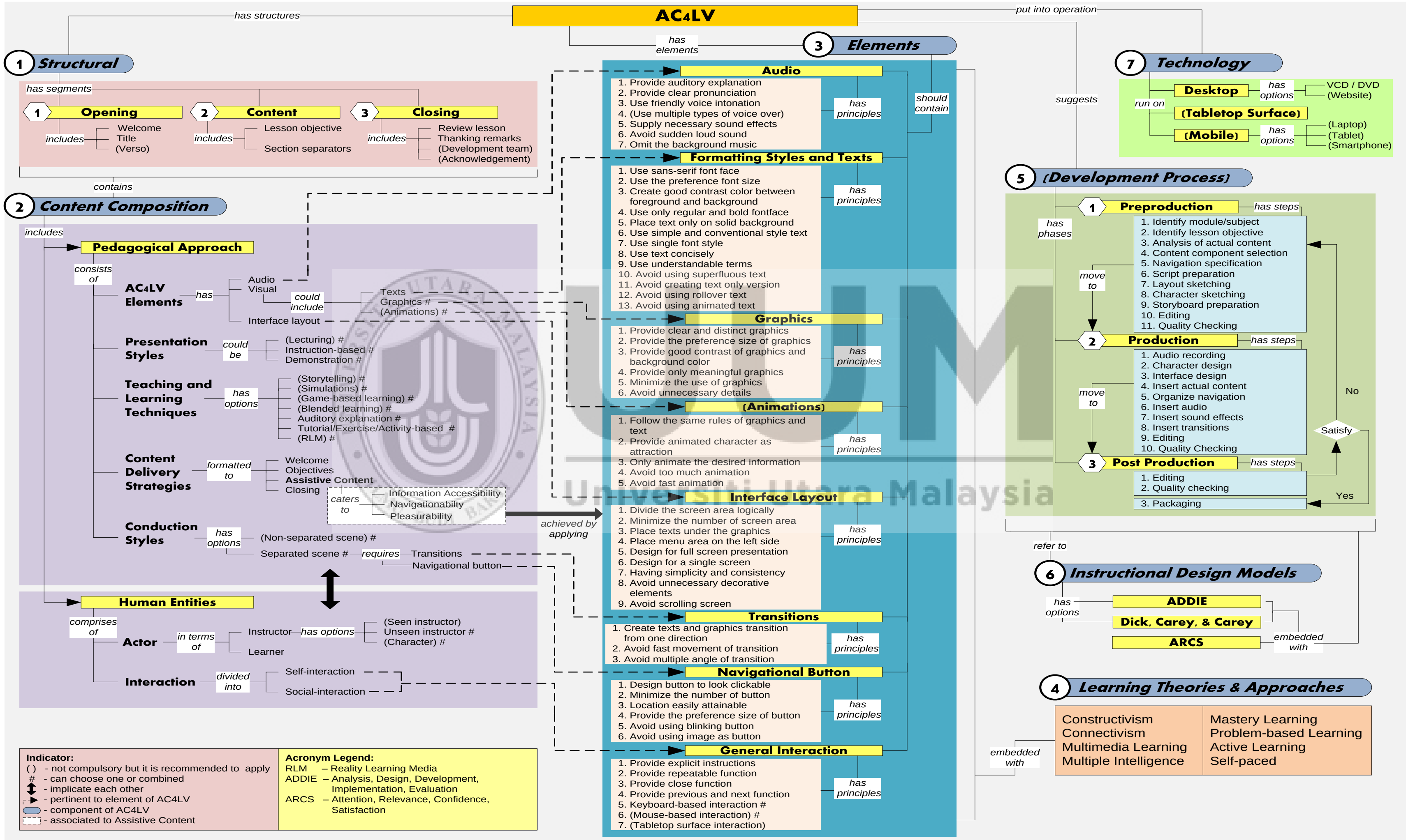


Figure 4.13: Revised Conceptual Design Model of AC4LV

4.6 Summary

This chapter explains the activities involved in constructing the Conceptual Design Model of AC4LV in detail. It starts with analyzing the previous conceptual design models by plotting the desired components and elements through a series of comparative studies on 20 existing models; the TC and AC. Seven main components of AC4LV were identified and formalized. It is followed by an explanation on the UCD approach, which is an important method for this study to serve the needs of low vision learners. It is combined with analyzing the previous related literatures in Chapter 2. From then on, special features which named as design principles were derived. These design principles were expected to support the needs of low vision learners in information accessibility, navigationability, and pleasurability. Having met these three aspects in the proposed model, it proves that AC4LV is "assistive content". These outcomes serve to support the first and second objectives of this study. In addition, expert review method was also carried out to validate the proposed conceptual design model. Hence, revised Conceptual Design Model of AC4LV was formed.

This study translates the model in Figure 4.13 into AC4LV. This is to examine whether the expectation as stated in Objective 3 and readdressed in the above paragraph is met. The details for these are explained in Chapter 5. Later, a comprehensive user experience testing procedure was conducted which described in Chapter 6.

CHAPTER FIVE

PROTOTYPING OF AC4LV CONCEPTUAL DESIGN MODEL

5.1 Overview

The previous chapter delineates the tasks carried out to construct the Conceptual Design Model of AC4LV. A detailed consideration was given in comparing the existing models to determine the intended components and elements of the AC4LV. Also, deep efforts were spent to gather the accurate input from experts and intended users in ensuring the proposed model meets the user requirements. Then, all the components and elements were then merged as a conceptual design model and reviewed by 12 experts (described in Chapter 4). As a result, a Conceptual Design Model of AC4LV was proposed.

In achieving the objective 3 of this study, the proposed conceptual design model was validated through prototyping which involves external parties (courseware developer from industrial). This interprets that, to ensure that the proposed model is useful; it must be translated into a working prototype. Once the prototype is successfully developed (as desired), it indicates that the proposed model is validated. So, the steps in designing and developing the prototype is carried out based on the proposed conceptual design model. This study named the prototype as AC4LV. A team of developer has been employed to translate the Conceptual Design Model into AC4LV based on their experience.

The next sections provide detailed descriptions regarding development process of AC4LV, followed by the prototype of AC4LV that maps with the conceptual design model developed in Chapter 4, and the connections of AC4LV with learning theories and approaches. Finally, the last section concluded this chapter.

5.2 The Development of AC4LV

As stated in the proposed model, the development process of AC4LV proposed in this study is recommended to apply especially for non-technical or novice developers that have interest in developing AC4LV. Also, they may refer to other ID models as recommended in the proposed model. This interprets that, AC4LV is able to be developed by everybody by utilizing any step or any applicable software. The content of AC4LV is also up to their preference. As an illustration if the developer is a teacher or parents, their existing knowledge related to the course content is highly useful, which means the development process is getting easier without worrying about the costing and quality. However, it is important that they have to follow the proposed elements and the design principles as well as other compulsory components as stated in the proposed model. So, for non-technical and novice developers, they are recommended to apply the development process provided in the proposed model.

This study follows the basic steps which are usually required in developing multimedia applications. It consists of three phases which are pre-production, production, and post-production. Most of the steps in these three phases require the developer to refer to other compulsory components provided in the proposed model including ARCS model. They are elaborated in the following subsections.

5.2.1 Pre-production Phase

There are eleven steps involved in the pre-production phase as exhibited in Figure 5.1.

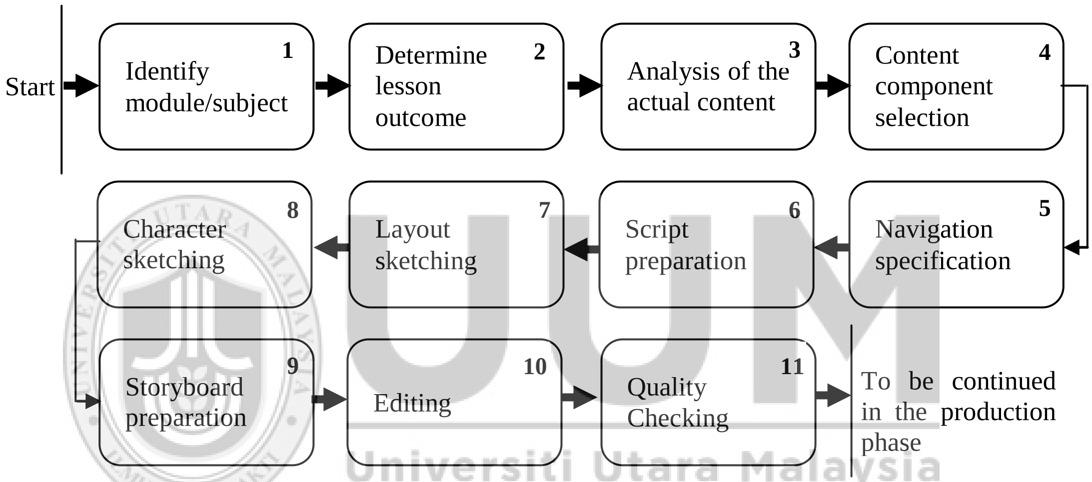


Figure 5.1: Pre-production Phase

i) Identify module or subject

First, the developer team (G-Elite Holdings Sdn Bhd) and the low vision learners had few discussions to identify module or subject. This is to confirm which subject or module that they prefer to be included in the AC4LV. They are the actual users of AC4LV, who know which subject or module that are timely appropriate to be developed. Additionally, input from teachers and parents are also highly useful. At the end of the session, the teachers suggest one topic from the Science subject to be selected for the AC4LV which is “Animal”.

ii) Determine lesson outcome

After identifying the module or subject, it is important to determine the expected outcome that the low vision learners will acquire at the end of the lesson, which is able to be obtained from the standard textbook. The lesson outcome act as a direction for the developer to outline the script and sketch the storyboard in ensuring the AC4LV is successfully catered the needs for information accessibility, navigationability, and pleasurability aspects. It should describe the skill or knowledge that the low vision learners will acquire after learning through AC4LV. It is not only in theoretical aspects but also able to touch them practically. As an example, by referring to the lesson outcome of the AC4LV proposed in this study, it is expected that the low vision learners are not only able to describe the theoretical knowledge about the animals, but practically they also have the ability to distinguish the animals when necessary.

iii) Analysis of the actual content

The actual content should be analyzed after the learning outcome has been determined. This is important to ensure the topics and activities intended to be included in AC4LV are sufficient and satisfy the users. The steps involved in this phase are (i) analyzing the number of topics and activities, (ii) identifying the title for each topic and activity, (iii) organizing the relationship between topics and activities, and (iv) analyzing the appropriate form of activities. These were carried out by referring to the standard textbook and discussion with low vision learners and their teachers as they are expert in course content. In the first draft, this study proposed to include activities after the learners complete learning all the topics. However, based on the study plan provided by the teachers, they recommend that activities are appropriate to be performed after the learners learning each of the topics. So, the instructional strategy was changed by considering the suggestions by the experts. As low vision learners utilizing keyboard as their pointing device, so the form of activities provided in AC4LV also have to be planned carefully due to the limitation of keyboard function. However, it does not mean that the activities part in AC4LV cannot be prepared interestingly. In addition, creativity from the developer is also needed in organizing the actual content (Ariffin, 2009). In later section, the steps (i) until (iii) of this task can be seen in Figure 5.8, while step (iv) is exhibited in Table 5.3.

iv) Content component selection

Once the actual content is successfully analyzed, the work to select appropriate contents to be the components for AC4LV is no longer needed. By referring to the proposed model, this study comes out with three main components of the content for AC4LV, which are lessons that are delivered through lecturing, demonstration, and activity (Figure 5.8).

v) Navigation specification

In achieving the navigationability aspect of AC4LV, the developer has to refer to the design principles provided in the navigational button, interface layout, and general interaction elements. Also, hybrid navigational style must be applied among topics and activities. Meanwhile, linear navigational style was employed within topics and activities to support next-and-next task sequences. Figure 5.2 and Figure 5.3 illustrate the flow of navigation for the AC4LV.

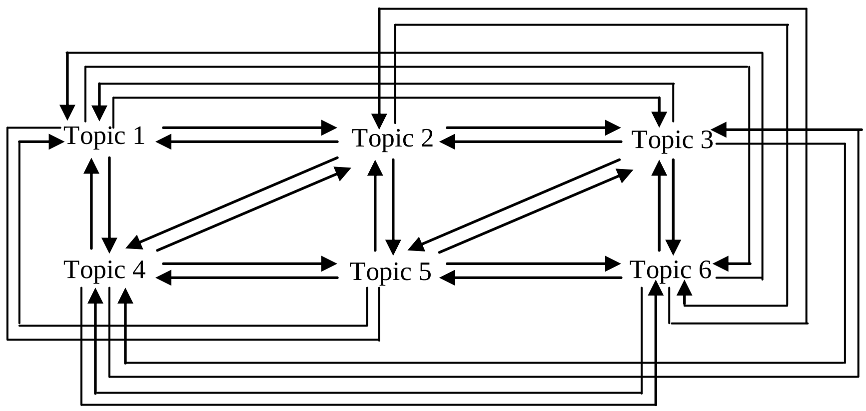
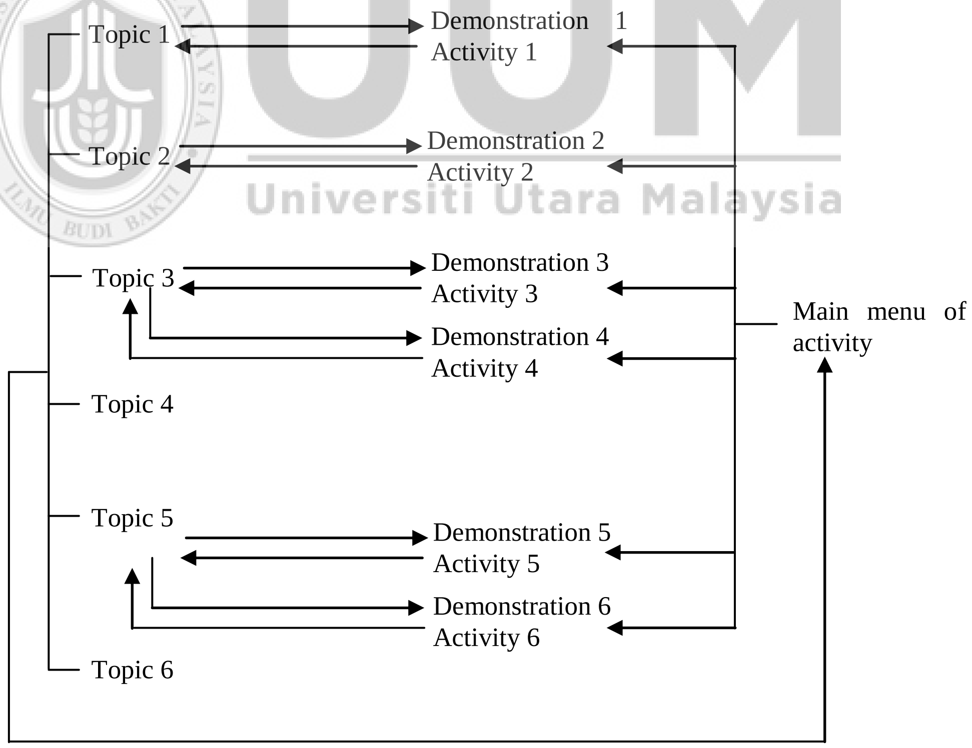


Figure 5.2: Navigation Specification between Topics in AC4LV



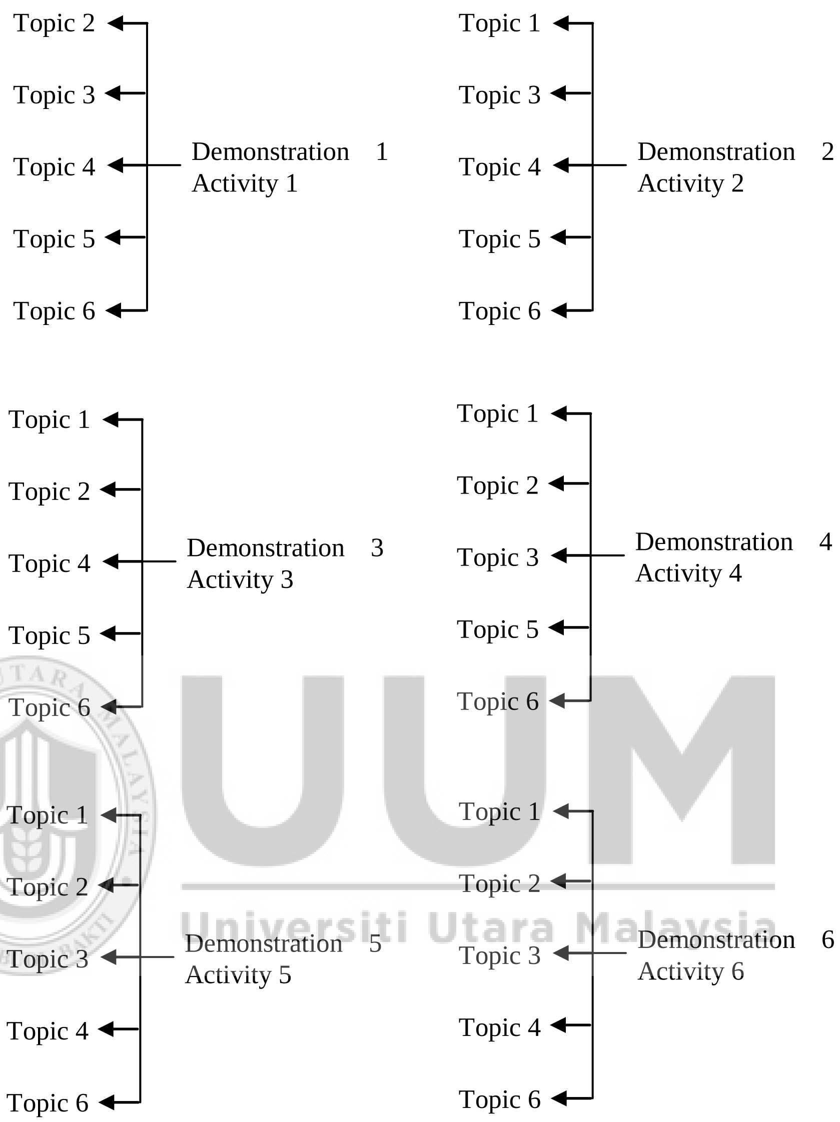


Figure 5.3: Navigation Specification between Topics and Activities in AC4LV

As illustrated in Figure 5.2, each of the topic in AC4LV can have access to each other very flexibly. This means that the users are flexible to navigate to any topics that they prefer throughout the learning process occurs. Also, Figure 5.3 illustrates the navigation specification between topics and activities, in which the users are flexible to access both of them. However, the suggested flow is after complete learning one topic they have to do activity. Each of the activity starts with demonstration of instruction. In performing the activity, they are also allowed to go back to any scene of the topic that they have learnt previously. This function is provided for low vision learners who have problem in catching the knowledge during the lecturing process. Also, during activity they are allowed to access to any topic they prefer to. This function is provided if the user has previously finished the activity. The main menu of the activity is provided, which allows them to access to any preferred activities when they are in any scene of the topic. This function is provided if the user has already learned that topic previously. In short, flexibility is important in organizing the navigation of AC4LV, to ensure it caters the navigationability aspect. However, it must be ensured that the flexibility in the AC4LV is under control.

vi) Script preparation

After satisfied with the navigation specification, the scripts of the AC4LV were prepared based on all inputs gathered from the previous step. The script is important to keep track all the elements provided in the show. The next steps which are layout sketching, character sketching, and storyboard design have to be prepared based on the script. Additionally, one of the pedagogical approaches provided in AC4LV is auditory explanation. Since, the users of the AC4LV are low vision children, it is important to ensure that the script match with the design principles and content composition component. The script that has been prepared for AC4LV is provided in Appendix G.

vii) Layout sketching

Once the script has been prepared it is easy for the developer to sketch the layout. Script that has been prepared in the previous step would act as the direction for the developer to come out with the layout sketching for each of the scene. In achieving the information accessibility and navigationability aspect, the developer have to refer to the design principles of interface layout and general interaction provided in the proposed model.

viii) Character sketching

Once the actual content has been identified and the scripts are prepared, it is time for sketching all the characters. In this study, one character that acts as the instructor called "Smiley" was created. Besides, there are 20 animals characters created because the actual content of the AC4LV is animal. The combination of colors for all characters was also determined.

ix) Storyboard preparation

The storyboard (available in Appendix G) was designed based on the layout sketching. At this stage the developer has identified all the graphics, animations, texts, audio, navigational button, and transitions that are required in the production phase. Also, the appropriate colors for graphics, animations, texts, and navigational button were determined.

x) Editing

In this study, editing process was performed especially on navigation specification, scripts, and storyboard parts. Again, the proposed model was referred to (design principles for audio, graphics, animations, and navigational button). Also, the script and storyboard were shown to the low vision learners and their teachers. Based on their comments, several modifications have been made particularly on the "topics" and "activities" parts.

xi) Quality checking

The last step in pre-production phase requires all the materials being previewed to check the quality. In this study, two minor steps of quality checking were performed. Firstly, the developer and the researcher self-check the artifacts. Both the researcher and the developer came out with a list of errors. Secondly, based on the findings in the first step, both the researcher and the developer checked the artifacts together. Then, corrections have been made through discussion. Finally, all the materials produced in the pre-production phase were ready for production phase.

5.2.2 Production Phase

Altogether, there are ten steps involved in the production phase. At this phase the development process of the AC4LV was started. The AC4LV was composed using Adobe Flash. Figure 5.4 illustrates that steps one until three could commence simultaneously. This means that the production time could be shortened. It is possible because, it involves a team of developer.

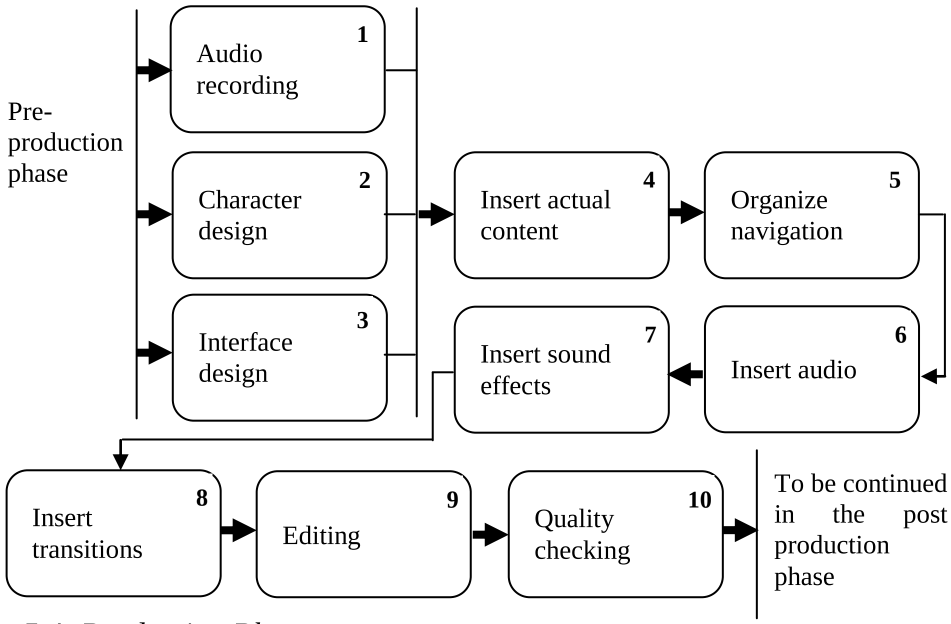


Figure 5.4: Production Phase

i. Audio recording

In this step, the scripts prepared in the pre-production phase were recorded. During the recording process, the design principles for audio were referred to. It is very important to ensure that the recorded voice meet the required quality because the low vision learners rely 100% on the audio.

ii. Character design

Based on the sketch of the characters prepared in the previous phase, all the characters were designed by utilizing Adobe Illustrator.

iii. Interface design

The interface of the AC4LV was design based on the storyboard prepared in the pre-production phase by utilizing Adobe Flash.

iv. Insert actual content

Then, all the actual content including characters, content for “topics” and “activities” were combined and integrated with the actual coding, especially for “activity” part, which allows users to actively interact with the AC4LV by utilizing keyboard. Besides, mouse-based interaction was also provided for the main menu.

v. Organize navigation

At this point, all navigation buttons that has already been specified in the pre-production phase were made active.

vi. Insert audio

Then, it is time for inserting audio that has been recorded in the previous step to match with the displayed content.

vii. Insert sound effects

It is followed by inserting the sound effects that has been identified during the script preparation. Some example of sound effects that are included in the AC4LV is animals’ sound (i.e. mooing, roaring, mewing, and quacking) and environment sound (i.e. bird chirp, wind blowing, and water murmur). They are important to enhance the user understanding.

viii. Insert transitions

The AC4LV does not require too much transition. So, inserting simple transition is adequate.

ix. Editing

Each topic and activity in the AC4LV was developed separately, scene by scene. At this step, all the separated scenes were combined into one and executed as a Flash movie. Editing was conducted by the development team after having a number of discussions with the researcher. Some parts of the AC4LV were edited including the recorded voices, navigational button, and the utilization of color for actual content.

x. Quality checking

Similar with the previous phase, the quality checking in the production phase also involved two minor steps, which are (i) self-checking by the developer and the researcher and (ii) both of the developer and the researcher checked together. The checking process was carried out by previewing the prototype and lists all the errors.

