Conceptual Design Model of Assistive Courseware for Low Vision (AC4LV) Learners

Nurulnadwan Aziz[1], Ariffin Abdul Mutalib[2], Siti Mahfuzah Sarif[3]

School of Multimedia Technology and Communication, Universiti Utara Malaysia (UUM), 06010 Sintok Kedah, Malaysia
[1]nuruln746@tganu.uitm.edu.my, [2]am.ariffin@uum.edu.my, [3]ctmahfuzah@uum.edu.my

Abstract - This paper describes an ongoing study related to the design of conceptual design model which specific to learning content application for low vision learners. Reviews from literatures indicate that content application such as courseware which is specifically designed to cater the needs of low vision learners in learning is highly scarce. It was found that most of the existing content applications including courseware focus to the needs of normal student, in which most of this courseware mean too little to the low vision learners in terms of information accessibility, navigation ability, and pleasure aspects. In addition, the use of Assistive Technology (AT) such as magnifying glass was also problematic for them. Thus, this study aims at creating an alternative content application particularly courseware for low vision learners. It is called as Assistive Courseware for Low Vision (AC4LV). Prior to develop an AC4LV a specific design model has to be proposed as guidance for the developer to refer to. So, this paper proposes a Conceptual Design Model of AC4LV by utilizing three phases of activities. Future works is to validate the proposed model through expert review and prototyping method.

Index Terms - Assistive Technology (AT), Assistive Courseware (AC), Conceptual Design Model, Low Vision Learners.

1. Introduction

Courseware is a tremendous instructional aid that has been practiced in teaching and learning since past few years. A lot of subjects has been translated into a courseware to make the learning activities more pleasure and easy to access the content. Content in the textbook could be transform into digital format which created as multimedia elements (i.e. texts, graphics, audio, video, and animation). Fun and pleasure aspects could be derived from those customized elements [1] . This indicates most of the coursewares could provide a lot of positive impact to the learners especially for children. It makes easy for them to understand or remember the content. Most of the content for the available courseware are developed for normal students. Usually they are called as Typical Courseware (TC).

Based on the preliminary studies that have been carried out ([2], [3], [4], [5]), TC which is currently used in schools (as depicted in Fig. 1) means too little to the low vision learners. This is because the usage of blinking button, decorative font face, decorative graphics, unsuitable animations and transitions is actually problematic for the low vision learners to grasp the content presented in the courseware [6]. With their restrictions in seeing sense they have to give a lot of concentrations on audio which is less provided in TC [7]. Also, through TC the low vision learners unable to access the presented information and unable to navigate the courseware. All this factors lead to the frustration in learning through the courseware. In fact, having pleasure in learning is important for the learners to grasp and understand the presented knowledge [8].

Fig. 1 Online TC is played to the low vision learners.

Furthermore, comparative studies carried out by [9], [10] also found that twenty existing conceptual design model of courseware (including TC and Assistive Courseware (AC)) do not highlight the low vision learners as part of the users. This indicates that the conceptual design model of courseware that specifically designed for low vision learners is highly lacking.

In addition, at present Assistive Technology (AT) focus on the development of software or system (i.e. screen reader (JAWs), screen magnification) and hardware (i.e. Close Circuit Television (CCTV), magnifying glass) which means content is not their main concern [11], [12], [13]. Using AT products requires the low vision learners to have extra knowledge on technical function which is less possible for the low vision children to operate it on their own. Furthermore, the use of AT such as magnifying glass was psychologically problematic for the low vision children as they do not want to look different between their sighted peers [14]. All this problems addressed that the needs of low vision learners in learning through content application is necessary. The problems also addressed that information accessibility, navigation ability, and pleasure is the main aspects that have to be emphasized in designing the content application for the low vision learners. This means certain characteristics that match to the needs have to be identified.

Based on the justified problems this paper aims at proposing a Conceptual Design Model of Assistive Courseware for Low Vision (AC4LV) learners. Prior to design the proposed model this study has to identify the main component, elements and design principles of Conceptual Design Model of AC4LV. To achieve both of the objectives, two phases of activities has been carried out as further details in the next section.

2. Methodology

In this study a series of activities were carried out, as shown illustratively in Fig. 2. The figure explains that this study involves two phases of activities which are specification identification, and model development [3]. The activities involved in the first phase include document study and interview. This method is call User Centered Design (UCD) approach. Also, comparative analysis has been carried out. From this phase, data regarding the components, elements, and design principles of AC4LV were gathered and the first objective of the study was achieved. They are discussed in detail in the next section. The second phase is model development, in which a Conceptual Design Model of AC4LV was developed based on the data gathered in phase one. At this stage, this study has achieved its second objective. Having finished the second phase, the whole objective of this study is achieved.

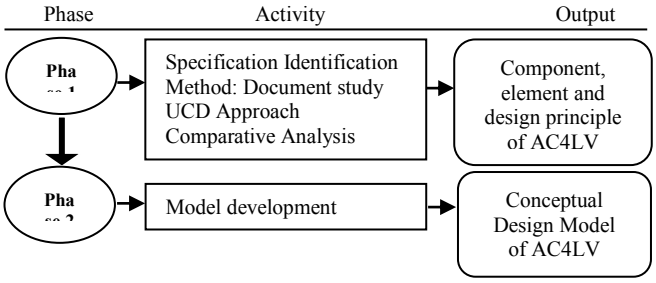

Fig. 