5.2.3 Post-Production Phase

The final stage of developing the AC4LV is post-production phase, which involves only three steps as illustrated in Figure 5.5. They are discussed in the following paragraphs.

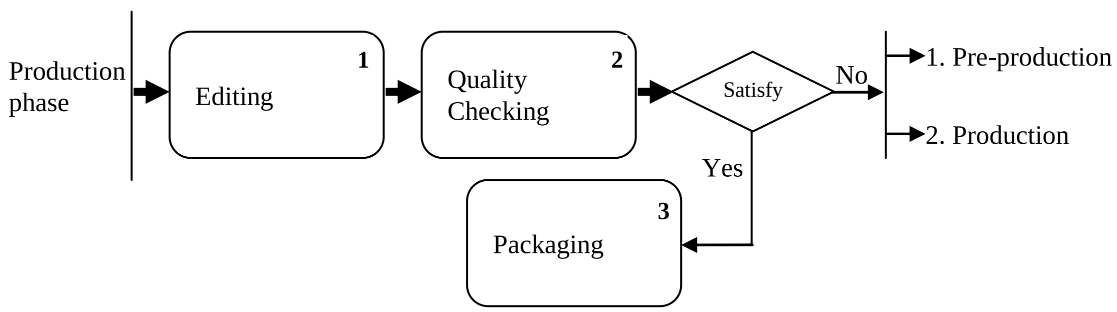


Figure 5.5: Post-Production Phase

i. Editing

Based on the errors which have been listed in the previous phase, the artifacts were again edited. In this study, the final editing process for the AC4LV was conducted by the development team.

ii. Quality checking

When the AC4LV was completed, previewing it is necessary to check the quality. To achieve the required quality, the AC4LV was inspected from different points of view. It involved the researcher, the developers including the non-technical, the actual users (low vision learners), and expert including teachers and academicians of higher institution. Then, the iteration process is required if the AC4LV still have to be improved.

iii. Packaging

Packaging of the AC4LV could be made either in the form of VCD or DVD. Then, the AC4LV could be distributed after packaging. Besides, the AC4LV could also be distributed through the Internet platform which allows users to download at anytime and anywhere they prefer. Desktop is the best platform to run the AC4LV.

5.3 Principles of ARCS Model in the Development of AC4LV

As mentioned in Chapter 2 other than referring to ID models, the principles in ARCS model (Keller, 2000) also contribute to support each of the development step consisted in the development process. The steps are concluded and mapped with the principles of ARCS as illustrated in Figure 5.6.

ARCS Model	Development Step in AC4LV
(A) Attention	Gaining attention through the usage of characters and AC4LV elements
(R) Relevance	Identifying lesson objective and presenting the learning content
(C) Confidence	Providing learning guidance and instructions through audio and visual
(S) Satisfaction	Providing feedback and assessing performance in activities

Figure 5.6: Principles of ARCS Model Mapped to Development Process of AC4LV

5.4 The AC4LV

After going through the three-phase-development-process, a prototype of the AC4LV was produced as depicted in Figure 5.7.

Figure 5.7: The Prototype of AC4LV

Subsequently, this section maps the prototype with the proposed conceptual design model. As suggested by the teachers, AC4LV was developed based on the school subject. Based on their experience, they also suggest that Science is the most appropriate course to be prototyped. Further, for the purpose of this study, the animal topic was agreed together for prototyping. Based on the textbook provided by the

MOE, this topic is introduced to all primary school students', from standard one until standard six. However, the levels of lessons are different, which means the syllabuses cater different levels of degree.

The AC4LV is in Malay to suit the target learners. This is based on the request by teachers in the preliminary studies. The actual content of the AC4LV includes five topics about animal and one topic for revision. Each of the topic is attached to activities, except for topic four. Table 5.1 describes the descriptions of the prototype. It is followed by Table 5.2 that describes the actual contents for each of the topic and activity. Also, Table 5.3 provides detailed descriptions for form of activities in the AC4LV.

Table 5.1: Descriptions of the Prototype

Main topic	Animal
Target learners	Low vision learners
Type of actor	Unseen instructor and smiley character
Type of content	Formal lesson
Concept	Learning through audio and visual

Table 5.2: Actual Content of AC4LV

Topic	Title	Activity
1	The world of animal	Activity 1: Which one is me?
2	The part of animal's body	Activity 2: Which is the part of my body?
3	The similarity and the differences of animal's body	Activity 3: Ups! We are same! Activity 4: What is my difference?
4	The animal's sound	
5	The movement of animal	Activity 5: How do I move? Activity 6: Love me
6	Revision	

Table 5.3: Description for Form of Activity in AC4LV

Activity	Title	Form	Description
1	Which one is me?	Selection	This type of activity provides two choices of answers. It allows the low vision learners to select the appropriate answer by utilizing the left and right arrow keys. Then, they press the Enter key after choosing the correct answer.
2	Which one is part of my body?	Matching	This type of activity requires the low vision learners to match the correct part of the body into the animal to generate the complete animal. Four options of answers are prepared to them. Left and right arrow keys are utilized to choose the correct answer and Enter key is used to match the correct answer into the animal body.
3	Ups! We are same!	Selection	In this activity, the users have two options, either A or B. They have to choose it by pressing either A or B key.
4	What is my difference?	Multiple Choice	For this activity, three options of answer are provided, either A, B, or C. After confirm the correct answer, they have to press either key A, or B, or C to answer the question.
5	How do I move?	Fill in the blank	In this activity the low vision learners have to fill in the blank box with the correct answers. They are also provided with several options of answers.
6	Love me	Selection	This activity also requires the users to choose the correct answers from two options of answers either A or B. The correct answers are chosen by pressing key A or B.

It is important to emphasize that each of the topic and activity has its own learning outcomes. After learning the course the learners should be able to:

- name the animals.
- name various parts of the animals' body.
- distinguish the animals that have similar and different parts of body.
- determine the types of animals through their sounds.
- identify the movement of animals and the way to love animal.
- recall the whole lesson after learning and do exercise for all topics.

Then, Figure 5.8 exhibits the structural of the AC4LV.

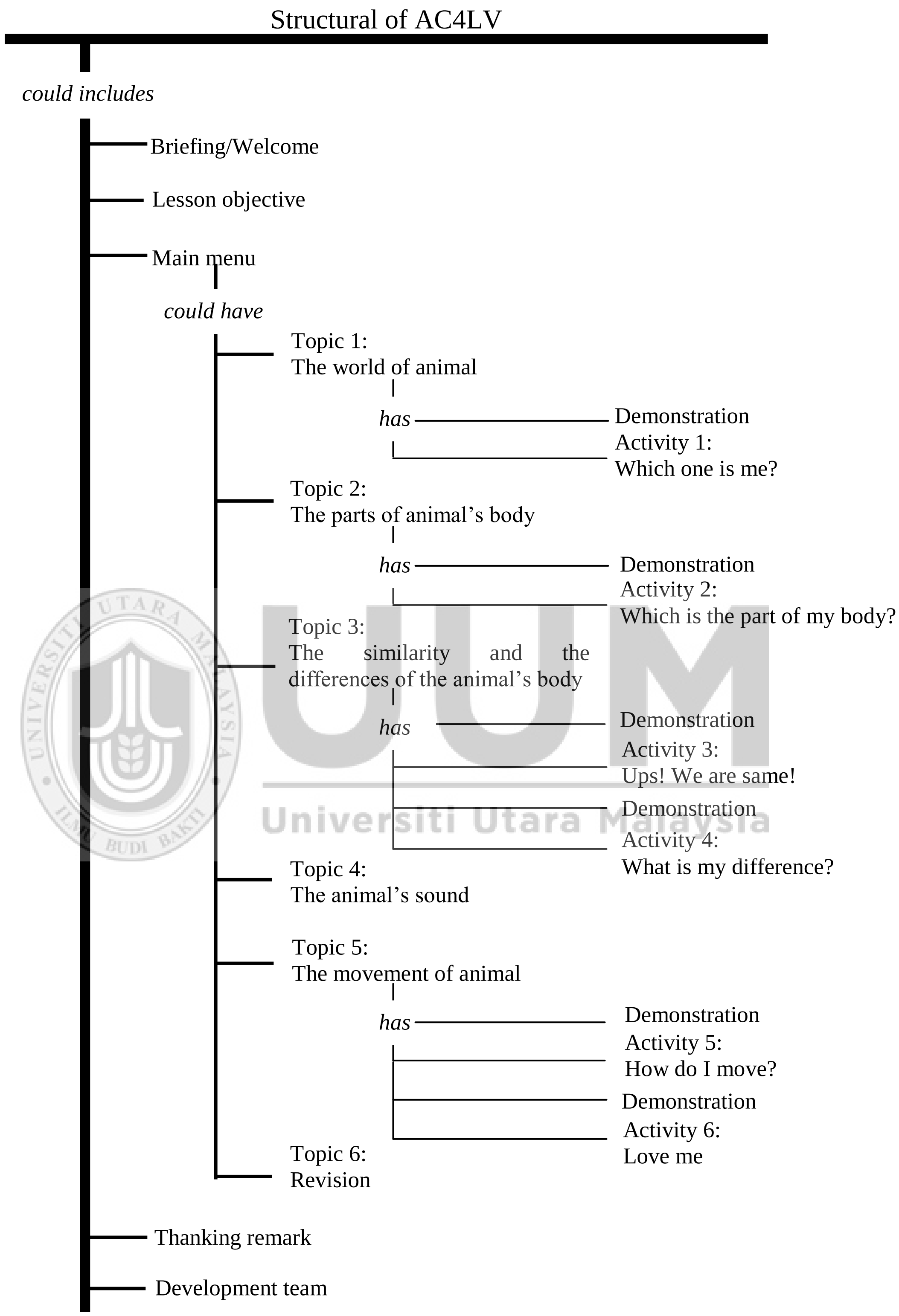


Figure 5.8: Structural of AC4LV

5.4.1 The Opening Segment

In the opening segment, a welcoming note and the title are displayed. Verso is also recommended. They are able to be presented in the form of text, speech, or combination of both types. The opening segment for the prototype of this study starts with a simple initial welcoming text as depicted in Figure 5.9. In this scene, the entrance sound is also played simultaneously with the welcoming text. This is to alert the low vision learners that the AC4LV is going to be played to them. At the bottom of the screen, an entrance button is provided. Friendly instructions are addressed by an actor in a speech form. To proceed, the users are directed to press the “Enter” key. Without this scene, it is difficult for the low vision learners to understand that the lesson in the AC4LV is going to begin. The welcoming speech and title are addressed in the next scene, which is delivered by an actor, a “Smiley” character. The opening segment is concise but attractive to the low vision learners. Accordingly, having the opening segment in speech form is sufficient to avoid the low vision learners facing overloaded information and instantly feel pressured in starting the lesson. For that reason, the use of text is minimized. Figure 5.10 depicts a snapshot of the “Smiley” character addressing welcome and title elements in the prototype.

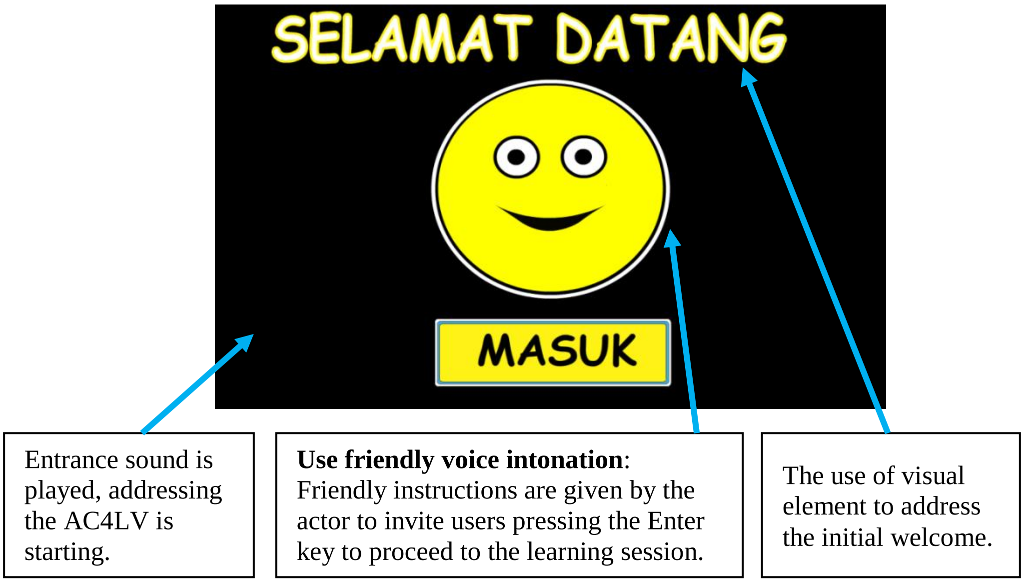


Figure 5.9: Initial Welcome Element

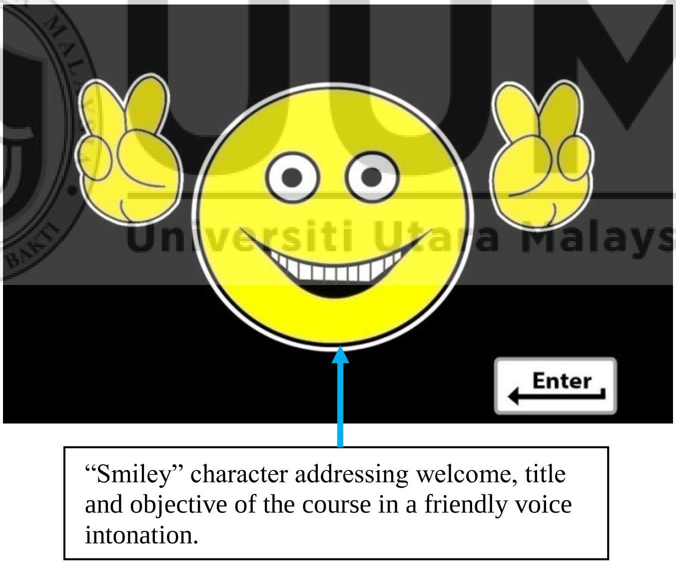


Figure 5.10: The Actor Addressing the Element of Welcome, Title, and Objective of the Course

5.4.2 The Assistive Content Segment

Assistive content segment consists of two divisions which are pedagogical approach and human entities. Both divisions have implication to each other. Also, in the content of the AC4LV, both of them are designed by applying all the design principles included in the AC4LV (Chapter 4). The pedagogical approach is composed of AC4LV elements, presentation styles, teaching and learning techniques, content delivery strategies, and conduction styles. Further, AC4LV is supposed to combine audio and visual elements as well as interface layout by including human voices, sound effects, texts, graphics, and animations. There are three options of presentation style in AC4LV which are lecturing, instruction-based and demonstration. Meanwhile, auditory explanation and activity-based are the teaching and learning techniques.

Content delivery strategies are formatted based on the structural component, which starts with welcoming note and introducing the title, followed by objective and assistive content, and ended with closing; in which the course content are designed by catering the assistive aspects, specifically information accessibility, navigationability, and pleasurability. The conduction styles could either be non-separated or separated. For this study, AC4LV only applies separated scenes, which require transitions and navigational button. Meanwhile, there are two division of human entities; actor and interaction. Further, actor is divided into instructor and low vision learners in which the instructors are unseen instructor and character. In terms of interaction in the AC4LV, they are are self-interaction and social interaction, which apply some principles of MI theory and active learning approach.

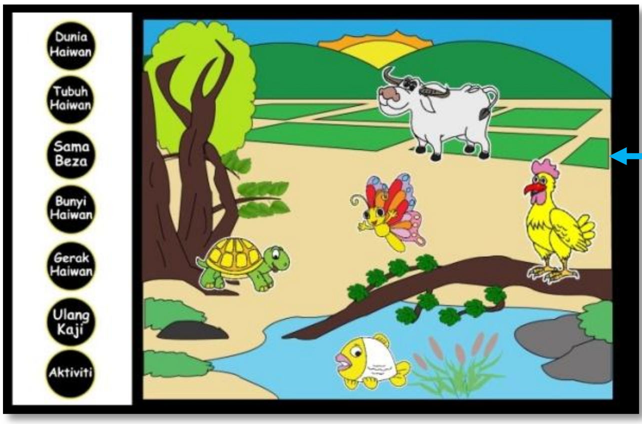
5.4.2.1 Pedagogical Approach

The components of the pedagogical approach in the prototype are composed to make the learning content among the low vision learners accessible, navigable, and pleasurable. These three aspects are important to ensure the AC4LV is sustainable with assistive features in assisting the low vision learners in their learning process. These three aspects that could be achieved through the provided design principles are expected to overcome the problem found in existing courseware as discussed in Chapter 1 (Problem Background).

i) AC4LV Elements

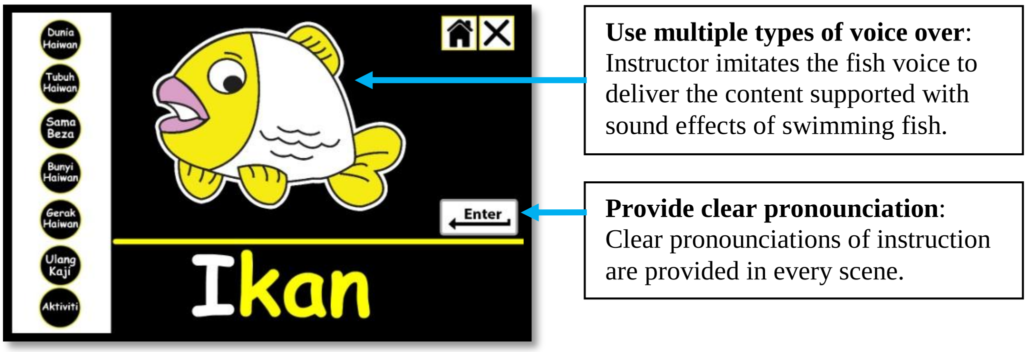
AC4LV consists of three main elements which are audio, visual, and interface layout. The connections of them are explained in the subsequent paragraphs:

Audio – In AC4LV, audio is the most important element. As stated in the proposed model (Chapter 4) there are seven design principles for audio. The forms of audio that are utilized in AC4LV are human voices and sound effects. Human voices are used in delivering the actual content, instruction, and all the visual information displayed on the screen including navigational buttons. To attract the learners' attention and to differentiate between the actual content, instruction, and visual information, friendly female voices with multiple intonations are used. As the actual content of AC4LV for this study is about animal so, some parts of the content are delivered by imitating the animals’ voice (i.e. bird, buffalo, and fish). This could enhance the learners’ attention when they feel like the animal talks and interacts with them. Furthermore, this could avoid them feeling uninterested with the lesson. Every single word is pronounced clearly. Besides, sudden loud sound and background music are omitted to avoid them facing shock and feel confused especially for the severe low vision learners. In addition, sound effects are used to enhance the learners’ understanding. As an example, the sounds of water flow, soft wind, and birds chirping are provided in the prototype to inform the low vision learners that they are in paddy field environment. All this features are provided in the AC4LV to intensify the learning and further ensuring accessibility. Figure 5.11 shows a few examples of screenshots that are delivered in animals’ voice, and sound effects in a paddy field environment. They have no background music and sudden loud sound. Also, the design principles of audio, which are listed in the proposed model, are mapped with the prototype.

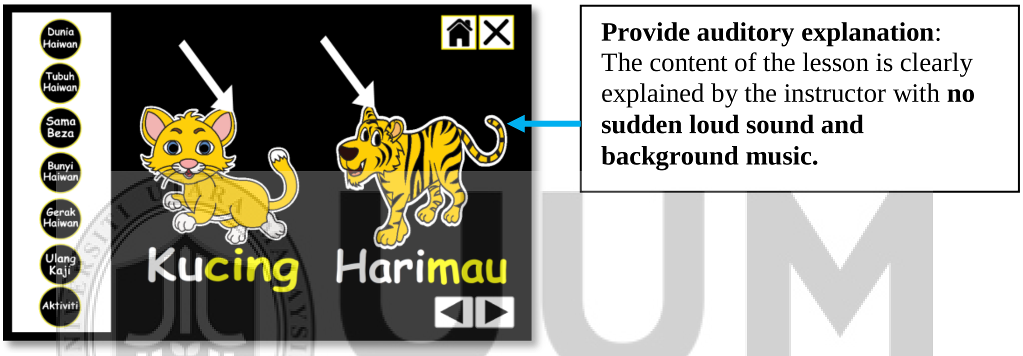


Supply sound effects:
Sound effects are supplied in this scene to enhance the learner understanding (i.e. water murmur, bird chirping, and soft wind).

a. The use of sound effects



b. The use of multiple types of voice over with clear pronounciation



c. The use of auditory explanation in AC4LV

Figure 5.11: Audio Element Applied in the AC4LV

Visual – Even the low vision learners have a profound visual disability, they still preserve a little useful eyesight. So, the use of visual elements are significant and one of their main concern in learning activities. Accordingly, in the AC4LV each of the visual element is designed by referring to the design principles provided for texts, graphics, and animations. Concerning on the content of AC4LV that have to be assistive to the low vision learners, the use of these three visual elements is sufficient. The prototype makes use of texts and graphics to deliver the lesson. In addition, simple 2D animations are supplied especially for characters to catch the attention of the low vision learners. However, 3D animations are also recommended as long as the other principles of visual are followed. This also includes the utilization of color combination for them. All this is to guarantee that the AC4LV practically works for the low vision learners in terms of information accessibility, navigationability, and pleasuring them in learning activities. Figure 5.12 displays the screenshots for texts, followed by graphics, and animations (Figure 5.13) connected with the design principles applied in AC4LV.

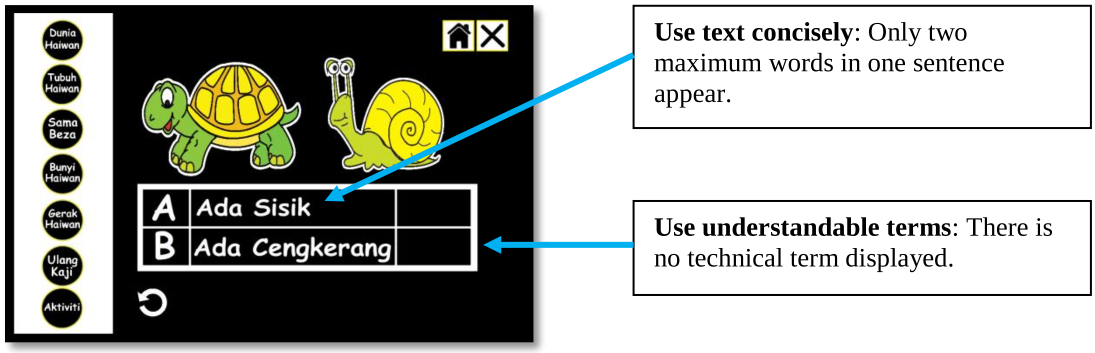
Use sans serif font face: Comic sans is the best example of sans serif font face as applied in this scene.

Use the preferenced font size: The best font size for the low learners is 18-point and above.

Use only regular and bold font face: All texts apply only regular and bold font face.
Place text only on solid background: All texts are placed on black solid background.
Use simple and conventional style text: Comic sans is a good example of simple and conventional style text compared to others.
Use single font style: A single font style is applied in both words as well as in all scenes throughout AC4LV.

Create good contrast color between background and foreground: As suggested by the low vision learners, teachers, and academicians from higher learning institutions the good color for text is either white or yellow and black for background.

a. Font and color



b. Texts and terms

Figure 5.12: The Use of Texts in the AC4LV

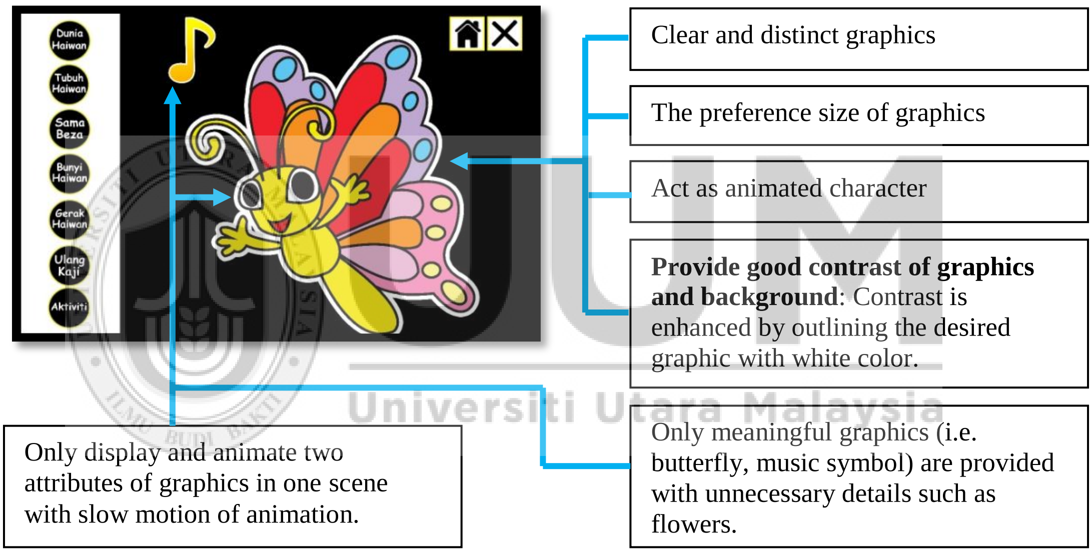


Figure 5.13: Graphics and Animations in the AC4LV

Interface Layout – The interface layout in the AC4LV is designed to achieve information accessibility and navigationability aspects. So, each of the designed principle provided for the interface layout is applied in AC4LV. Figure 5.14 labels the design principles of the interface layout applied in the AC4LV.

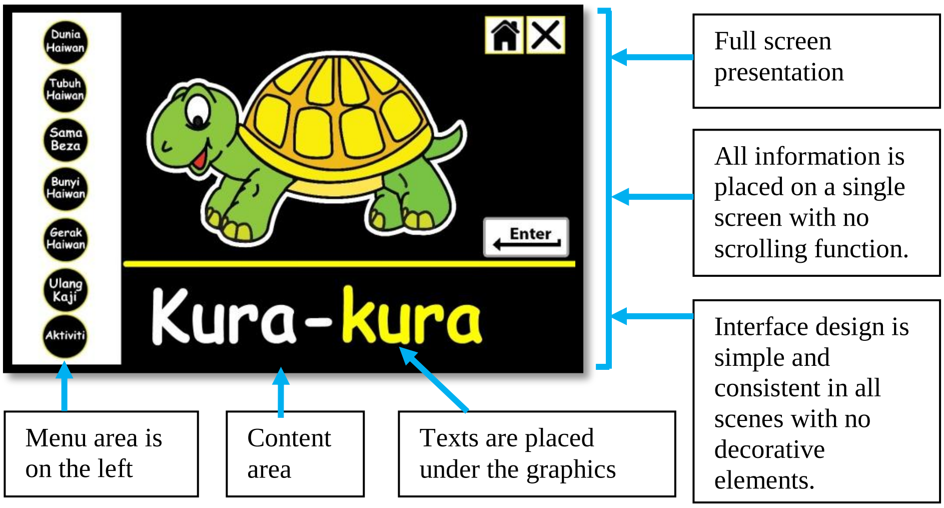
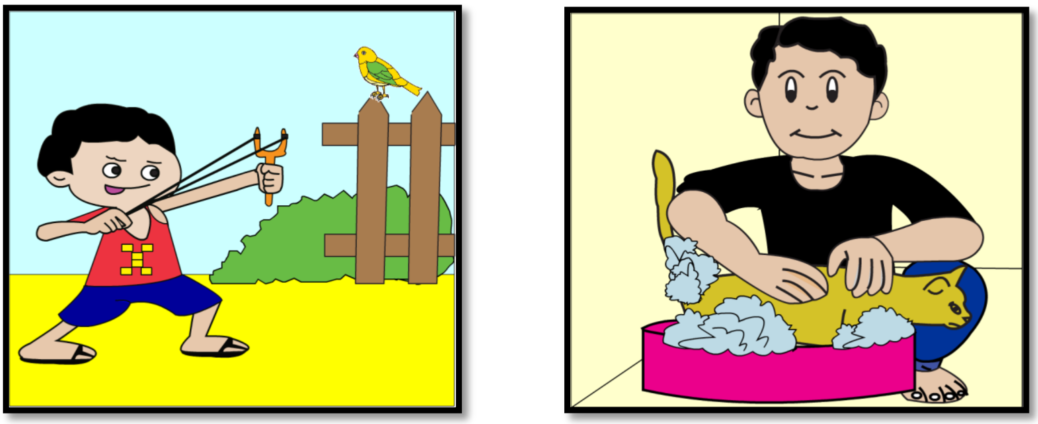


Figure 5.14: Interface Layout in the AC4LV

ii) Presentation Styles

Delivering the actual content is related with presentation styles. Three types of presentation styles applied in the AC4LV are lecturing, instruction-based, and demonstration.

Lecturing – Lecturing in the AC4LV is applied to emphasize certain outcomes of actions or any concept when needed. However, not too much lectures are given in a single scene to meet the needs of the low vision children. One point of information presented in one scene is sufficient for them. This is to avoid information overload. At this point, knowledge is delivered to them by applying the design principles provided for audio and animations. This is possible because the main actor in the course is the "Smiley" character, which acts as the instructor in the course. In this situation, the character speaks to the learners' (similar to a teacher speaks to the students in conventional classroom). However, proper intonations with friendly sentences are utilized in making the content accessible by the low vision learners. In this case, the actions in Figure 5.15 are followed with a lecture by “Smiley” in Figure 5.16.



a. Bad action *b. Good action*

Figure 5.15: Sample of Bad and Good Action

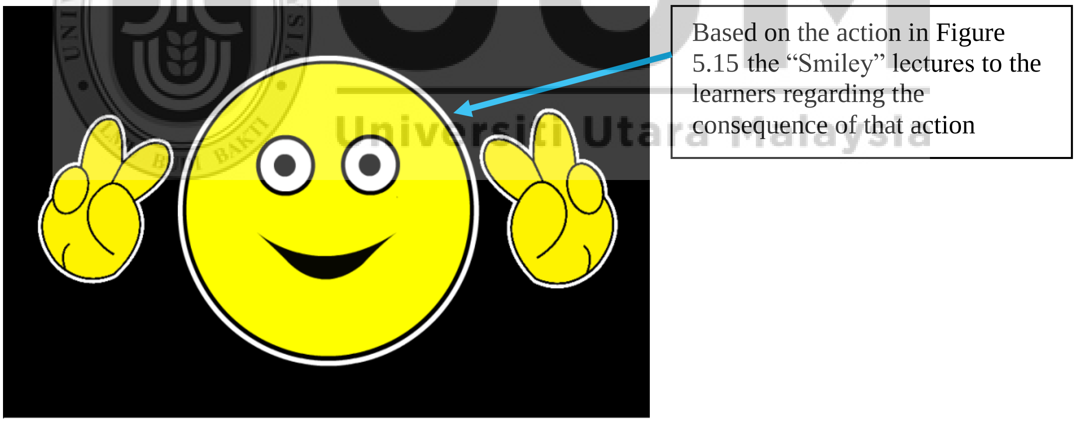
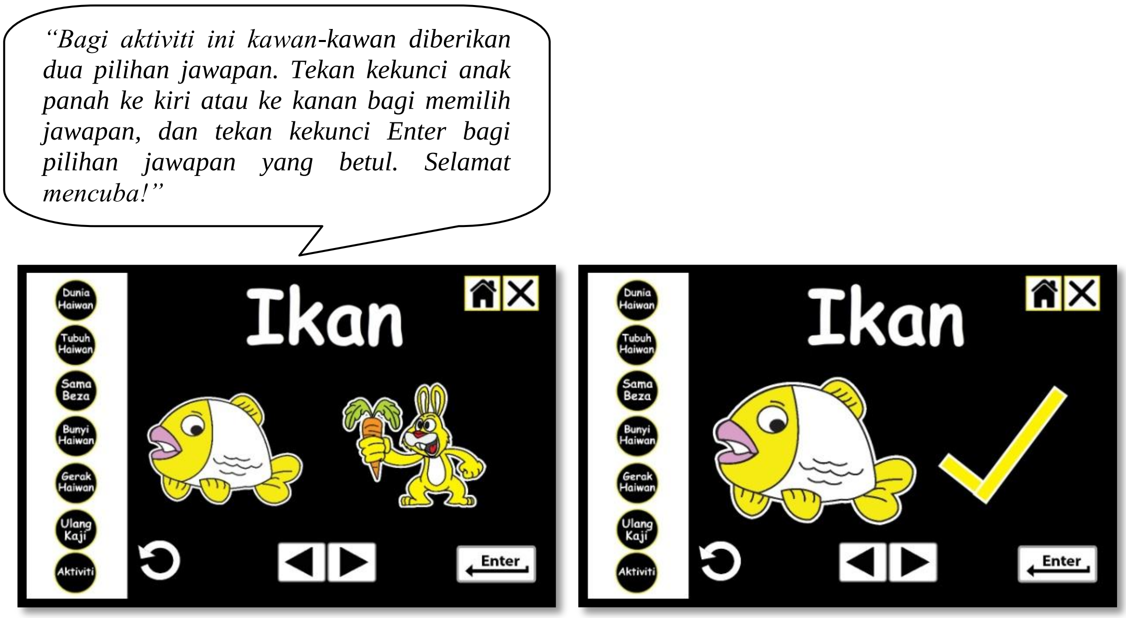


Figure 5.16: Lecturing Presented by “Smiley”

Instruction-based – Besides lecturing, instruction-based style is are also provided in some parts of the AC4LV, including instructions in introducing the menus, performing exercise/activity, and recognizing operational function in the AC4LV (i.e. enter, exit, repeat, forward, and backward). Delivering instructions in speech form, with the graphics and animations presentation is the most preferred practice for the low vision learners compared to texts presentation only. This is to avoid them from getting tired in reading the displayed instructions which could instantly negatively affect their learning motivation. In AC4LV, instructions are presented explicitly, which are delivered by the actor in two modes; as an unseen instructor or the "Smiley" character when necessary. Also, proper intonation and clear pronunciation are used to ensure the instructions are delivered and understood. Besides, using meaningful and understandable terms are also important to avoid the low vision learners misunderstand the content or provide wrong action since their limited eyesight could sometimes restrict them to notice the displayed desired information.

Demonstration – In AC4LV, instructions prior to starting the activity are presented simultaneously with demonstration. Demonstration is displayed in the form of graphics and simple animations, which follow certain design principles for visual. This is to enhance the learners understanding before they begin the activity. Besides, repeatable function is provided for users who misunderstand the information in the first round of demonstration. Figure 5.17 exhibits two samples of instruction-based and demonstration style provided in AC4LV.



a. Instructions are delivered by the unseen instructor

b. Demonstration are displayed in animations

Figure 5.17: Instruction-based and Demonstration in the AC4LV

iii) Teaching and Learning Techniques

Teaching and learning techniques applied in the AC4LV are auditory explanation and activity-based. This is to comply with the AC4LV, which is designed as a pleasurability learning material to assist the low vision learners compared to conventional learning techniques and existing courseware.

Auditory Explanation – Auditory explanation means each of the information displayed in the AC4LV has to be explained through audio by incorporating certain design principles for audio. This explains that the use of text is minimal. Most of the auditory explanation in the AC4LV is applied in delivering the actual content for each topic except for topics 4 and 5. With the limited eyesight that the low vision learners have, it is possible for them to misunderstand some of the information that are visually presented. So, this style of presentation is required. At this point, the script prepared in production phase is really important. The explanations have to be synchronized with the desired visual information. Figure 5.18 illustrates two screenshots for the auditory explanation.

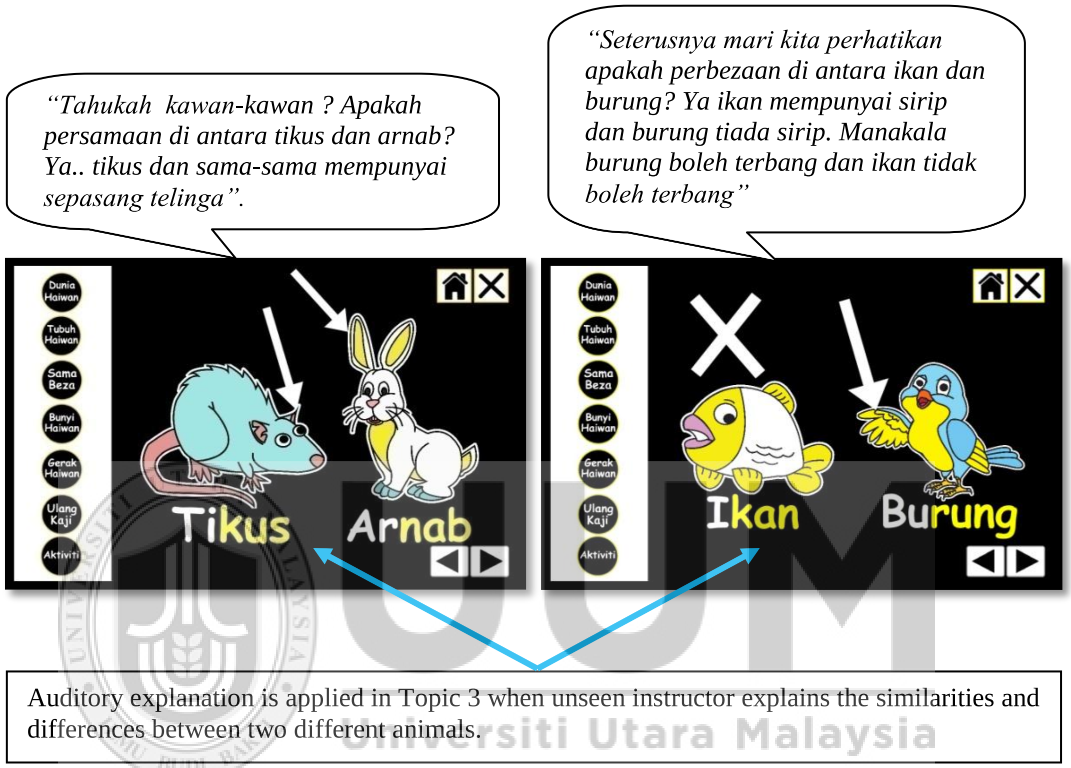


Figure 5.18: Auditory Explanation

Activity-based – The low vision learners are also able to learn through activities in topics 1 until 5 except for topic 4. Activity is one of the techniques that could influence the low vision learners to actively interact with the courseware. In the activity part, keyboard-based interaction would facilitate the learners in answering the questions. After finished answering each question, results are informed to the learners and they are rewarded with marks at the end of the activity. From here, the learning process occurs. In fact this technique seems similar with TC. However, it is important to inform that each activity provided in the AC4LV is presented by incorporating the design principles for formatting styles and texts, graphics, and general interaction. This makes the AC4LV differ from the TC. It is to confirm that the low vision learners could access the activity provided for them. Samples of related shot can be seen in Figure 5.19.

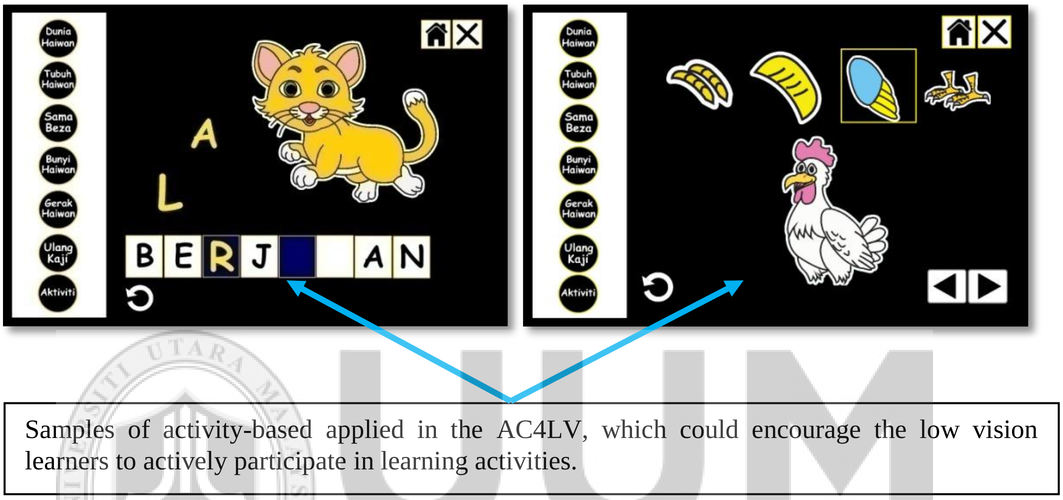


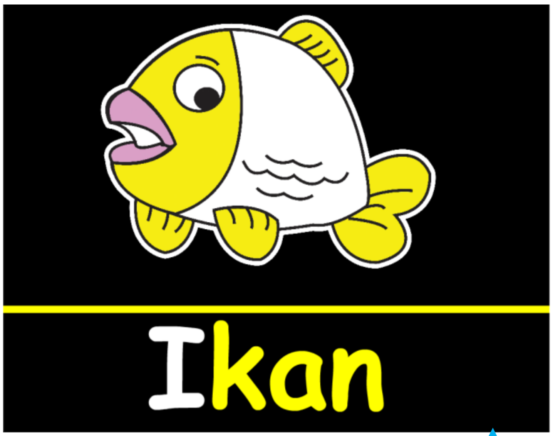
Figure 5.19: Samples of Activity-based Applied in the AC4LV

iv) Content Delivery Strategies

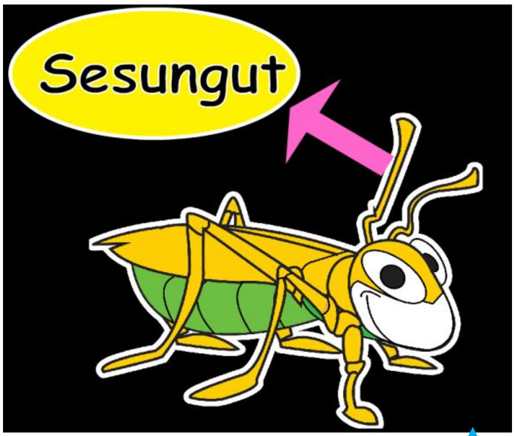
Welcome, Title, Briefing, and Lesson Objective – The actor clearly and friendly welcomes the learners by wishing them "*welcome*" and introducing the title of the content. Briefing is included together with the learning outcomes, which comes next. Subsequently, the actor reminds the learners to get ready to enter into the course content. The actor addresses all of it verbally in the form of narration. At this beginning scene, a "Smiley" character appears to catch the learners' attention. The related shot is as displayed in Figure 5.10.

Assistive Content – Assistive content is the core part in the AC4LV. This interprets that the whole part of AC4LV is designed to have information accessibility, navigationability, and pleasurability aspects. Come to the next point is the elaboration of these three aspects associated to AC4LV.

- **Information Accessibility -** Information accessibility refers to all contents that presented in AC4LV are able to be accessed by the low vision learners. The prototype makes use of audio, texts, graphics, animations, transitions, and interface layout as discussed previously to assists the low vision learners in acquiring the information as well as generating knowledge. Generally, this statement seems that the AC4LV is similar to TC (most courseware provided those multimedia elements to facilitate users). However, it has to be emphasized that each of the elements and the design principles provided inside it are associated to each other to make the AC4LV accessible to low vision learners. This interprets that, in delivering the content, each of the elements not only implements their own design principles (as the proposed model) but also they support each other. As an example, in the prototype of this study even though texts and graphics are already displayed on the screen as desired, auditory explanation is still provided to ensure the low vision learners do not misunderstood the displayed information. In addition, a single angle of transition in displaying the content is also applied when necessary. This means no transition in presenting the actual content is also encouraged to apply. Figure 5.20 clarifies these.



a. Sample of screenshot of Topic 1



b. Sample of screenshot of Topic 2

Text: Sans serif, regular, and bold font face are used. The foreground and background color is highly contrasted. Text is placed on a solid background. Single font style is applied. Comic Sans is a conventional style text, which is applicable for children. Minimum use of text on a screen is applied. Only static text is utilized, which means no rollover and animated text applied. Concise and similar type of text are applied throughout the content.

Graphic: Graphic is created to have the contrast outline bordered the desired attribute. The size occupies the screen. The combination of color between foreground and background is highly contrasted. Only the meaningful graphic is placed on the screen with no unnecessary detail.

Audio: Auditory explanation is supplied to support the presented information for both topics.

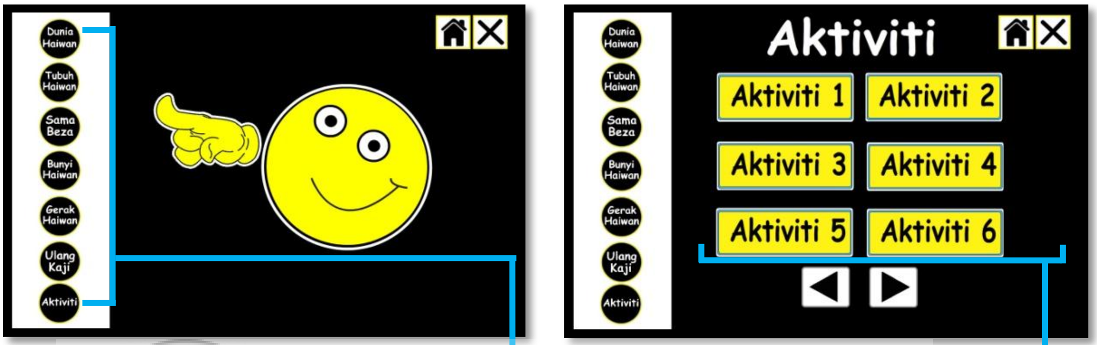
Animation: Simple animations are created on animals' character to attract the learners' attention and to strengthen the learners' understanding after the desired information is explained to them.

Transition: Single angle of transition for text and graphic is applied in Topic 2.

Information accessibility is addressed in these elements, with their reduced visual acuity, the low vision learners are able to grasp the learning content in the AC4LV.

Figure 5.20: Integration of Text, Graphic, Audio, Animation, and Transition to Cater Information Accessibility.

- **Navigationability** – Navigationability not only refers to flexibility in navigating the content in the AC4LV as discussed in the pre-production phase, but also to what extend the flexibility meets the low vision learners' requirements. At this point, the elements for navigational tool, interface layout, and general interaction are designed to fulfill the navigationability aspects. The consistency of the interface layout guides the low vision learners to navigate the AC4LV on their own. Audio is provided to mention that there are navigational buttons as well as other operational functions on the screen. General interaction is discussed in subsection of "Human Entities". Figure 5.21 clarifies the navigationability aspects implemented in the AC4LV.



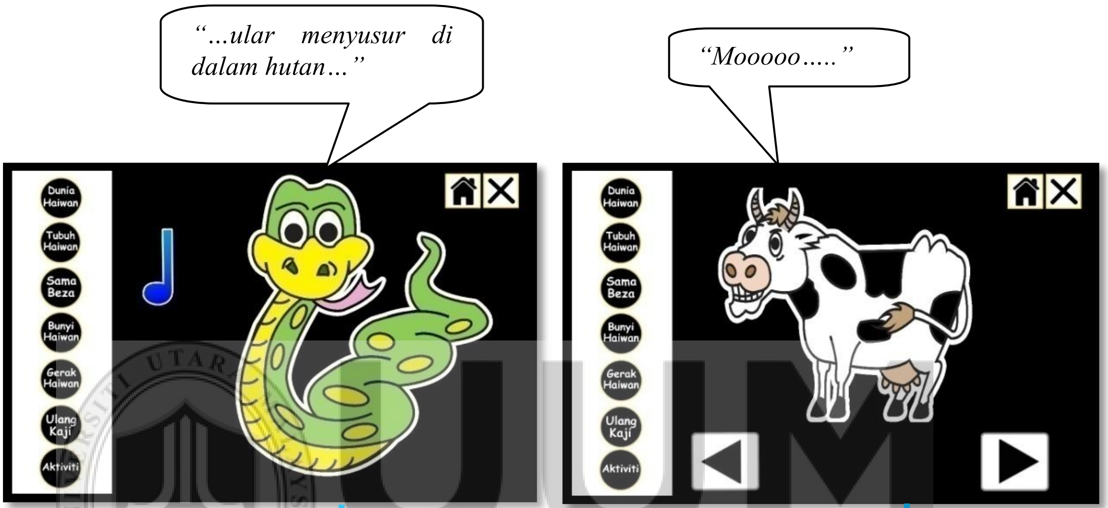
a. Navigational button for main menu   *b. Navigational button for activities*

Navigational button – Buttons are designed to look clickable by following the design principle for texts and graphics in terms of size and color. The number of buttons matches the content. Locations of buttons are supported with the design of interface layout, which is easy for the low vision learners to attain it when necessary. There is no blinking button or image button in the AC4LV, because they restrict the users in accessing the navigationability aspects. Other than audio, navigationability are also supported with animations when the Smiley's hand points to the button one by one while the instructor narrates the instructions for the main menu buttons. With friendly voice and intonation, the users are explained on how to navigate to each of the topic or activity.

The ability of the users to navigate the whole content in the AC4LV through the provided design principles without losing control addressing that navigationability is successfully achieved.

Figure 5.21: Sample of Snapshots for Navigational Button in the AC4LV

Pleasurability – Pleasurability takes place when the low vision learners keep amused throughout the AC4LV. This can be obtained through animated characters and friendly voice intonation as depicted in Figure 5.22. AC4LV attempts to reduce the difficulties that are currently faced by the low vision learners. This implicates that no pressure in using the AC4LV is also one of the main concern in gathering the pleasurability aspects. This could be achieved through information accessibility, navigationability, and all the "don'ts" in the design principles (i.e. "avoid using unnecessary decorative elements"). Fun elements through songs and sound effects also contribute to the pleasurability aspects in AC4LV.



a. Song and animations　　*b. Sound effects*

Song and animations – Children unproblematic to have fun through song and animations. In AC4LV song related to the content (*Gerak Haiwan*) are provided for them in Topic 5. To ensure the song is able to be delivered to the low vision learners, the design principles of audio, graphics, and animations are applied. No texts (the lyrics of the song) displayed on the screen to avoid crowded interface, which could affect the users negatively in accessing the information.

Sound effects – Children are entertained easily through sound effects. In AC4LV, sound effects are provided to support visual and auditory explanation. As an example, the sounds of animals are supplied in Topic 4 (*Bunyi Haiwan*).

c. Multiple types of voice over with multiple level of intonation

d. Reward wish with friendly voice intonation

Multiple types of voice over – Voice over is one of the audio elements that supports the needs of low vision learners. So, having multiple types of voice over with different intonation established with interesting script could engage the low vision learners in their learning activities.

Reward wish – Children like to get recognition from others, so providing reward wish after completing the activities could make them happy. But, for the low vision learners, having voice over with friendly intonation in delivering the reward is important.

Figure 5.22: Sample of Snapshots of Pleasurability Aspects Addressed in the AC4LV

v) Conduction Styles

The content in AC4LV is separated. Slide-based separators are provided when shifting to another exclusive topic to alert the learners about the change of those topics. The contents are mentioned through voice over. In most cases, the prototype applies speech-based separator to mention about the change of the content. This can be found when the instructors express phrases such as "*kawan-kawan sila tekan kekunci Enter untuk mengetahui bahagian tubuh saya yang lain*". This shows that sub-content in AC4LV is designed separately to avoid the necessity to face with crowded information. So, speech-based separators are applicable to alert them as illustrated in Figure 5.23.

a. *Separator of topic*

b. *Separator of activity*

Sample of separated scenes for topics and activities applied in AC4LV which follow the design principles for formatting styles and texts.

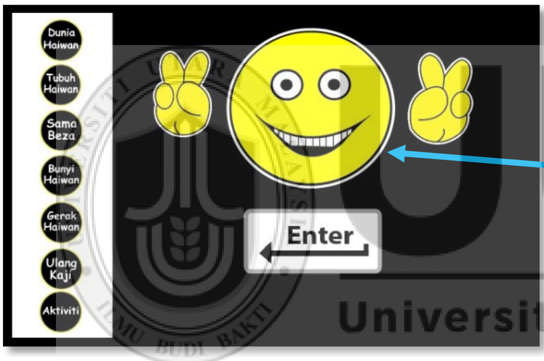
Figure 5.23: Separator Scene Applied in AC4LV

5.4.2.2 Human Entities

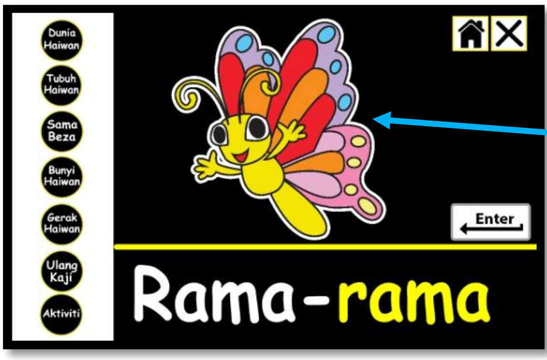
Two aspects related to human entities applied in the prototype are actor and interaction.

i) Actor

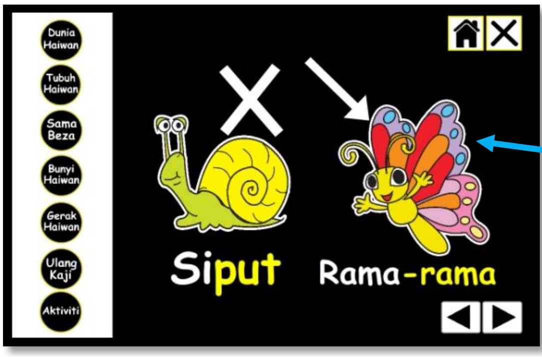
In teaching and learning, there must be an instructor and learners being involved. Both of them are actors. In the prototype, unseen instructor and character act as the actors with the main role to teach the low vision learners as well as advice and motivate them related to actual contents. With the limited visual acuity that the low vision has, it was hard for teachers to attract them in conventional teaching classroom, also with TC. In AC4LV, the teaching process is different in terms of presentation styles and teaching techniques. Both of actors are designed to attract the low vision learners' attention in terms of the color usage, voice over, and size. In conjunction to that, a "Smiley" character comes out in the show when needed with her friendly voice and intonation (i.e. opening segment, shifting to the new topics, and closing segment). Meanwhile, an unseen instructor takes place to enlight the necessary concept. Nevertheless, content characters appear with multiple types of voice over, either in topic or activity which mostly is to clarify about the content. All this can be seen in the related shots presented in Figure 5.24.



a. Sample of "Smiley" character



b. Sample of content character



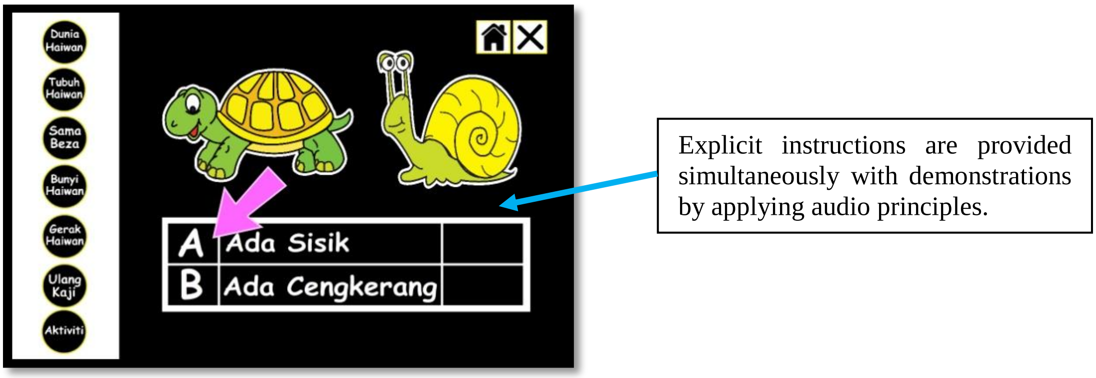
Only the voice of instructor appears here to explain about the content.

a. Sample of unseen instructor

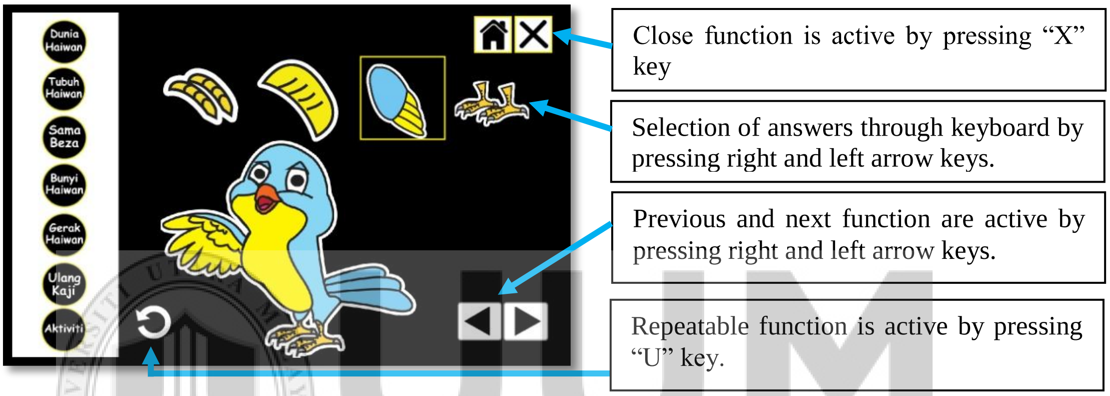
Figure 5.24: Instructor in AC4LV

ii) Interaction

Instead of teaching, having instructors in the prototype would also encourage the low vision learners to interact with the courseware and their peers. The instructor instructs the learners in learning the contents and performing the activities as well as guiding them in utilizing the operational functions. In overall, keyboard-based interaction is applied in each of the topics, activities, and operational functions. In return, the low vision learners would response based on the instructions from the instructor provided in the prototype. As a complementary, mouse-based interaction is provided as an optional at the main menu. All this is called as self-interaction as labeled in Figure 5.25. Besides, social-interaction is applied when the instructor and the content in AC4LV indirectly influence the low vision learners to arouse their idea, and encouraging them to discuss with their peers especially when comes to the problem solving activities. This is elaborated in Section 5.5.



a. Explicit instructions

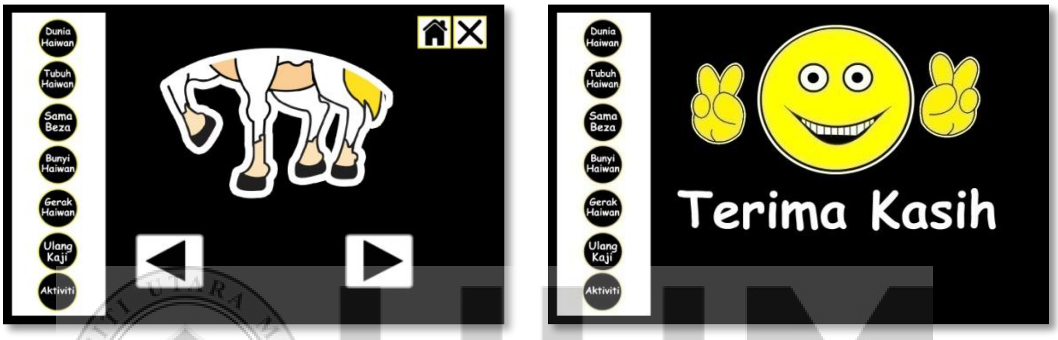


b. Keyboard-based interaction

Figure 5.25: General Interaction Applied in AC4LV

5.4.3 The Closing Segment

At the end of the courses, the prototype debriefs the learners by recalling the learning content. This is done through Revision Topic (Topic 6). Due to the lack of their visual ability, that depends 100% on audio. It is important for the low vision learners to recall the content that they have learnt. Recalling the contents is also executed by catering to information accessibility, navigationability, and pleasurability aspects. This supports the learners to understand the learning content and memorize it theoretically and practically after finishing the course. Figure 5.26(a) visualizes a debriefing segment, where the unseen instructor speaks to the learners recalling the learning content. Also, appreciation to the learners is addressed at the end of the show through narration speaks by the “Smiley” character (Figure 5.26(b)). It is followed by the list of production team presented in the form of text. The prototype in this study makes use of all original self-collected material. Hence, acknowledgement is not required.



a. Review lesson *b. Thanking remarks*

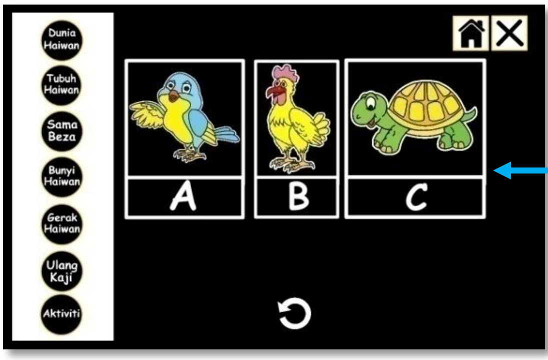
Figure 5.26: Closing Segment Addressed in AC4LV

5.5 Learning Theories in AC4LV

All learning theories applied in AC4LV are described in Table 5.4, Table 5.5, and Table 5.6. Also, some samples of related shots that show their connections with AC4LV are depicted in Figure 5.27 through Figure 5.30.

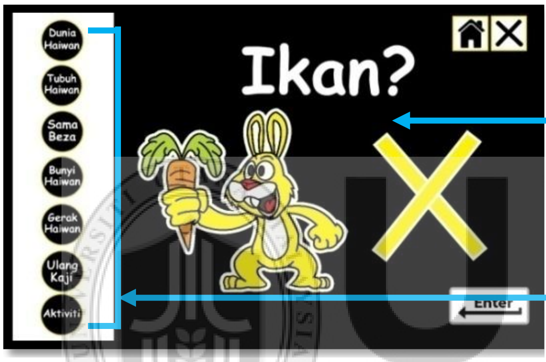
Table 5.4: Constructivism and Connectivism Theories Associated with AC4LV

Learning Theories	
Constructivism	**Connectivism**
• Create interesting learning experience by providing keyboard-based interaction. • Create interesting learning activities by offering multiple types of activities. • Pose meaningful learning content. • Construct realistic problem solving through activities.	• Audio, texts, graphics, and animation are nodes that connected to each other in delivering the knowledge to the low vision learners. • Create the social interaction among the learners as well as ensuring that knowledge is successfully delivered. • Provides opportunity for the low vision learners in making decision to choose what to learn.



Constructivism:
Interesting learning experience gained through keyboard-based interaction (e.g. press the key of "A" or "B" or "C" to select the correct answer). This requires the low vision learners to actively participate in seeking correct answers. Experience obtained from interaction with AC4LV would be meaningful knowledge for them.

Figure 5.27: Sample of Snapshot of Constructivism Theory Applied in AC4LV



Connectivism:
Audio, texts, graphics, and animation are nodes that connected to each other in delivering the knowledge to the low vision learners.
Through hybrid navigational style it provides opportunity for the low vision learners in making decision to choose which topic they prefer to learn.

Figure 5.28: Sample of Snapshots of Connectivism Theories Associated with AC4LV

Table 5.5: Multimedia Learning Theory Mapped to AC4LV

Principles	AC4LV Characteristics
Multimedia	AC4LV combines texts and graphics to be displayed on a screen in delivering the contents.
Spatial Contiguity	For the low vision learners, placing text under the graphic is more efficient compared to placing text within the graphic. This facilitates them to differentiate between texts and graphics.
Temporal Contiguity	In AC4LV, texts and graphics are presented simultaneously on a screen.
Coherence	No extraneous texts, graphics and sounds included in AC4LV. This presentation assists the low vision learners to have focus, clear and concise in their learning activities. Superfluous multimedia elements are actually impeding their learning focus.
Modality	This could be seen when "Smiley" character briefs and outlines the learning outcomes in narration to catch the low vision learners' attention in starting the learning activities rather than providing animation and on-screen texts, which actually makes them confuse and bored.
Redundancy	There is no redundancy in AC4LV. This explains graphics and texts are presented simultaneously with auditory explanation. Animations and musical are show concurrently with no text elements.

Individual Difference	This is proven through sound effects provided in the AC4LV, which is specially designed for novice and low spatial learners.
Signaling	AC4LV provides guidance for the low vision learners to navigate the courseware. Also, demonstrations are provided for them before start doing activities.
Segmenting	The topics and activities in AC4LV are presented logically from easy to hard. AC4LV allows the low vision learners to control the presentation by providing section separators and navigational button.
Pre-training	AC4LV form low level activities (e.g. two option of answers) before proceeding to the complicated exercise (problem solving activities).
Personalization	Font face utilized in AC4LV is conventional style (e.g. Comic Sans), which is more suitable to low vision children.
Voice	All words in AC4LV are spoken by friendly women voice with proper intonation, which could be a magnet for the low vision learners to stay focus on screen, rather than uses machine voice, which is quiet boring.
Image	No image teacher is presented in AC4LV. Only voice and character appear in the show. This assists the low vision learners to learn without facing crowded interface.

Multimedia Learning Theory:
Multimedia
Spatial Contiguity
Temporal Contiguity
Coherence
Redundancy
Individual Difference
Signaling
Personalization
Voice
Image

Figure 5.29: Sample of Snapshot of Multimedia Learning Theory Adapted in AC4LV

Table 5.6: MI Theory Connected to AC4LV

Intelligence	**AC4LV Characteristics**
Verbal-Linguistic	In AC4LV, the linguistic aspects are provided in written and auditory form such as in lecturing and instructions by providing auditory explanation and text-based information. Also, the low vision learners could learn spelling through the fill in the blank activities. This embedded both intelligences.
Logical	Multiple forms of activities provided in the AC4LV force them to use logical thinking.
Interpersonal	The learning content in AC4LV including topics and activity influence the low vision learners to discuss with their peers when comes to the complex content or problem solving activities. Motivations also could appear through discussion with peers.
Intrapersonal	Accessible content in AC4LV might encourage the low vision learners to monologue in the process understanding the content.

Visual-spatial	Accessible visual content in various formats such as texts, graphics, and animations makes the low vision learners actively interacting with space provided in the AC4LV.
Bodily-kinesthetic	AC4LV offers keyboard-based interaction and mouse-based interaction as options, which could assist the low vision learners to interact with the courseware through the part of their body movement such as hands.
Naturalist	This concept provides experience in terms of numerous species of flora and fauna, which could be achieved in the actual content provided in the prototype. A part from that, geographical concept was also included. This is addressed in Topic 1.
Musical	This aspect is embedded in the AC4LV by providing song, starting music, and sound effects to give fun elements to the low vision learners (e.g. Topic 5 - "*Gerak Haiwan*").
Existential	Having the naturalist content in the AC4LV could influence the low vision learners to have the sensitivity to the elements in their surrounding. This motivates them to ask deep questions.

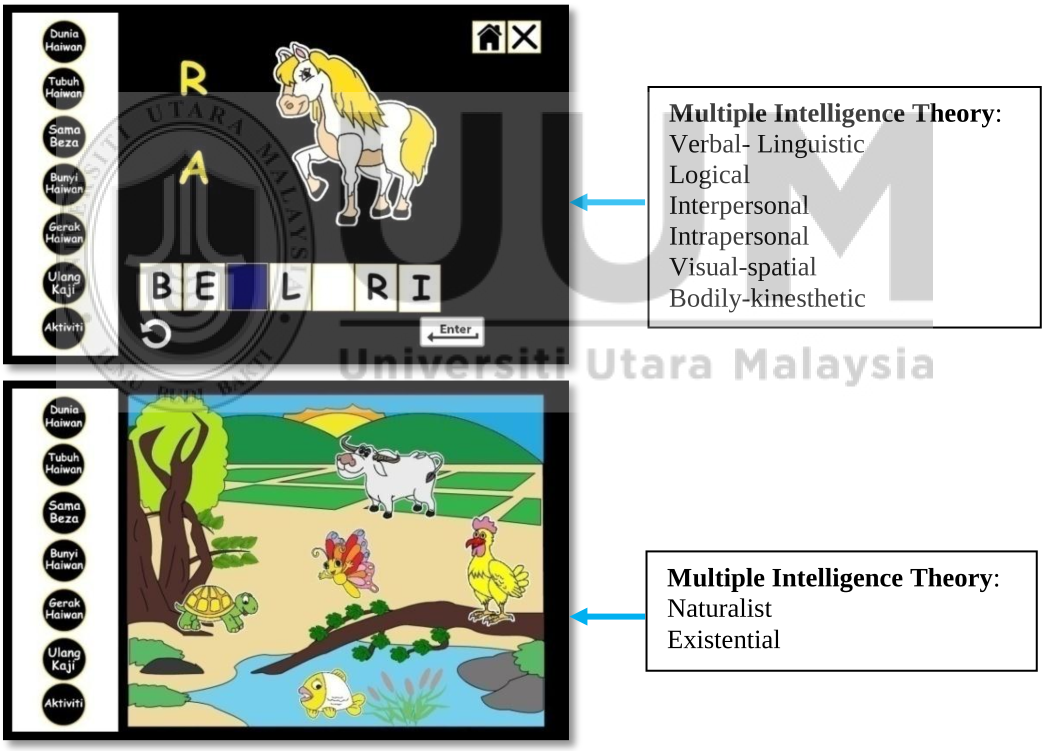


Figure 5.30: Sample of Snapshots of Multiple Intelligence Theory Applied in AC4LV

5.6 Learning Approach in AC4LV

All learning approaches as discussed in Chapter 2 are mapped with the AC4LV and explained in Table 5.7. Then, they are visualizes in Figure 5.31 and Figure 5.32.

Table 5.7: Learning Approach in AC4LV

Learning Approaches	AC4LV Characteristic
Mastery Learning	• AC4LV clearly states the objective of the course. • The chapters are divided into small topics and each topic has its own objective. • AC4LV applies appropriate instructional strategies through the presentation styles (i.e. Instruction-based and demonstration), and teaching and learning techniques (i.e. through auditory explanation which also involves formative assessment and activities which have summative assessment). Review lesson and reinforcement through instructions are also provided. • Each topic is preceded with activities. • The formative assessment provided in the learning content helps the low vision learners to do correction in activity. • No specific time is allocated to low vision learners in learning and doing activities in AC4LV. • This approach is embedded in AC4LV ensuring that, with the abilities that the low vision learners have they are able to achieve the similar level of learning among them without having pressure.
PBL	• The content in AC4LV use problem as the starting point to start the learning process (i.e. Topic 1 – with the sound effects and illustration of the paddy field environment the low vision learners start thinking where the location is, then they have to focus to decide on the desired information and finally get the explanation). • The above example also may involve small group discussion among the low vision learners in order to solve the problem. • Flexible guidance from instructor is provided in navigating the AC4LV as well as doing exercise. • Lecturing is provided in AC4LV only when necessary. • AC4LV give ample-time for the low vision learners to have their self-study which means they have their own initiative when and where to start the learning activities.
Active Learning	• AC4LV encouraged the low vision learners to be active during the learning process occurs. • This could be achieved by learning through song, sound effects, keyboard-based interaction, and meaningful learning content offered in AC4LV. • They not only listen to formal lecturing but they have to interact with AC4LV in gathering the inputs. • This explains AC4LV embedded the active learning approach.
Self-paced Learning	• AC4LV allows the low vision learners to have the self-paced learning by offering accessibility in content, navigationability in navigating the content, and pleasuring in learning. • This implicate that, AC4LV could facilitate the low vision to precede the learning process without intermediate response from instructor. • With the design principles applied in AC4LV, it allows the low vision learners to learn anywhere and anytime at their own pace (i.e. explicit instructions, understandable demonstrations, and clearly guidance).

Mastery Learning:
Low vision learners have no specific time to complete the activities. This could avoid them from facing pressure in learning and doing activities. They also are allowed to repeat the activities until they find the satisfied result.

PBL:
Through visual and audio this activity requires the low vision learners to think and solve the problem alone or discussed with peers.

Figure 5.31: Mastery Learning and PBL Approaches Mapped to AC4LV

Active Learning:
Meaningful learning content appears after pressing the left arrow key. This encourages the low vision learners to know more about the next attribute.

Self-paced Learning:
With the provided instructions (auditory explanation with friendly voice intonation), it facilitates the users to have their own learning pace.

Figure 5.32: Active Learning and Self-paced Learning Approaches Adapted in AC4LV

Having mapped all those learning theories and approaches in the AC4LV, it could be noticed that learning unable to take place among the low vision learners if the learning content does not address to information accessibility, navigationability, and pleasurability aspects.

5.7 Summary

This chapter addresses the processes involved in validating the Conceptual Design Model of AC4LV, which is via prototyping. AC4LV was developed for this study with the main aim to validate the Conceptual Design Model of AC4LV. It was developed by following the component of development process recommended in the Conceptual Design Model of AC4LV. AC4LV make uses three phases of development process which are pre-production, production, and post-production supported with ARCS model.

Also this chapter translates all the proposed components, elements, and design principles into AC4LV, which are depicted in a series of snapshots. Learning theories and approaches embedded in AC4LV are also mapped in this chapter. Having detailed the above section, this study concludes that the third objective of this study was achieved.

Eventually, the prototype is ready for use to gather data in the planned user experience testing. As outlined in the fourth objective, it is necessary to use the developed prototype to determine whether the Conceptual Design Model proposed in Chapter 4 has the ability to cater information accessibility, navigationability, and trigger the feeling of being pleasurability. Chapter 6 discussed the user experience testing.

CHAPTER SIX

USER EXPERIENCE ON AC4LV

6.1 Overview

Chapter 1 and 2 explore and reveal the problems faced by the low vision learners in their learning activities. As a solution, a conceptual design model of a learning material designed specifically for the low vision learners has been constructed as explained in Chapter 4. The model has been validated through expert review method. Next Chapter 5 explains the validation process of the proposed model through prototyping method in effort to achieve the third objective. Consequently, in achieving the fourth objective, this chapter discusses the user experience of using AC4LV in terms of information accessibility, navigationability, and pleasurability aspects.

6.2 Special Testing Requirements

When working with disabled learners as the research subjects, it is important to adopt creativity, multi-method, and flexible approaches to tailor to their needs (Shaw, Brady, & Davey, 2011). They are special, who are less predictable than the adolescent or adult computer users. This means written instructions are meaningless because they are not able to understand the concepts used for adults (Raisamo et al., 2006). Similarly, Shaw et al. (2011) also do not advocate with questionnaire particularly self-completion type for children under 12 years old because they may not respond genuinely or their response are influenced by biasness. Also, questionnaire or web-based survey is certainly not appropriate if the research subjects are sensitive (Shaw et al., 2011). In this study, the subjects have restriction in their sense of seeing. Eventhough if the questionnaire is read-aloud, it is very hard for them to make decision in choosing the most appropriate answer. Many aspects would influence them in making decision, such as confused with the scales and finally getting tired because this study has to cover three aspects of user experience as mentioned in the earlier chapter. Eventually, the biased responses may affect the credibility of this study. Hence, with reference to the discussions in Chapter 3, quantitative approach is less applicable for this study.

Hence, multidisciplinary aspects have to be covered in order to obtain the truthful results. As of the sensory impairment, VI children including low vision can have unclear concepts about trying out new things which differ from the sighted children. For that reason, concepts connected to the testing situation have to be carefully explained and presented to ensure that the subjects have the correct understanding (Raisamo et al., 2006). Accordingly, the testing procedures for this study cover the aspects of communication, disabilities, social and developmental psychology, and special pedagogy as suggested by Raisamo et al. (2006). They are applied in both techniques of qualitative approach; observation and interview. To seek findings of user experience on AC4LV and to increase the credibility, validity, and reliability interpretation of the findings, this study manage to have two cycles of pilot test and two cycles of user experience testing. They are as illustrated in Figure 6.1 and Figure 6.2.

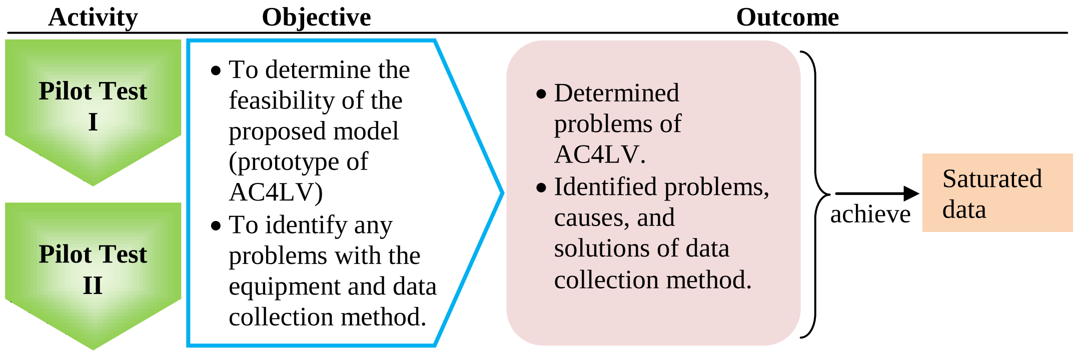


Figure 6.1: Two Cycles of Pilot Test

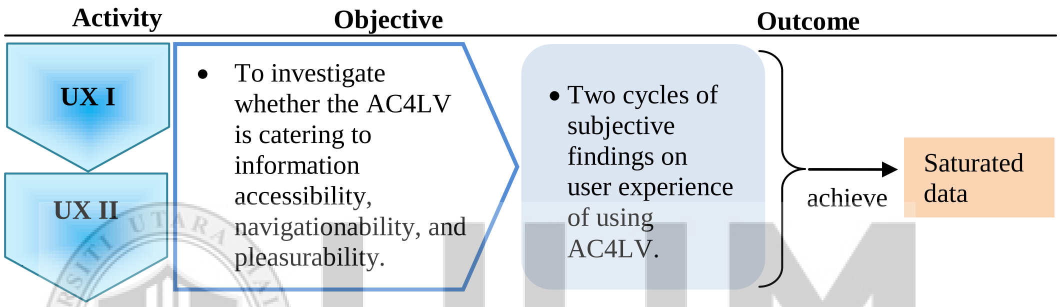


Figure 6.2: Two Cycles of User Experience Testing

As this study applies qualitative methods in seeking the findings, so having two cycles of pilot test and two cycles of user experiences testing is significance to obtain the saturated results. Also, in achieving the saturated results this study manages to have different pattern of procedure in conducting the user experience testing as qualitative research could have flexible research procedure (Boeije, 2010). Saturation is important to ensure that there are replication in categories and replication in verifiying the data (Bowen, 2008). Having replication in both of them ensuring that the findings is reach to compherehensive and complete (Bowen, 2008).

6.3 Pilot Test with Low Vision Learners

The purpose of pilot test with low vision learners in qualitative approach is different than in quantitative approach. In this study, pilot test was carried out with the main objective to investigate the wellness and consistency of user experience testing. Meanwhile, the specific objectives are (i) to determine the feasibility of the proposed model (prototype of AC4LV) and (ii) to identify any problems with the equipment and data collection methods (Herrington, 1997). This investigative work is important in determining if there are flaws, limitations or other weaknesses in the prototype of AC4LV, equipment, or data collection methods which allow this study to make necessary revisions prior to commencing the main study of user experience testing as suggested by Turner (2010) and Kim (2010). To achieve both sub-objectives, this study manages to execute two cycles of pilot test which are discussed in the following subsections.

6.3.1 Pilot Test I

The first cycle of pilot test was carried out at one of the Integration Primary School (Visually-impaired) in Malaysia (Appendix H attach the sample of approval letter from the school). Seven low vision children between nine and 12 years old involved in this test. Four of them were males while the remaining were females. However, one of the girls has to be excluded, because she was standard two, which is beyond the scope of this study. So, the total of the subjects considered in the test is six.

The reasons for scoping that range of age are as discussed in Chapter 2. This number is sufficient for a pilot test of qualitative research to represent the population of low vision learners locally or broadly as they are homogeneous subjects.

6.3.1.1 Procedure

Subjects were expected to feel more comfortable in their natural environment such as their routine class. Accordingly, the test was carried out in their routine class they are used to. The test was segmented into four segments; (i) briefing, (ii) observation, (iii) focus group interview, and (iv) closing. Before the testing commenced, two laptops were setup with AC4LV. In addition, recording sheets, video recorder, audio recorder, and screen recorder are prepared to record the observation and interview session. Appendix I attach the sample of permission letter from the parents regarding the video recording.

Having setup the equipment, the subjects were asked to get into two groups. This study managed to have four subjects in Group 1 and two subjects in Group 2. One laptop was attached to one group. They were setting to sit comfortably next to each other as seen in Figure 6.3 and Figure 6.4. They were briefed by introducing the team of the researcher and the purpose of this study. Finishing the first session, the second session started by playing the AC4LV to them. Think-aloud protocol as discussed in Chapter 3 was utilized in obtaining the truthful results. 30 minutes was enough for them to explore all the topics and activities in the AC4LV. That allocation time was also used by the researcher and the team member to record the observation in the form of video, notes, and photographs. Then, focus group interview was carried out in the third session of the testing. In this session, semi-structured interview questions were addressed to them. Having finished this session, the session was closed by thanking and giving token to the subjects.

Figure 6.3: Group 1

Figure 6.4: Group 2

6.3.1.2 Findings of the Pilot Test I

The *pilot test I* revealed a number of problems and inadequacies that have to be attended to, prior to conducting the main study. The adjustments that needed to be made are related to the feasibility study of the prototype itself and the practicalities of the data collection methods.

i) Problems with AC4LV (feasibility study of the prototype)

The AC4LV was completed seven days before the pilot study commenced. It was expected that there was no problem with AC4LV after quality checking and packaging. However, the use of prototype in the *pilot test* revealed a little "bugs" that needed to be attended to. The problems are (i) suddenly activity 2 stucks, which could not be accessed. So, the subjects were quite frustrated, (ii) there are noise in some of the topics and activities that needed to be removed, (iii) the screen resolution of AC4LV played in laptop for Group 2 was not fix to the screen size when viewed in full screen presentation and (iv) the timing of transition was quite bored . Thus, none of the "bug" was found serious to obstruct the data collection of the pilot study. Nevertheless, all of the problems were brought to the attention of developer who corrected them for the use in the main testing.

ii) Problems with the Data Collection Methods

The first cycle of the pilot test also revealed some problems with data collections methods primarily with the equipment setting, which impedes the fluency of the user experience testing. All problems encountered with data collection methods, their causes, and solutions are listed in Table 6.1.

Table 6.1: Problems, Causes, and Solutions Detected in the Pilot Test I

Problems	Causes	Solutions
Have to run the user experience testing in routine class not in school computer lab as scheduled.	Technical problems with school computer lab.	Setting to have the second cycle of pilot test in other school that completed with computer lab facilities.
One of the subjects from Group 1 showing uninterested emotion to join the testing.	Face restricted access to the laptop.	Each of the subjects should be attached to one computer for them to get the experience of using the AC4LV individually.
Audio disturb each of the group.	The usage of speaker provided in the laptop to ensure all the subjects get the content in the AC4LV.	Provide headset to each of the subject.
The subjects trying hard to get close to the laptop.	Limited access of audio.	
Very hard for the researcher to observe the subjects behavior for both group simultaneously while using the AC4LV.	Subjects' position was not proper.	Setting the subjects sitting in two lines.
Video camera have automatically stop recording in 30 minutes.	Memory card have no enough memory.	Have to standby extra backup of memory card.
Have problems in organizing tasks with research assistant.	Have no enough research assistant.	Hire one more research assistant.

It is important for this study to attach one computer for one subject in order for them to get the experience of using AC4LV individually. This is due to the results obtained from the observation, that one of the subjects of Group 1 showed uninterested to join the testing as he faced restricted access to the laptop. Furthermore, it was found that audio is not applicable to be played through loud speaker, which could disturb each of the group. Even this procedure has not affected the whole results but the experience of using the AC4LV is important to each of the subject. However, this study found that this type of testing would encourage the subjects to have active social interaction among each other regarding the content in the AC4LV. This influences them for not feeling afraid or introverted during the focus group session, so that they cooperate positively. Due to the detected problems, the second pilot test was conducted as detailed in the next paragraph.

6.3.2 Pilot Test II

Having gone through the experience in the *pilot test I*, the strategy was changed in the *pilot test II*. It was conducted at one of the Special Primary School of Visual Impairment in Malaysia. This school is facilitated with a computer lab that is specifically designed for VI learners including low vision. There were nine low vision learners participated in the test, ranging between nine and 12 years old. Seven of them were boys while the remaining two were girls. However, one of the boys has to be excluded from the analysis because he was totally blind, which is beyond the scope of this study. So, the total subjects involved in the *pilot test II* are eight. Next subsection discusses the detailed procedure of the pilot test.

6.3.2.1 Procedure

In this pilot test, two research assistants were employed to assist the researcher in setting up the testing. Having setup the AC4LV on the desktop as well as other equipment for observation as mentioned in the *pilot test I*, the subjects were asked to sit next to each other as comfortable as they prefer. It has to be emphasized that getting natural setting of learning environments is important for this study to obtain the truthful results. Each of the subjects was attached to one desktop that was equipped with headset individually as exhibited in Figure 6.5. Getting familiar scenario is important for qualitative study to obtain the valuable and truthful data.

Figure 6.5 also shows the similar scenario of the learning environment that the subjects go through in their routine learning activities. This is highly important in avoiding the subjects feeling weird, afraid, or stressed during the testing.

Figure 6.5: Subjects involved in Pilot Test II

Similar to *pilot test I*, the testing was segemented into four. By utilizing the complete equipments, the subjects were shortly briefed about the researcher and the team members as well as the purpose of the testing. Having finished the first session, session two started by recording the observation through notes, video, and photographs using think-aloud protocol. The time allocated for them is 30 minutes, which was sufficient for them to explore all the topics and activities contained in the AC4LV. After that, focus group interview was conducted in a relaxed environment to encourage them to talk as much as they desired. The last but not least, tokens were given to each of the student as appreciation of their involvement in the testing.

6.3.2.2 Findings of the Pilot Test II

After encountered all the problems addressed in the previous pilot test, the second pilot test found no problem with the prototype itself. Each of the subject has experienced the AC4LV smoothly. The observation in the test has given rich data in terms of the subjects' behavior and their reactions while using the AC4LV. The data are really important for this study to interpret the experience of the low vision learners in going through the AC4LV. Meanwhile, in terms of data collection methods, focus group was found quite challenging, especially in handling the subjects. At this stage, it was very hard for the researcher to get their own opinion in regards to answering the similar set of semi-structured interview questions. However, with the existing communication and psychological skills, this study successfully gathered the intended data. As to compliment the data, the subjects were interviewed individually face-to-face.

6.3.3 Observation and Interview of Pilot Tests

By utilizing non-participant and structured observation with think-aloud protocol as discussed in Chapter 3, rich and valuable data of subjects' behavior while using AC4LV were gathered from both of the pilot tests. Eventhough the operationalizing the activities in *pilot test I* were quite challenging for the researcher, to observe the two groups simultaneously due to their position, the session was backed-up with the video recording for observation. Due to that, in the second cycle of the pilot test, this study managed to set the position of the subjects in two lines, which was easy for the researcher to observe and record their behavior in the recording sheets as well as annotating their comments alive. Also, video recording is important as the backup for any missing data.

To consolidate the information gained from the observation and to provide corroboration of the data, interviews were conducted with the low vision learners in both of the pilot studies and the main study of the user experience testing. Interview questions were conducted in semi-structured format as discussed in Chapter 3. Patton (2002) discussed different types of interview questions as exhibited in Table 6.2.

Table 6.2: Types of Interview Questions

No.	Types of questions	Information Collected	Example
1.	Background or demographic	About the background or characteristics of the subject such as name, age, and level of school.	How old are you?
2.	Experience or behavior	About what the subjects do or have done.	Have you ever used a courseware before? If so, which course/title?
3.	Opinion or values	About what the subjects think regarding their experience and interpretive process or believe to be important.	What are the strengths of this courseware?
4.	Feeling	About the subjects' emotional reactions to their experiences and thoughts.	What are some of the things you really like about this courseware?
5.	Sensory	About what the subjects experience through their five senses (seen, heard, touched, tasted, and smelled).	What have you seen in this courseware?
6.	Knowledge	About the factual information that the subjects know or have.	Since when have you used computer?

Interview would provide means in obtaining genuine information from children because children even as young as three years old are able to give graphic representations and are able to recall their experience excellently (Docherty & Sandelowski, 1999). However, to ensure that the children could recall and convey their experience completely, accurately, and consistently, the content, timing, number, and structure of interviews have to be set in a proper way (Docherty & Sandelowski, 1999). So, it is particularly important that the interview questions are piloted to guarantee that the structure, language, and length of the interview questions are acceptable (Shaw et al., 2011).

It was found that majority of VI learners in Malaysia, face difficulties in understanding English, so mother tongue language was decided as the most appropriate medium (Nurulnadwan, Nur Hazwani, Erratul Shiela, & Ariffin, 2011). The interview was started with informal chats with the subjects to build-up the harmonized environment (Patomäki, Raisamo, Salo, Pasto, & Hippula, 2004). Table 6.3 classifies the interview questions for this study according to Patton's classification together with a brief rationale for each of the question.

Table 6.3: Classification and Rationale of Interview Questions

No.	Question	Type of Question						Rationale
		Demo	Exp	Opin	Feel	Sen	Know	
Background of subjects								
Q1	Ask about name, age, gender, level of school, race, and level of low vision.	√						Brief demographic information to make the subjects feel comfortable along the interview session. Furthermore, demographic information can explain the results or trends.
Experience of using computer and any courseware								
Q2	Since when have you learned to use computer?						√	Knowledge question to ascertain the level of experience of using computer.
Q3	Where do you learn it?						√	
Q4	Have you ever used a courseware before? If so, which titles/courses?		√					Experience question to ascertain the level of experience of using courseware.
Q5	What do you think of the courseware?		√					Open-ended question to encourage the subject to talk descriptively rather than forming the habit of providing the short answer (M. Patton, 1990). This question permits the subject to reply in their own terms and sentences (Herrington, 1997).
General experience of using AC4LV								
Q6	What do you think of the AC4LV?			√				Opinion question to influence the subject to review the AC4LV prior to offering more detailed opinion question.
Q7	What are the strengths of AC4LV?			√				These are presupposition question that assume the AC4LV has strengths and weaknesses that could elicit useful information.
Q8	What are the weaknesses of the AC4LV?			√				
Q9	What have you learned from the AC4LV?		√					Open-ended experience question to elicit whether the subjects understand about the course that they have learnt. This is to ensure whether the AC4LV achieve the objectives to fulfill the needs of the low vision learners in terms of information accessibility and navigationability prior to ask more specific questions.
Q10	If you have the power to change the AC4LV, what would you make different?			√				Opinion question which seeks recommendation for changing or improving the AC4LV.

Q11	How do you think the AC4LV will affect your performance in learning?			√				Speculative question which can be compared to preliminary study.
Elements in the AC4LV								
We have been talking about your experience of using the AC4LV in general. Now, I would like to ask your opinion on some of the specific features of the AC4LV.								Transition statement to move into the discussion of each of the specific elements and features of the AC4LV.
Information Accessibility								
Q12	What have you seen in the AC4LV?					√		Sensory questions to elicit on seeing sense whether the subjects, could access the information displayed on the screen.
Q13	What do you think about the texts in the AC4LV?			√		√		Open-ended opinion question to elicit whether the subjects could access the information presented through the texts, which is also related to their seeing sense. This is important to find out whether the texts could be accessed by the subjects.
Q14	What do you think about the terms displayed in the AC4LV?			√				This is an extended question if all the texts displayed in the AC4LV are accessible. So, open-ended opinion question to seek whether all the terms displayed in the AC4LV is understandable should be asked.
Q15	What do you think about the graphics and animations in the AC4LV?			√		√		Open-ended opinion question related to the graphics and animations to seek whether they make sense to the subjects in accessing knowledge.
Q16	What have you heard through the AC4LV?					√		Since low vision learners rely 100% on audio, this sensory question elicits whether the subjects could access the information conveyed audio form.
Q17	What do you think about the audio provided in the AC4LV?			√	√	√		Open-ended sensory question that requires opinion from the subjects to seek whether the design principles supplied for audio is meet to their needs in accessing the knowledge. Also, because of audio support, the subjects could express their emotion.
Q18	What do you think about the transition provided in the AC4LV?			√		√		Open-ended question targeted to find out whether the subjects are able to catch the information displayed on the screen through their seeing sensory.

Q19	What do you think about the layout of the AC4LV? (in terms of information accessibility)			√		√		Open-ended opinion question related to their seeing sensory to inquire whether the interface layout designed in the AC4LV could assists them in accessing the displayed information.
Navigationability								
Q20	What do you think about the layout of the AC4LV? (in terms of navigationability)			√		√		Open-ended opinion question related to their seeing sensory to inquire whether the interface layout designed in AC4LV could assists them in navigating the AC4LV.
Q21	What do you think about the navigational button in the AC4LV?			√		√		Open-ended opinion question to obtain whether the navigational button in the AC4LV could assist them in navigating through their seeing and hearing sense.
Q22	What do you think about the instructions provided by the AC4LV?			√		√		Open-ended opinion question to find out whether the instructions in the AC4LV could assist them in accessing the information and guide them in navigation.
Q23	What do you think about the interaction in the AC4LV?			√	√			Open-ended opinion question to seek whether the subjects could interact with the AC4LV.
Emotional reactions of using the AC4LV (Pleasurability)								
Q24	What do you feel of using the AC4LV?				√			Feeling question to find out the emotional reactions of using the AC4LV. This is to elicit whether the AC4LV could make them pleasurability.
Q25	What are some of the thinks do you like most about the AC4LV?				√			
Q26	What are some of the thinks do you dislike about the AC4LV?				√			
Q27	What do you think about the character in the AC4LV?			√	√			Open-ended question which are aimed at finding out the information accessibility which is provided through animated character. This question can also identify subjects' emotional reactions.
Closing Comments								
Q28	You are very helpful. Do you have any other thoughts or feelings on using the AC4LV?			√				Final open-ended question to obtain any further comment. Closing remarks, giving tokens, and thanks.

Note:

Demo	=	*Demostration*	*Opin*	=	*Opinion*	*Sen*	=	*Sensory*
Exp	=	*Experience*	*Feel*	=	*Feeling*	*Know*	=	*Knowledge*

6.3.4 Implication of the Pilot Test to the Study

Based on the two cycles of the pilot test, rich experience were collected as guidance for this study to conduct the real study of user experience testing. As Kim (2010) points out, a pilot study may not be intended to produce results. Thus, this study aims to investigate the wellness and consistency of user experience testing. Thus, both of the pilot studies have achieved the objectives. It was found that, the AC4LV has to be experienced individually. This means that one computer is attached to one subject because testing the AC4LV in groups was found not practical for this study. Also, semi-structured interview has to be conducted individually not as focus group interview for the reason as discussed previously.

6.4 Ensuring Validity and Reliability

Ensuring the validity and reliability is the fundamental aspect in research. Through careful sampling, appropriate instrument, and appropriate statistical treatments of the data, the validity and reliability of the findings for quantitative study might be improved (Cohen et al., 2007). However, for qualitative study, the technique is different in which difficulty is also commented by a number of previous studies (Herrington, 1997; Nantanoot, 2013). Nevertheless, it is important to increase the confidence of the research findings, so this study attends to it through the validity and reliability of the research procedures (Herrington, 1997; Nantanoot, 2013).

Validity in qualitative study means whether the findings of a study are true and convinced (Guion, Diehl, & Mcdonald, 2011). True means the sense the empirical findings adequately reflect the real meaning of the concept under consideration (Guion et al., 2011). Meanwhile, convinced refers to the sense that empirical findings are supported evidences (Guion et al., 2011). Validity also concerns the extent to which the findings are plausible, credible, and trustworthy (Bashir, Afzal, & Azeem, 2008). It is impossible for a qualitative research to be valid 100% (Cohen et al., 2007). However, the invalidity of the findings is able to be minimized by providing the best available approximation to the certainty of a given proposition, inference, or conclusion (Nantanoot, 2013). So, this can be defended when challenged (Bashir et al., 2008). As there are several types of validity (Cohen et al., 2007), only four were found most relevant to be addressed in this study which are (i) construct validity, (ii) internal validity, (iii) external validity, and (iv) expert validity. These four types of validity were also performed by the research related to accessibility evaluation of online learning management system for person with VI carried out by Nantanoot (2013).

i) **Construct Validity:** Construct validity refers to the extent to which a particular instrument for data collection confirms to the underlying theoretical context (Cohen, Manion, & Keith, 2011; Nantanoot, 2013). The main purpose of testing in this study was to investigate the experience of low vision learners in using the AC4LV in terms of information accessibility, navigationability, and pleasurability. To consider these research inquiries, the experimental testing is the most appropriate for collecting data, in which experimental testing allows the subjects to use and interact with the AC4LV in their actual educational setting. Meanwhile, the researcher is able to directly observe their interactions and reactions.

On the other hand, this would also provide opportunities for them to express their behaviors and emotions. In addition, semi-structured interview questions would also offer the subjects to express their opinions regarding their experience in using the AC4LV. At the same time, the researcher could flexibly probe to gain in-depth responses which are not possible by using structured interview or questionnaire (Nantanoot, 2013).

ii) Internal Validity: Internal validity concerns on the credibility which means the extent to which a causal inference of the study is reasonable. Such reasonable is the extent to which a study minimizes the systematic error or bias. This study achieves the internal validity through triangulation methodology and user experience testing that has been conducted in two cycles.

iii) External Validity: External validity refers to the degree to which the results can be generalized to other group of people, time, cases, or situations. In the context of this study user experience testing was carried out to the homogeneous subjects. Accordingly, the findings of the study can be generalized to all low vision learners of the same age.

iv) Expert Validity: Expert validity involving two or more experts to review, evaluate, and comment the gathered transcripts through their experience in effort to increase the confidence of findings prior to analyze the data (Lacey & Luff, 2001). This study involved two experts in reviewing, evaluating, and commenting the gathered trasncripts.

In naturalistic inquiries, reliability refers to the consistencies of the inferences of research findings (Rubin & Babbie, 2008). In qualitative studies, reliability concerns on the issues of replicability, which can addressed in three ways (Cohen et al., 2007; Rubin & Babbie, 2008):

i) **Stability of observation:** whether the researcher would give similar interpretations if the observations are performed at different time or at different place.

ii) **Parallel forms:** whether the researcher would give similar interpretations if she/he pay attention to another phenomenon during the observation.

iii) **Inter-coder reliability**: whether another coders that have similar expertise would give consistent estimates on the same phenomenon.

Having discussed the concept of reliability in qualitative study, this study admits that reliability is really important. Accordingly, this study has performed all possible efforts in ensuring the reliability. For stability and parallel form, this study applied it in triangulation methodology. Similarly, all the gathered themes, codes, quotations of interview, and occurrences of observation also have to be reliable before analyzing the datasets (Campbell, Quincy, Osserman, & Pedersen, 2013; Burla et al., 2014). Thus, this could be obtained through inter-rater reliability or inter-coder reliability in the coding of response (Cohen et al., 2011; Nantanoot, 2013).

6.4.1 Inter-rater (coder) Reliability

Inter-rater (or inter-coder) reliability refers to the extent to which independent raters or coders (two or more) evaluate the codes on the same transcripts and reach the same conclusion (Freelon, 2010). In this study, the transcripts gathered from the *user experience II* are given to two raters as the data has achieved the saturation. The external rater was asked to code two transcripts. Cohen's Kappa was utilized to measure the agreement between the two raters. Finding indicates that the Kappa value between rater 1 and rater 2 reach the satisfactory results (observation session: K = 0.856 and interview session: K = 0.966) (Figure 6.6 through Figure 6.7). A Kappa coefficient of K = 0.81 – 0.99 indicates the output is reach to almost perfect agreement by referring to Viera and Garrett (2005).

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.856	.060	18.307	.000
N of Valid Cases		38			

Figure 6.6: Cohen's Kappa Value from Rater 1 and Rater 2 for Observation Session

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.966	.023	26.041	.000
N of Valid Cases		65			

Figure 6.7: Cohen's Kappa Value from Rater 1 and Rater 2 for Interview Session

Having satisfied with the output, the transcripts then were transformed into the semantic network as visualized in the next section.

6.5 The Semantic Network

Having carried out the inter-coder reliability for the data collected, this study manages to illustrate the semantic network to visualize the qualitative information prior to analyzing the data. Appendix J illustrates the sample of semantic network for the information accessibility, navigationability, and pleasurability theme for the gathered data.

6.6 User Experience I

As discussed in the ealier section of this chapter, *user experience I* on AC4LV was carried out to investigate the experience of low vision learners using the AC4LV in terms of information accessibility, navigationability, and pleasurability aspect. The next subsection provides detailed explanation on demographic background of the subjects involved and the analysis of findings.

6.6.1 The Demographic Background of the Subjects

Testing of *user experience I* was conducted at Special Education Primary School of Alma (Visual impairment) (Appendix K attach the application letter and endorsement from the school principle). As tabled in Table 6.4 there were eight subjects involved in the testing; six of them are male (75%) and the remaining are female (25%) (depicted in Figure 6.10). This number of subjects is sufficient in qualitative study as discussed in Chapter 3. Most of the subjects have been introduced to computer since they were in standard three except for Subject 1, who mentioned that he learned to use computers since he was in pre-school. Also, all of them have experienced using online TC in school such as learning ABC, numbers, shapes, and school rhythm. All of them are exposed to the courseware as their school is specifically designed for VI learners which is complete with the required facilities. Figure 6.8 and Figure 6.9 illustrate the percentage of experience of using computer and experience of using TC.

Table 6.4: Demographic Background of the Subjects involved in User Experience I

Subjects	**Age**	**Gender**	**Race**	**Level of School**	**Experience of using computer (years)**
Subject 1	9	Male	Malay	Standard 3	3 years
Subject 2	10	Male	Chinese	Standard 4	1 year
Subject 3	11	Male	Malay	Standard 5	2 years
Subject 4	12	Male	Malay	Standard 6	3 years
Subject 5	12	Male	Malay	Standard 6	3 years
Subject 6	12	Male	Malay	Standard 6	3 years
Subject 7	12	Female	Malay	Standard 6	3 years
Subject 8	12	Female	Malay	Standard 6	3 years

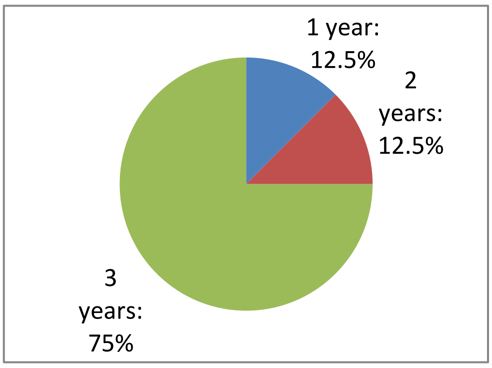


Figure 6.8: Experience of Using Computer

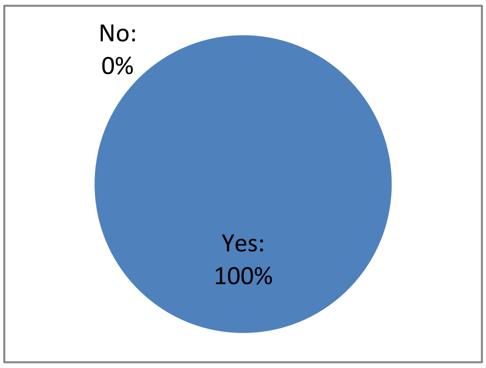


Figure 6.9: Experience of Using TC

Figure 6.10: Subjects involved in User Experience I

6.6.2 Analysis of Findings on User Experience I

The findings on *user experience I* were analyzed based on three themes: (i) information accessibility, (ii) navigationability, and (iii) pleasurability. The analyses are also divided into observation and interview.

6.6.2.1 Observation

Observation has been carried out based on three themes, in which each is discussed in detail.

Theme 1: Information Accessibility

User experience I investigated the information accessibility on the extend the low vision learners perceive the usefulness of texts, audio, graphics, animations, transitions, and interface layout. All those codes were gathered through their behavior while using the AC4LV. Their perceived usefulness on texts, audio, graphics, animations, and transitions were detected when the subjects were found speaking-aloud the content (i.e. "*Topik 4… Bunyi Haiwan*"). In particular, Subject 1 and Subject 2 express-aloud almost all the contents loudly. They also commented about the graphics (i.e. "*hi hi the butterfly is so beautiful*"). An example of the scenario can be seen in Figure 6.11. While the remaning subjects were also speaking-aloud softly. Sometimes, they also imitated the "Smiley" actions and sound effects (i.e. Smiley jump into the screen with sound effect "*toink, toink, toink*"). While using the AC4LV, all of them were found comfortable with their sitting. All this behavior and reactions indicate that the subjects have no problem in accessing the information in the AC4LV, which means they were able to see the texts and graphics, to hear the sound, and to capture the animations and transitions. On the other hand, through their ability to distinguish between texts, graphics, and menu it indicates that the subjects were able to accept the designed interface layout. This means that the interface layout of the AC4LV could assist the low vision learners in accessing the information presented on the screen.

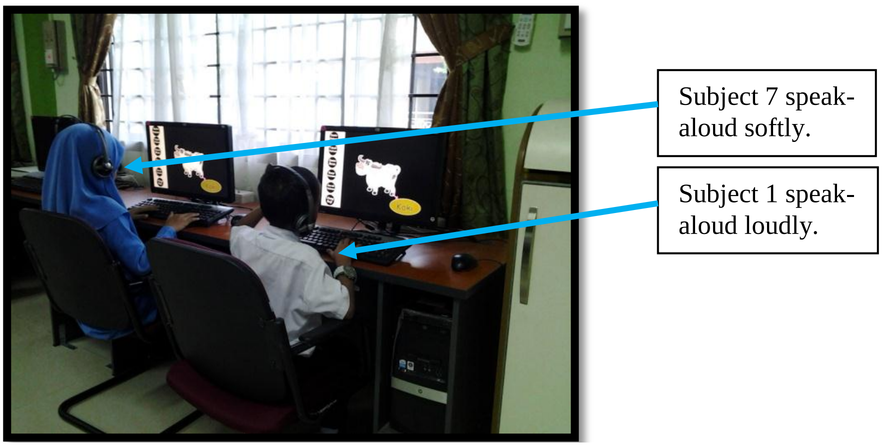


Figure 6.11: Speak-aloud the Content

Theme 2: Navigationability

Navigational button, interface layout, and general interaction are codes found in theme 2; navigationability. All the subjects were found able to recognize the buttons. In fact, they pressed the buttons in advanced confidently by skipping the instructions after they got familiar with the AC4LV. They were able to have self interaction. This means the provided button in the AC4LV are able to assist the low vision learners in navigating the content in the AC4LV. Also, in terms of interface layout, through their ability to identify the content area and menu area, the subjects were found are able to navigate the AC4LV on their own without any interference or assistance from anybody (Figure 6.12). They were found confidently pressing the keys on the keyboard, showing that they have no problem in interacting with the AC4LV. This also indicates that instructions provided in the AC4LV are acceptable, which could guide the low vision learners to interact and navigate the content of AC4LV. Thus, navigational button, interface layout, and general interaction in the AC4LV have met the needs of the low vision learners in navigationability.

Figure 6.12: Navigate the AC4LV

Theme 3: Pleasurability

After installing the AC4LV in each computer and setup the subjects' position, Subject 3 and Subject 4 started the AC4LV without the permission from the researcher. Eventhough after the researcher requested them to wait for the minutes, Subject 4 asked the researcher *"teacher can I start?"*. This explains that the subjects were enthusiastic and excited to try new things which also indicate that the low vision children have similar behavior with normal children when they face new technologies. Simultaneously, it also indicates that curiosity was also in their mind. Throughout the experiment, all the subjects were found concentrating and stayed focus on the content. This means that the subjects were interested with the AC4LV. It is because they had no problem with information accessibility and navigationability which made them to feel released in learning.

Enthusiastic, excited, curiosity, and interested are positive behaviors that lead the low vision learners to feel pleasurability as well as have no pressure while using the AC4LV. All subjects were able to follow the contents without any pressure. They were relaxed and enjoyed learning all the contents comfortably (Figure 6.13). On top of that, Subject 1 was found communicating with his peers; Subject 7, Subject 5, and Subject 8 to clearly understand about the content. Besides, Figure 6.14 depicts a picture of Subject 7 who was looking at her peers' screen to ensure that the content is similar. This means AC4LV led social interaction among the learners, which sometimes made them laugh. This indicates that the AC4LV could entertain the low vision learners in learning. When comes to Topic 5 "*Gerak Haiwan*", all the subjects were found enjoying the song. Subject 1 and Subject 2 sang the song loudly.

Meanwhile, the other subjects sometimes sang it loudly and sometimes softly. Their voices were bobbing. They also imitated the “Smiley” voice (i.e. “*Hai kawan-kawan…*”) and imitated the animals’ sound, explaining that the subjects were enjoying the contents in the AC4LV. Besides, instead of enjoy, the subjects were also laughing when they heard the cows’ mooing, indicating that the sound effects are humourous. They were also laughing with the “Smiley” response when they got wrong answer. For them it was glee. During the experiment, the subjects were found smiling especially everytime the “Smiley” appears on screen. This indicates that the AC4LV was amusing. After scoring 100% for the activities, the subjects clapped their hands. This indicates that they were happy. Enthusiastic, excited, curiosity, interested, released, comfortable, enjoy, sense of humor, amused, and happy are the behaviors found during the observation of *user experience I* which indicate that the AC4LV is pleasure.

Figure 6.13: Subjects Concentrate on the Content Comfortably and Relax

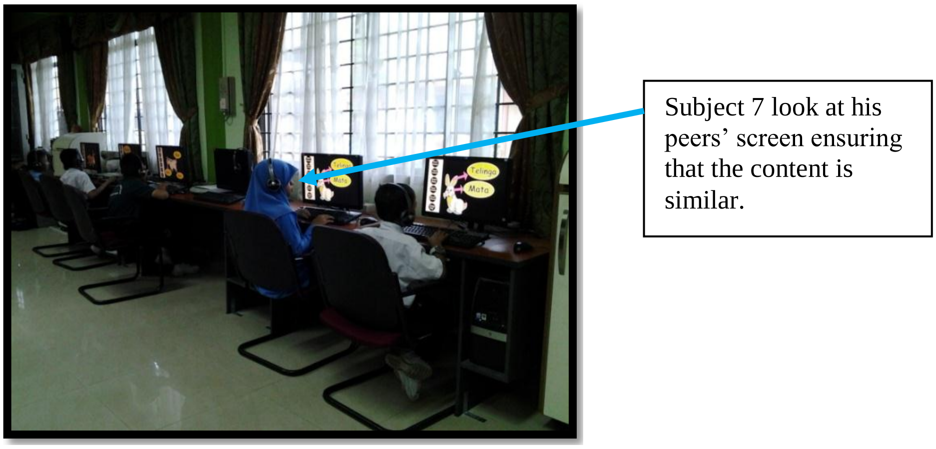


Figure 6.14: Ensuring the Similar Content

6.6.2.2 Interview

A series of interview was carried to support the data gathered in observation. In the interview, a set of questions was asked (Table 6.3). Q5 through Q11 regarding their opinion about the courseware and their general experience of using AC4LV was asked prior to ask in-depth questions regarding their opinions on elements of AC4LV. All of the subjects mentioned that they like learning using courseware (Q5). However, they have never used a courseware like AC4LV. They also mentioned that most of the courseware that they have used before have too little interaction and sound especially instructions. This means that, AC4LV is new to them. When asking their opinion about the AC4LV, they quickly answered that it was wonderful (Q6). Their face while answering the questions potrayed happiness. For them the strength of AC4LV is the sound (Q7).

Then, they were further asked "*what do you mean by sound?*". This study found that they like all the explanation, instructions, and sound effects in the AC4LV. Thus, this indicates that for the low vision learners audio is the most attracted element. This implies that providing audio according to the proposed model is really important. In contrast, the question regarding the weaknesses of AC4LV was also asked (Q8). It was found that 88% of the subjects agreed that there was no weakness in the AC4LV because all the problem found in *pilot test I* has been corrected. Nevertheless, Subject 2 disagreed with his friends' opinion because for him the provided sound for Topic 4 "*Bunyi Haiwan*" made him suddenly shock. "*I really don't like with the animals' sound in topic "Bunyi Haiwan" because it hurt my heart*". This implies that sudden loud sound has to be avoided.

Providing play and stop function could assist the low vision learners to get ready with the content. For Q9 all the subjects mentioned that they have learned about animals. Generally, all the subjects understand about the content, which means they are able to grasp the information in the AC4LV. For Q10, all the subjects wished to have more activities. For them the activities in the AC4LV were too little. Also, Subjects 2 expressed his recommendation to adjust the sound volume in Topic 4, which means sudden loud sound is not appropriate to the low vision learners.

Then, Q12 until Q28 were analyzed based on the themes. They are discussed separately.

Theme 1: Information Accessibility

Questions related to information accessibility theme is to seek whether the subjects were able to grasp the contents in the AC4LV through texts, audio, graphics, animations, transition, and interface layout. Particularly, Q12 determines whether the subjects could access all the displayed elements on the screen. For that, the subjects simultaneously answered that they have seen the animals and they also expressed the animals that they have seen on the screen (i.e. "*we see tiger, fish, rooster, buffalo...*"). Other than animals, they were also able to name plants and flowers. This indicates they were able to recognize the graphics and animations in the AC4LV.

Q13 is to determine their opinion about the texts used in the AC4LV. It was found that 100% of them mentioned that they like the text. This means that they were able to accept the provided texts and had no problem with it in terms of color, size, font type, and font face. So, further question was asked to ensure that all the provided term was able to be understood (Q14). For that question, 100% of the subjects were clear with the terms in the AC4LV. Meanwhile, Q15 is about the subjects' opinion on graphics and animations. Also, 100% of them were found able to accept the graphics. They mentioned that the color was clear and they had no problem with the size and movement of the animations.

In terms of audio (Q16), they mentioned that they heard variety of sounds. Then, they named the sounds (i.e. bird chirping, tiger roaring, water murmur…). This indicates that the subjects were able to access the information conveyed in audio form. For the next questions regarding the subjects' opinion about the audio, 88% of the subjects were able to accept all the provided audio in the AC4LV except for Subject 2, who expressed his frustration about the animals' sound provided in Topic 4. Again, he expressed "*I really don't like the animals' sound…it hurts my heart*".

This means the animals' sounds in Topic 4 have to be corrected prior to run *user experience II.* This is because providing appropriate sound effects is really important for the low vision leaners to ensure that the knowledge could be delivered successfully without disturbing their emotions. Moving on to the subjects' opinion about the transition (Q18), all of them responded that it was acceptable, which means through the provided transitions they have no problem to catch the information displayed on the screen. Meanwhile regarding the interface layout (Q19), all of them mentioned that "*it is okay*". Then, a contradicting question was asked "*does it make you feel crowded in accessing the content?*". Confidently they answered "*no*". So, this means that the designed interface layout in the AC4LV could assist the low vision learners to access the content in the AC4LV.

Theme 2: Navigationability

Moving on to theme 2, questions regarding navigationability aspects in the AC4LV were asked. In conjunction, opinion about the layout of the AC4LV related to navigation aspect was asked to the subjects (Q20). Their answer was similar with the previous question. Then, further question was asked "*does it make you feel difficult to navigate the AC4LV?*". Simultaneously, their answer was "*no*". This proves that the subjects have no problem with the interface layout in assisting them navigating throughout the AC4LV. About the navigational button in the AC4LV (Q21) the subjects' responses show that the button was clear enough. Then, further question was asked "*how about the size?*", which was responded "*yes the size is acceptable*". They were then asked "*could the button help you navigate the AC4LV?*". The answer was "*Yes*". This is to confirm whether they have any problem with the button or not.

So, the navigational buttons provided in the AC4LV was able to guide the low vision learners in navigating the content in the AC4LV. About the instructions provided in the AC4LV, it was asked next (Q22). They agreed that the instructions were adequately clear. Then, further question was asked "*Do the instructions make you confused?*". Their answer was "*no*". This confirmed that the instructions in the AC4LV could guide the subjects to navigate the AC4LV smoothly. The last question related to navigationability is about the interaction (Q23), which means whether the provided functions of interaction could assist the subjects to navigate the AC4LV. All of the subjects answered that they have no problem with the keyboard interaction. Then, Subject 2 added that interacting using mouse was also acceptable for him. This proves that mouse-based interaction can be created as optional.

Theme 3: Pleasurability

In investigating their pleasurability of using the AC4LV, questions regarding their emotions were asked (Q24-Q28). Before the interview session was started, Subject 5 expressed his feeling "*I feel want to do it again*". Then, he requested to the researcher by asking "*teacher can I do it again?*". This indicates that he was interested with the AC4LV. When asking about the question regarding their feeling of using the AC4LV the subjects cheerfully responded that "*it was fun*". Eventhough it is just a simple word, through their face reactions supported with their behavioral while experiencing the AC4LV, its' answering that AC4LV is pleasure. Then, responding to Q25 all of them answered that they really like the sound. Then, further question was asked *"what do you mean by sound"?*. Similar with *user experience I,* they mentioned that it is the "Smiley" voice. This means they like all the explanation and the instructions by the "Smiley", which interprets that auditory explanation is important in attracting the low vision learners to learn. Next, a contradicting question was asked (Q26). Again Subject 2 expressed his dissatisfaction as mentioned earlier. Subsequently, a question about character was asked (Q27). Also, without self-doubting all of the subjects said that they love all the character especially the "Smiley". This provides evidence that the characters make the AC4LV pleasure. As the closing question, the subjects were asked to express their feeling or thought. Again, Subject 2 repeated his frustration. In contrast, other subjects mentioned that they like using the AC4LV and have nothing to comment. Then, Subject 2 suggested *"teacher can you develop it for the English course?... because I love English".* It was followed by other subjects *"I want it for Bahasa Melayu course"* (Subject 6), and *"I want Mathematic"* said Subject 5. All their requests indicate that they are really interested to learn through the AC4LV in their learning activities.

6.6.3 Conclusion

In the *user experience I*, each of the subjects experienced the AC4LV individually. It was observed that through their behavior and reactions the AC4LV caters to their needs in terms of information accessibility, navigationability, and pleasurability. It is also supported with their thought gathered in the semi-structured interview. This means all the elements in the AC4LV are useful to them. Having corrected all the comments regarding their dissatisfaction on the AC4LV, again at the similar location the *user experience II* was conducted.

6.7 User Experience II

In effort to achieve the saturated data and to increase the confidence of findings, the second round of user experience testing was conducted. In *user experience I*, the AC4LV was tested to the low vision learners. From the testing, rich and valuable data were gathered through their behaviors while using the AC4LV. Also, their opinions regarding the AC4LV were gathered through their thought in the interview session. Thus, to overcome the weaknesses and intrinsic biasness that came from the previous testing and to produce a more comprehensive interpretation, the second round of testing is needed. The demographic background of the subjects, procedure, and analysis of findings are further detailed in the next subsection.

6.7.1 Demographic Background of the Subject

User experience II was conducted at Special Education Primary School of Alma (Visual impairment) as this school is completed with facilities that are specifically designed for the low vision learners. Table 6.5 provides detail demographic background of the subjects. Totally 11 subjects involved in the experiment, in which ten of them (90%) were male and only one (10%) was female. The unevenness of male and female subjects are not the main issue, as the main purpose of this study is to investigate to what extend the AC4LV could fulfill the needs of low vision learners in learning. All of them were in the range of nine to 12 years old. Their maximum experience in using computer is three years. While, the minimum is three month as seen in Figure 6.15. Particularly, Subject 7 has experienced using computer since he was in pre-school. In contrast, Subject 10 has only been using computers since the three month after moving into the school from an ordinary primary school. All of them have experienced using online TC as mentioned in the previous testing except for Subject 10, who was still new in exposure of TC. He has been using online TC since the last three months. So, this study concludes that all of the subjects have experienced using TC as illustrated in Figure 6.16.

Table 6.5: Demographic Background of the Subjects involved in User Experience III

Subjects	**Age**	**Gender**	**Race**	**Level of School**	**Experience of using computer (years)**
Subject 1	12	Male	Malay	Standard 6	3 years
Subject 2	12	Male	Malay	Standard 6	3 years
Subject 3	11	Male	Chinese	Standard 5	1 year
Subject 4	11	Male	Chinese	Standard 5	2 years
Subject 5	11	Male	Chinese	Standard 5	1 year
Subject 6	10	Male	Chinese	Standard 4	2 years
Subject 7	9	Male	Malay	Standard 3	3 years
Subject 8	10	Male	Malay	Standard 4	1 year
Subject 9	10	Male	Malay	Standard 4	1 year
Subject 10	10	Male	Indian	Standard 4	3 month
Subject 11	10	Female	Malay	Standard 4	3 years

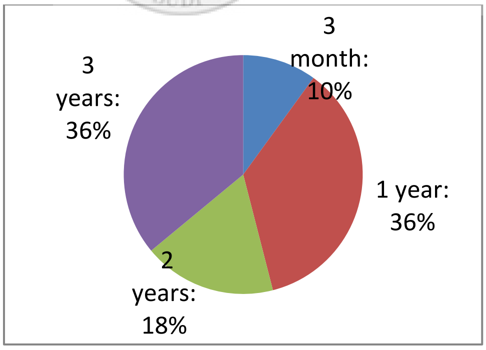


Figure 6.15: Experience of Using Computer

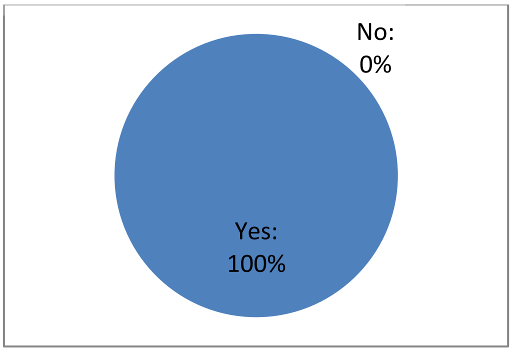


Figure 6.16: Experience of Using TC

6.7.2 The Procedure

As in *user experience I*, the testing in *user experience II* also comprises of four sessions: (i) briefing, (ii) observation, (iii) interview, and (iv) closing. Having setup all the materials, the experiment commenced by introducing the researcher and the team members. This session also highlighted the purpose of the testing and the matter that the subjects have to do next. In the second session, the subjects were assigned to use the AC4LV for 30 minutes. Having finished the observations, the interview session was conducted next face-to-face. Tokens were given to the subjects in the closing session as an appreciation of participating in the testing. Figure 6.17 illustrates the flow throughout *user experience II*.

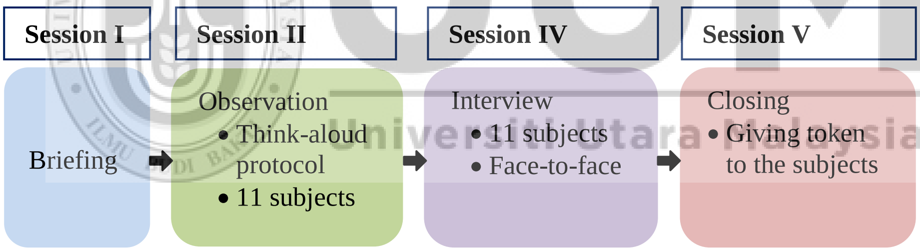


Figure 6.17: Flow of the User Experience II

6.7.3 Analysis of Findings on User Experience II

The analysis of findings on *user experience II* is also categorized into three themes as in the earlier testing; (i) information accessibility, (ii) navigationability, and (iii) pleasurability. They are discussed differently in Subsections 6.7.3.1 and 6.7.3.2.

6.7.3.1 Observation

In *user experience I* this study let the subjects to use the AC4LV on their own until they finish. Also, in *user experience II*, AC4LV were played to them and let them use it without assistance or interruption by anyone until the end. Their behaviour while using the prototype was recorded through notes, photographs, and video.

Theme 1: Information Accessibility

Having conducted the observation, their behavioral related to texts, audio, graphics, animations, transitions, and interface layout were found and recorded as in Table 6.6.

Table 6.6: Information Accessibility Codes' and Occurrences of Using the AC4LV

Codes	Occurrences
1. Texts	• Subjects spoke-aloud by reading the contents appear on the screen. (i.e. "Ikan.., kura-kura").
	• Subjects spoke-aloud the questions for activities that appear on the screen.
2. Audio	• Subjects followed the instructions carefully and smoothly.
	• Subjects concentrated on auditory explanation.
	• Subjects imitated the auditory explanation by "Smiley".
	• Subjects imitated the songs.
	• Subjects imitated the animal sounds (i.e. quacking).
3. Graphics	• Subjects named the parts of the animals' body (i.e. tail, horn, and ears) before the instructor explains it to them.
	• Subjects were able to select the attributes on their own.
4. Animations	• Subjects mimic the "Smiley" movement.
5. Transitions	• Subjects captured the texts or graphics by reading the texts or name the graphics every time they transit on the screen. (i.e. "*Topik 4… Bunyi Haiwan*")
6. Interface Layout	• Subjects were able to recognize the location of menu area and content area by pressing the keyboard confidently without guidance from anyone.

When the AC4LV was started, they followed the instructions carefully and smoothly scene by scene. Sometimes, the subjects were found imitating the songs (Figure

6.18), the animals sound (i.e. "*quack, quack, quack*"), and the explanation by the "Smiley" (i.e. "*Saya adalah seekor kucing*").

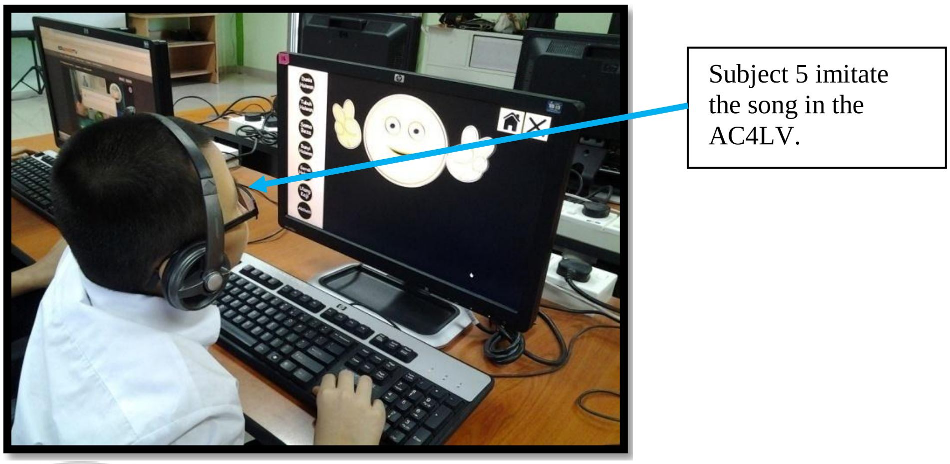


Figure 6.18: Subject Reactions on Audio in the AC4LV

This situation indicates that the audio provided in the AC4LV is useful which means providing meaningful sound effects is really important to the low vision learners. Also, this situation proves that audible instructions and auditory explanation is much more important to the low vision learners in order to make the learning material provide means to them.

Moving on to texts, similar with the findings in the *user experience 1*, the subjects were found speaking-aloud the contents on the screen, indicating that they were capable to read the provided texts in the AC4LV without struggling themselves (i.e. "*ikan…kura-kura*"). They also spoke-aloud the questions for activities that appear on the screen without any difficulties. This helped them to perform the activities smoothly. Having found their reactions on texts in the AC4LV, this study deduces that texts provided in the AC4LV are able to be accessed by the low vision learners as well as the knowledge presented on the screen.

Regarding graphics, this study concerns on whether the subjects could recognize graphical elements or not to ensure knowledge is well-delivered. Through the AC4LV the subjects faced no problem in selecting the attributes while performing the activities (Figure 6.19). They were also able to recognize the graphics in advanced before the instructor explained it to them (i.e. name the parts of the animals' body) (Figure 6.20). These occurrences were also found during the *user experience I,* which explains that graphics provided in the AC4LV are able to be accessed by the low vision learners without facing any problem.

Figure 6.19: Selecting Attributes in the AC4LV

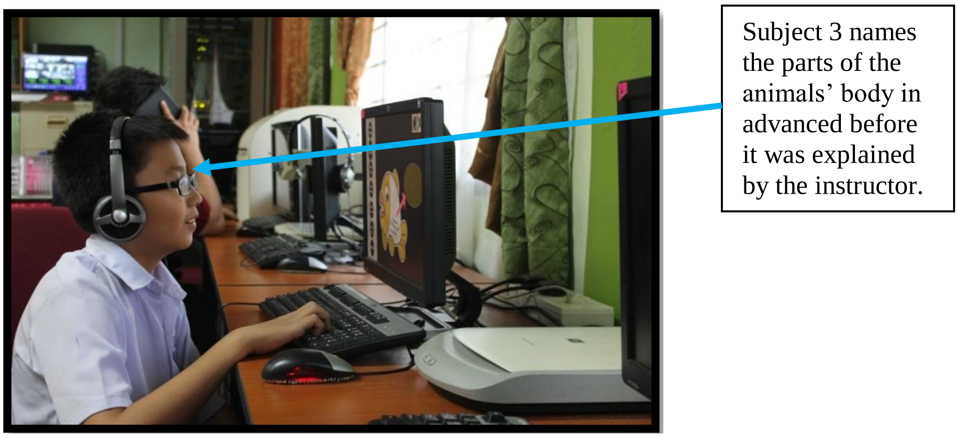


Figure 6.20: Recognizing the Graphic

For the animations provided in the AC4LV, subjects were observed mimicking the "Smiley" movement showing that they were able capture the provided animations. Result of observing the subjects' reactions to animations indicating that providing the slow motion animation is more meaningful to the low vision learners compared to animations that are commonly provided in TC for normal users. In regards to transition the observation reveals that the subjects were observed able to capture the texts or graphics every time they transit on the screen. This could be seen when they were able to read texts simultaneously with the transition (i.e. "*Topik 5…Gerak Haiwan*"). This means the transitions in the AC4LV is useful to the low vision learners.

The last but not least, the elements that was also observed in confirming the information accessibility is interface layout. They were observed able to recognize the menu area and content area by pressing the button for the menu confidently without asking anyone throughout their exploration. All the findings indicate that the interface layout in the AC4LV is catering to information accessibility.

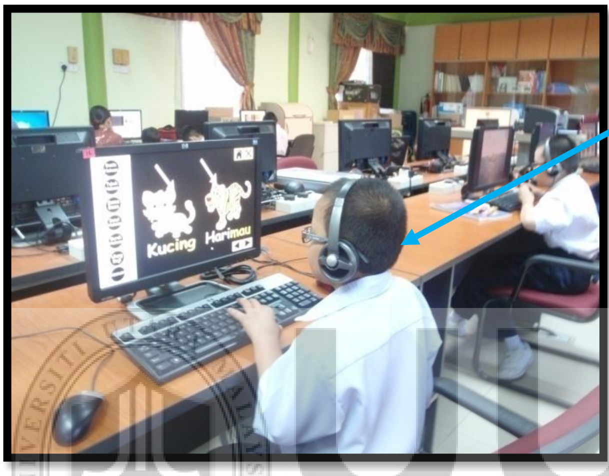
Theme 2: Navigationability

To find out whether the AC4LV could fulfill the needs of low vision learners in navigationability, three codes were observed; navigational button, interface layout, and general interaction. Table 6.7 exhibits the findings, which are further discussed in the remaining parts of this section.

Table 6.7: Navigationability Codes' and Occurrences of Using the AC4LV

Code	Occurrences
1. Navigational button	• Subjects were able to press all the buttons themselves without assistance from anyone.
	• Subjects recognized how to navigate to other page by counting the button carefully.
	• Subjects were able to navigate the contents and activities themselves without assistance from anyone.
2. Interface Layout	• Subjects were able to explore throughout the contents and activities logically as expected.
3. General Interaction	• Subjects interacted with the AC4LV based on the instructions (self-interaction).
	• Subjects sometimes looked at their peers to make sure the content is similar.
	• Subjects were able to press the keys before the instructions completed.
	• Subjects sometimes discussed about the content with their peers (social interaction).
	• Subjects were able to interact with the AC4LV smoothly.
	• Subjects were able to remember most of the keys that they have to press after got the first guidance.

During the observation, all of the subjects were able to press all the provided navigational buttons themselves without assistance from anyone. Interestingly, they were observed counting the buttons carefully to confirm which keys they have to click to move to another topic. They were also found able to navigate the content and activities in the AC4LV without guidance from anyone (Figure 6.21). These findings prove that the subjects were able to recognize the navigational buttons provided in the AC4LV that could guide them navigating the AC4LV on their own without make the low vision learners lost in their learning activity.



Subject 8 was able to recognize the back/next buttons and navigate the AC4LV by himself.

Figure 6.21: Recognizing the Navigational Button

It was also interesting to notice that how the subjects made use of the interface layout provided in the AC4LV. The subjects were able to explore throughout the contents and activities in the AC4LV logically as expected. It pointed out that the interface layout in the AC4LV caters the navigationability more effectively, that could assists the low vision learners navigating the AC4LV on their own.

Further, this paragraph and the remaining discuss the general interaction provided in the prototype. While using the AC4LV, the subjects were found able to have self-interaction with the AC4LV based on the provided instructions (Figure 6.22). Interestingly, as found in *user experience 1*, the subjects were able to press the keys in advanced before completing the instructions. They were also sometimes looking at their peers to ensure that the content is similar and they are not lost (Figure 6.23).

Figure 6.22: Sample of Self Interaction with the AC4LV

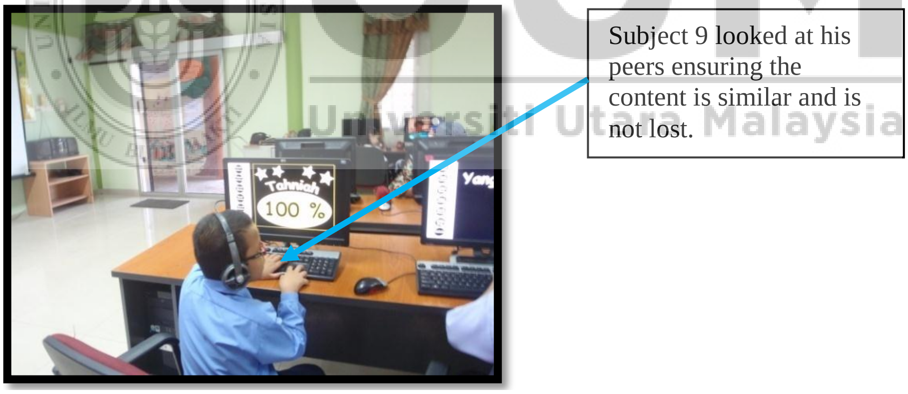


Figure 6.23: Sample of Social Interaction with the AC4LV.

Sometimes, they were also clarifying about the content with their peers which then create social interaction among them. Throughout the testing, the subjects were found facing no difficulty in interacting with the AC4LV, which means they were able to interact sequentially and smoothly. After getting the first guidance, the subjects were found able to remember all the keys that they have to press. This can be seen when they skipped the instructions.

Having tested the prototype, this study found that providing auditory guidance and instructions is important for the low vision learners to interact with the learning material provided for them. This is because the subjects are stucked, lost, and misunderstand without clear guidance as found in *preliminary study II*.

Theme 3: Pleasurability

While using the AC4LV, the subjects expressed their pleasurability as noted in Table 6.8.

Table 6.8: Pleasurability Codes' and Occurrences on AC4LV

Codes	Occurrences on AC4LV
1. Excited	• Subjects pressed the Enter button trying to start the AC4LV themselves.
2. Enthusiastic	• Some of the subjects already started playing the AC4LV without permission.
3. Curiosity	• Subjects asked "*Teacher, can I start?*"
4. Interested	• Subjects stayed focused on the content explained to them.
5. Comfortable	• Subjects followed the contents in relax mode without any pressure.
6. Enjoyed	• Subjects sang along with the AC4LV. • Most of the times subjects imitated the "Smiley" voice. • Subjects imitated the animals' sound.
7. Sense of humor	• Subjects laughed when listening to the animal's sound (i.e. cow mooing) • Subjects laugh when they got wrong answer (glee with the "Smiley" response).
8. Amused	• Subjects smiled when "Smiley" starts introducing herself and the objective of the course. • Subjects smiled when the instructor explains the content.
9. Happy	• Subjects clapped their hands when got 100% marks for the activity. • Subjects raised a hand when got 100% marks for the activity. • Subjects expressed "*yeay*" when got 100% marks for the activity.
10. Released	• Subjects were able to finish all the topics and activities smoothly without any interference.

At the beginning of the AC4LV, Subjects 4, 8, and 9 were found excited, trying to press the Enter button to start the AC4LV themselves. Also, Subject 7 was enthusiastic and started playing the AC4LV without permission. Also, Subjects 8, 9, and 11 were found curious because they requested to start the AC4LV *"teacher, can I start?"*. They were also found smiling when the "Smiley" start introducing herself and the objective of the course. All these behavior indicate that having seen the first scene, the subjects already feel pleasure in their heart, and makes them excited, enthusiastic, and curious to start the AC4LV. Having started the learning activities, all of them were found staying focused on the content, indicating that they were interested with the content in the AC4LV. This could be seen when they were able to follow all the content in relax mode without any pressure. This means they were comfortable. They were also smiling when the instructor explained the content, indicating that they were attracted to the voice intonation (Figure 6.24). This means the AC4LV amused them. All of the subjects were observed singing along with the AC4LV and most of the times they imitated the "Smiley" voice and the animals' sound (Figure 6.25). They enjoyed the AC4LV. All of the subjects were found laughing for the animals sound (Figure 6.26), and when they got the wrong answer. For them, it was humorous. Subjects were also happy when they got 100% marks for the activity by clapping their hands, raising a hand, and expressing "*yeay*" (Figure 6.27). Because of they have no problem with the information accessibility and navigationability the subjects were found released and able to finish all topics and activities smoothly without any interference.

Subject 2 smiles when the instructor explains

Figure 6.24: Amused

Subject 3 imitating the instructor voice and enjoyed the AC4LV.

Figure 6.25: Enjoyed

Subject 8 laughed when listening for the sound of monkey.

Figure 6.26: Sense of Humor

Subject 7 raising his hands and expressed "*yeay*" when scoring 100% for the activity

Figure 6.27: Happy

Having tested the prototype this study found that AC4LV successfully caters to pleasurability aspect. This could be seen obviously through their behavior and reactions while using the prototype.

6.7.3.2 Interview

A similar set of questions was used to conduct the interview in the *user experience II* (Table 6.3) Prior to the commencement, more specific questions on their opinions regarding courseware (Q5) and general experience while using AC4LV were asked (Q6 through Q11). It was found that all of them have experienced using courseware (Q5) including online TC, in which most of the TC has less interaction. Generally, in those TC, they just listen to the audio that have limited audible instructions. With unclear graphics, they just imagine the content. Eventhough they are unable to grab the content smoothly they just use the TC because the choise is limited. This is contradicts with their opinion for the AC4LV. All of them agree that it was fun because of AC4LV provides clear instructions, with suitable sound effects, graphics, and animations (Q6).

Then, Q7 was asked regarding the strength of AC4LV. All of them agree that the sound is the strength. They mean the instructions and the explanation by the instructor make them attracted to the AC4LV. When asked about the weaknesses of AC4LV (Q8), they have no idea as they have no problem with the overall content.

Then, to seek whether the subjects could understand about the course that they have learnt through the AC4LV, Q9 was asked. The subjects confidently answered they have learnt about animal. They also agree that they got 100% score for most of the activities. Then, to confirm that they really understand about the course, some simple questions related to the course were asked and they were able to answer them confidently. This indicates that the subjects could understand the content in the AC4LV clearly. Moving on to a recommendation question (Q10), they recommended to have more activities. In particular, subjects above 11 years old agreed that they want more challenging activities because they perceived that some of the activities are too simple. This recommendation was similar with the subjects interviewed in the *user experience I*, which indicate that the low vision learners are really interested with the interaction (that made them to have contact with the AC4LV, more than just sit and hear to the content). Regarding the speculative question (Q11), they mentioned that they are more motivated and enthiuasistic to learn using it daily for every course if they have chance to do that and they are more confident that their performance in learning could be improved. Through those subjects' responses it is clear that the AC4LV provides more means to the low vision learners. Subsequently, Q12 through Q28 are analyzed based on three themes (i) information accessibility, (ii) navigationability, and (iii) pleasurability.

Theme 1: Information Accessibility

Theme 1 is to identify to what extend the low vision learners perceive the texts, audio, graphics, animations, transitions, and interface layout provided in the AC4LV are useful. For that purpose, Table 6.9 lists the codes and quotations gathered from the interviews.

Table 6.9: Codes and Quotations of AC4LV for Information Accessibility

Codes	Quotations
1. Texts	• I can see the word.
	• I like the font…because it is clear.
	• The word is clear.
	• I can understand the content.
2. Audio	• I like the songs.
	• The song is good.
	• I like the animals' sound.
	• The audio is clear.
	• The voice of "Smiley" is so cute.
	• I like the teachers' voice.
	• I like the sound…all sound.
	• I can follow the instructions…clear.
	• I really like all the "Smiley" voice, sound effects, and the animals' sound.
	• The song sounds good.
	• I like the voice intonation.
	• The sound is best… all.
3. Graphics	• I can see the animal.
	• I can see the plants.
	• I like the picture
	• The color is clear to me.
	• I like the animals.
	• I really understand all the displayed pictures.
4. Animations	• I like all the characters.
	• The "Smiley" looks so cute.
	• I like the animations.
5. Transitions	• It is OK for me…
	• I like it because I can read the texts…
6. Interface Layout	• The layout is OK. I have no problem with it.
	• Yes... I like the layout.
	• It is OK for me.

Prior to asking the specific questions, a general question related to sensory was asked (Q12). The subjects mentioned that they were able to see the animals and plants. In fact, they confidently named the pictures and texts on the screen. This indicates that the information in the AC4LV is generally accessible.

Regarding texts, their responses in Table 6.9 indicate that the texts in the AC4LV are able to be read (Q13). Then, questions regarding the terms in the AC4LV was asked (Q14). They found no problem with the term in the AC4LV. In fact, they demonstrated good understanding when asked about the terms. This indicates that they have no problem in terms of color, size, font style, and the displayed term. Then, their opinions regarding graphics of the prototype were investigated (Q15). Based on their comments this study found that 100% of the graphics in the AC4LV were accessible by the subjects.

About their thought related to animations, this study found that all of the subjects like the animations especially all the characters. Subject 7 commented that "*the Smiley character is so cute*". So, this study proves that graphics and animations in the AC4LV caters the information accessibility.

Next, sensory question to elicit on what the subjects have heard through the AC4LV was asked (Q16). The subjects named the sounds very cheerfully. This indicates that the sound in the AC4LV is clear.

Then, their opinion regarding the audio in the AC4LV was asked (Q17). They really like the explaination and instructions by "Smiley"; all the instructor's voice.

They also love the intonation. For them the audio is clear including the song and the sound effect. It was meaningful to them.

Moving on to the transitions (Q18), they were all saying "*OK*". Hence, they were assigned to read the texts that transit on the screen to determine the meaning of "*OK*". Obviously, all of them have no problem to read it. This indicates that the transition in the AC4LV enable the users to capture the information.

Lastly, their opinion regarding the interface layout was asked (Q19). All of them mentioned that it was okay. Particularly, they have no problem to access the information through the interface layout. For them, the position of the menu area and the content area is acceptable. Hence, this means the interface layout designed in the AC4LV is accessible.

Theme 2: Navigationability

Interviews have been conducted for navigationability means to elicit to what extend the low vision learners perceive the navigational button, interface layout, and general interaction provided in the AC4LV are useful. Their perceptions are as exhibited in Table 6.10.

Table 6.10: Codes and Quotations of AC4LV for Navigationability

Code	Quotations
1. Interface Layout	• Yes I like it.
	• I like it compare to the first one.
2. Navigational button	• I can see the buttons.
	• I am able to recognize the button.
	• I can navigate the AC4LV myself.
	• I can understand the button.
	• The button is clear.
3. General Interaction	• I like the keyboard interaction.
	• Keyboard interaction is okay.
	• I can learn using AC4LV myself.
	• I can follow the instructions.
	• It is easy… because it has clear instructions.
	• I can interact using keyboard and mouse.
	• It has voice instructions so it could assist me in learning.
	• Its guides me to do the activities.

Their opinion regarding the interface layout of the prototype was asked (Q20). Based on the responses, the subjects have no problem with the layout in navigating them throughout the AC4LV on their own. It is because the layout is well- organized. Moving on to Q21, they have no problem with the buttons either in terms of size or color. This indicates that the buttons in the AC4LV could assist the low vision learners to navigate the AC4LV on their own. To elicit whether the instructions provided in both of the prototype could guide the subjects in navigation, Q22 was asked. In AC4LV, the voice-based instructions are among the elements they like most. They never lost in the AC4LV. Moving on to interaction (Q23), general interaction in the AC4LV provides means to the subjects because they were able to interact with the AC4LV on their own without guidance from anyone.

Theme 3: Pleasurability

Theme 3 is to identify the users' feeling of using the AC4LV. The perceptions on the AC4LV are exhibited in Table 6.11. Pleasurability is created as a theme then based on the subjects' thought (Q24); excited, curiosity, happy, interested, enjoyed, amused, sense of humor, comfortable, released, and enthusiastic are the codes found.

Table 6.11: Codes and Quotations of AC4LV

Codes	Quotations
1. Excited	• I feel excited learning with this courseware…
2. Curiosity	• Teacher… what we call this? (subjects ask what is the AC4LV)
3. Happy	• I like the AC4LV…because I got 100% rights.
	• I like the AC4LV
	• I like AC4LV the because… it could help me in learning Science
4. Interested	• I feel want to do it again…teacher can I do it again?
	• I want to learn using this courseware for all subjects.
	• Teacher…can you develop it for other subject?
	• Teacher…can you develop it for Bahasa Melayu?
	• Teacher…can you develop it for Mathematic?
	• I like it more if you develop it for English subject… I love English.
5. Enjoy	• I like the AC4LV… because I enjoy it.
6. Amused	• AC4LV is really fun…
	• I like it because it is really fun…
7. Sense of humor	• The animal sounds are humorous.
8. Comfortable	• AC4LV is better than the courseware that I have used before this.
9. Released	• I like the AC4LV because I can hear the sounds, the questions… I can see the pictures, and the words…
	• I like the AC4LV because it has sounds…
10. Enthusiastic	• I am feeling want to use AC4LV everyday…
	• The activities are too simple… can you provide more activities…

Interestingly, Subject 7 mentioned that he felt excited using the AC4LV. Then, he also asked the interviewer "*teacher... what we call this?*". This shows that he was curious with new things. Then, he also mentioned that he likes the AC4LV. Other subjects also responded similarly. Then, the "*why?*" question was asked. All of them mentioned that it was fun. Then, to further explore on their feelings, they were asked "*what makes you feel fun?*". Subject 8 responded "*because it could help me in learning Science*". Meanwhile, Subject 6 responded "*because I got 100% rights*". Then, Subject 9 added "*because I can hear the sounds, the questions, I can see the pictures, and the words*". He meant that the AC4LV provides him auditory explanation and instructions, accessible graphics, and texts. Further, the rest mentioned "*because it is better than the courseware that I have learnt before this*". Other than that, they also mentioned that the animals' sound is humorous. Subject 7 also commented that he will use the AC4LV everyday.

However, Subject 2 was quite frustrated with the activities because it is too simple and too little. He requested the inteviewer to provide more activities. Their interest can be seen when the subjects asked and requested the interviewer to develop AC4LV for them for the subjects that they prefer individually. Accordingly, this study interprets that AC4LV has made the users felt excited, enthusiastic, curious, interested, comfortable, enjoy, humor, amused, happy, and released.

Other than their feeling of using the prototype, their thought of the things that they like most and dislike the AC4LV was also asked (Q25 and Q26). These questions are almost similar with Q7 and Q8 but Q25 and Q26 are to elicit their feeling about the elements provided in the prototype. The thing that they like most is the sound. They mean all the instructor voice and they have no idea for the things that they dislike about the AC4LV. Then, to elicit more comprehensible responses from the subjects, the "*Which one do you like most?*" (between TC (courseware that they have learnt before this in school) and AC4LV) question was asked. All the subjects confidently answered AC4LV. When asked "*why*", they answered that the AC4LV is easier and more fun compared to TC. It was because the AC4LV provides auditory explanation and instruction. On top of that, it was fun because the AC4LV supports their needs in information accessibility and navigationability. Those two aspects lead the subjects to have pleasure while learning with the AC4LV. Then, Q27 has already been answered by the subjects when asking about animations in Q15. Lastly, their thought related to prototype was asked. Again, they requested the researcher to develop the AC4LV for the course that they prefer. This enables this study to interpret that the AC4LV is useful to the low vision learners.

6.7.4 Conclusion

Having justified all the findings gathered in *user experience II* it indicates that this study has achieved the saturated results. This means all the elements and design principles provided for information accessibility, navigationability, and pleasurability are useful to the low vision learners. Table 6.12 mapped the summary of findings for both of the user experience testing.

Table 6.12: Summary of Finding

<table>
<tr><th rowspan="2">Objective</th><th rowspan="2">Testing Cycle</th><th rowspan="2">Technique</th><th colspan="3">Findings</th></tr>
<tr><th>Information Accessibility</th><th>Navigationability</th><th>Pleasurability (AC4LV)</th></tr>
<tr><td rowspan="4"><u>Information Accessibility</u>
• To investigate the extend the low vision learners perceive the usefulness of texts, audio, graphics, animations, transitions, and interface layout.

<u>Navigationability</u>
• To investigate the extend the low vision learners perceive usefulness on navigational button, interface layout, and general interaction.

<u>Pleasurability</u>
• To investigate the extend the AC4LV could entertain the low vision learners in learning.</td><td rowspan="2">User Experience I</td><td>Observation</td><td rowspan="2">Texts, audio, graphics, animations, transitions, and interface layout are useful to the low vision learners.</td><td rowspan="2">Navigational button, interface layout, and general interaction are useful to the low vision learners.</td><td>Released, comfortable, enjoyed, sense of humor, amused, excited, curiosity, and happy</td></tr>
<tr><td>Face-to-face Interview</td><td>Amused and excited</td></tr>
<tr><td rowspan="2">User Experience II</td><td>Observation</td><td rowspan="2">Texts, audio, graphics, animations, transitions, and interface layout are useful to the low vision learners.</td><td rowspan="2">Navigational button, interface layout, and general interaction are useful to the low vision learners.</td><td>Release, comfortable, enjoyed, sense of humor, amused, excited, curiosity, happy,enthusiastic and interested</td></tr>
<tr><td>Face-to-face Interview</td><td>Release, comfortable, enjoyed, sense of humor, amused, excited, curiosity, happy,enthusiastic, and interested</td></tr>
</table>

6.8 Summary

The AC4LV developed in Chapter 5 based on the conceptual design model proposed in Chapter 4 was evaluated and explained in this chapter. Qualitative approach was applied to investigate the user experience while using the AC4LV. Two cyles of pilot test has been carried out. As a result, a number of problems in the AC4LV and procedure have been identified. In addition, validity of the coding in this study was ensured through the construct validity, internal validity, external validity, and expert validity. Also, inter-rater reliability was applied to ensure the coding is reliable prior to analyzing the data. Besides, ensuring the data are saturated is important as this study conducted qualitatively. Thus, a two-cycle of user experience testing was conducted in which, eight subjects in *user experience I*, and 11 subjects in *user experience II*. To increase the confidence of findings and to avoid from the intrinsic biasness is also the reason the second evaluation was made. The AC4LV was empirically tested to these subjects. For overall cycles of evaluation, data gathered from observation was the main contribution because the subjects' behaviors and reactions tell the true findings. Meanwhile, through the face-to-face interviews, the subjects have expressed their thought verbally which could support the observed data. Generally, through the observation and interview, this study found that the AC4LV is useful in terms of information accessibility, navigationability, and pleasurability. It was found that texts, audio, graphics, animations, transitions, and interface layout in the AC4LV were successfully fulfilling the needs of low vision learners in information accessibility. Similarly, this study found navigational button, interface layout, and general interaction in the AC4LV meets the needs of the low vision learners in the navigationability aspect. The empirical data also revealed that the subjects feel pleasure (i.e. enthusiastic, excited, curiosity, interested, release, comfortable, enjoy, sense of humor, amuse, fun, and happy) while using the AC4LV. Overall, findings in this chapter indicate that all the elements in the AC4LV are useful to the low vision learners.

The next chapter summarizes this thesis by answering the research objective and research questions. Recommendation for future research is also elaborated.

CHAPTER SEVEN

CONCLUSION

7.1 Overview

The main aim of this study is to propose a conceptual design model of AC, which is specifically designed for the low vision learners. The target users of the proposed model are non-technical or novice developers that have interest in developing AC4LV such as teachers and parents. Accordingly, this study is carried out based on three research questions:

i) What are the suitable components and elements of the conceptual design model of AC for low vision learners?
ii) How to design the conceptual design model of AC for low vision learners?
iii) Is the conceptual design model of AC for low vision learners useful?

Hence, to accomplish the main aim four objectives were outlined:

i) To determine the components and elements of the Conceptual Design Model of AC4LV.
ii) To develop the Conceptual Design Model of AC4LV.
iii) To validate the developed Conceptual Design Model of AC4LV through expert review and prototyping.
iv) To investigate user experience of AC4LV in terms of information accessibility, navigationability, and pleasurability.

The subsequent sections provide explanation of the solutions proposed for each research question, discussion on implications of the study to theory and practical, then ends with a discussion of future research and overall conclusions of the study.

7.2 Research Question 1

What are the suitable components and elements of the conceptual design model of AC for low vision learners?

Prior to developing the Conceptual Design Model of AC4LV the suitable components and elements are identified. Overall, the proposed model contain seven main components, which are (i) structural component, (ii) content composition component, (iii) learning theories, (iv) learning approaches, (v) development process, (vi) ID model, and (vii) technology. Meanwhile, the Conceptual Design Model of AC4LV also contains special elements that make it different from the previous existing models. It is called AC4LV element which are divided into (i) audio, (ii) formatting styles and texts, (iii) graphics, (iv) animations, (v) transition, (vi) interface layout, (vii) navigational button, and (viii) general interaction. Although the proposed elements seem to be similar with the multimedia elements, but the design principles contain in each of the elements make the AC4LV unique compared to the previous existing models. All the proposed components and elements are gathered through the systematic processes, which are exhaustive literature study, comparative analysis, and UCD approach.

7.3 Research Question 2

How to design the conceptual design model of AC for low vision learners?

All the components and elements were then combined and made up the Conceptual Design Model of AC4LV. In the construction process, compulsory and recommended components and elements were determined through UCD approach involving the low vision learners, teachers, and developer. They were justified based on learning theories and approach (i.e. multimedia learning theory, MI theory, and PBL). All the components are compulsary to apply except the development process which are flexible, iterative, and can be customized based upon developer preference. To explain about the flow, each of the components are numbered sequentially. Each of the element particularly in the content composition component has implication to each other. The proposed model highlights that texts, audio, graphics, animations, transition, and interface layout are related to information accessibility. Meanwhile, navigational button, interface layout, and general interaction are designed to assist the low vision learners in navigationability. Pleasurability is achieved through all accessible and navigable elements. The Conceptual Design Model of AC4LV were also reviewed and found well accepted by the experts.

7.4 Research Question 3

Is the conceptual design model of AC for low vision learners useful?

The Conceptual Design Model of AC4LV has been evaluated through three stages namely; expert review (Chapter 4), prototyping (Chapter 5), and experimental study through user experience testing (Chapter 6). Expert review and prototyping ensure that the proposed model is validated. These three combined evaluation methods ensure that the final implementation of the Conceptual Design Model of AC4LV is useful and has been proven benefiting to the developer and low vision learners.

In general, the proposed Conceptual Design Model of AC4LV has been well-accepted by all the experts involved in this study. The proposed model was also employed by a courseware company developing an AC4LV prototype. The findings in the user experience testing through observation and interview indicate that the AC4LV successfully fulfill the needs of low vision learners in information accessibility, navigationability, and pleasurability aspects. Thus, it can be concluded that the proposed Conceptual Design Model of AC4LV is significantly useful in designing and developing AC4LV.

7.5 Aim and Objectives: Revisit

Having completed of the four supporting objectives, the main aim has been achieved towards the end of this study. The first objective was achieved through the identification of the components and AC4LV elements (Chapter 4). The second objective was achieved with the construction of the proposed Conceptual Design Model of AC4LV (Chapter 4), which combines seven main components and AC4LV elements that contain specific design principles for each of the elements. Expert review involved in this study reveals that the proposed model is valid to be prototyped. Next, the third objective was achieved with the development of AC4LV prototype, ensuring that the proposed model is validated and useful. Finally, the fourth objective was accomplished with the evaluation of AC4LV prototype through user experience testing involving low vision learners as the subjects. Through the subjects' response (from observation and interview) indicates that AC4LV is useful in terms of information accessibility, navigationability, and pleasurability.

7.6 Implications of Study to Theory and Practical

The implications of this study can be seen in two aspects; to the body of knowledge, theory and practical.

In terms of body of knowledge and theory, the findings of user experience testing reveal that AC4LV is catering the information accessibility, navigationability, and pleasurability among the low vision learners. Although the existing courseware were found providing sufficient content by utilizing multiple elements containing audio, texts, graphics, animations, video, interactivity, and easy to use as well as meeting others usability guidelines, but they were found not catering to the low vision learning needs. In conjunction, this study interprets that the design principles of AC4LV that are constructed based on the previous concepts and theories as well as supported with UCD approach, are important in making all the elements in AC4LV catering the information accessibility, navigationability, and pleasurability. This creates the AC4LV unique compared to the available courseware. So, with the careful designed by referring to the proposed model it is guaranteed that AC4LV is useful to the low vision learners as already proven in this study (Chapter 6). This make changes the existing knowledge that through the AC4LV, the low vision learners are able to access the information, navigates, and learns in pleasure environment.

Meanwhile, practically the proposed Conceptual Design Model of AC4LV was constructed as a guide and reference especially for the novice and non-technical developer particularly teachers and parents who interested to develop the AC4LV.

On the other hand, AC4LV is a type of tangible artifacts which could be benefits in the form of content selling. For people who have ideas and knowledge but lack of technical skills on the technique to market their knowledge, they could sell the AC4LV (knowledge) depends on their own initiatives. This could enrich the sources of learning materials in the market especially for low vision learners' community.

7.7 Limitations and Recommendations for Future Works

This study outlines two areas of limitation which are (i) the Conceptual Design Model of AC4LV and (ii) the AC4LV prototype. The following subsection address each of the limitation in details.

7.7.1 Conceptual Design Model of AC4LV

In constructing the Conceptual Design Model of AC4LV particularly to produce the components and elements various methods was implemented throughout this study, which are comparative analysis, content analysis, elicitation works, and UCD approach. A number of TC and AC models were based to derive the common components and elements. Nevertheless, the models used are less exhaustive since some of the models are in the form of screenshots of prototype and some are in the form of figures. The selection also represents the design models for the past six years (i.e. 2008-2013). Definitely, consideration of others such as comparing the current actual of TC and AC might produce different conceptual design model.

In this study, a UCD approach was utilized to strengthen the elements and design principles gathered from the comparative analysis, content analysis, and elicitation works involving low vision learners, teachers, developers, and academicians. However, this study manages to implement it in different time and place. Although it complies with the rich input, still it is considered as individual opinion. Perhaps with the focus group study, which involved a group of user might lead to the different elements and design principles.

Also, the Conceptual Design Model of AC4LV is a type of generic model which could be utilized as a reference to develop the AC4LV for any school subject that the user prefers to. Perhaps, the Conceptual Design Model of AC4LV that specifically focuses to certain school subject could be contructed in future study which might contain more specific elements and design principles.

7.7.2 The AC4LV Prototype

As elaborated in Chapter 5, prototyping is a method used in this study to validate the proposed model. Although the AC4LV was successfully developed only one industry participated in translating the proposed model to the AC4LV. This was not conducted for biasness reasons as no comparative study have been conducted. Thus, in future more developers are suggested to apply the Conceptual Design Model of AC4LV. It is not limited to industry only but the teachers are more encouraged being as developer. The teachers involves in the UCD cycles could be as developer for developing the AC4LV. Hence, a significant comparative analysis from the results could be carried out. Additionally, the developers could also produce more than one learning contents with many levels of topics and activities for AC4LV.

Besides, the AC4LV in this study only run on desktop. In fact, in the interview session this study found to date children are more attracted to mobile device such as tablet. Eventhough they are low vision, the enhancement of technology not restricting their curiosity. This actually could trigger their pleasurability while learning. So, studies to investigate the usefulness of the AC4LV in many different technologies should take place. Perhaps the results could be a good suggestion to improve some aspects of designing the AC4LV.

In addition, learning material such as AC4LV is also believed to facilitate the low vision learners with their learning ability. In learning through the AC4LV, the low vision learners are encouraged to utilize their cognitive ability, sensory, body-kinesthetic, and so on. Hence, this leads the low vision learners to detect their own potential and be aware of their ability. Accordingly, studies to explore the use of AC4LV as the effective learning material to the learning environment are necessary. So, AC4LV could be considered as one of effective learning materials.

7.8 Summary

This study has carried out an exhaustive and a systematic investigation in proposing a Conceptual Design Model of AC4LV. All pertinent components and elements in constructing the proposed model were considered and validated through expert review and prototyping. From the findings obtained, there were indications that the AC4LV which developed based on the proposed model has several points of advantages which could be listed as:

- The proposed Conceptual Design Model of AC4LV is useful in guiding the developer to develop the AC4LV.

- The proposed AC4LV is useful in assisting the low vision learners accessing the information.

- The proposed AC4LV is useful in assisting the low vision learners navigating the content.
- The proposed AC4LV is useful in making the low vision learners have pleasurability in learning.

It is important that the low vision learners' benefit from a learning material that deem the relevant theoretical framework in its design and development. The learning material should be as assistance for the low vision learners learning on their own without facing any difficulties as they deserve to have similar brighter future life with normal learners.

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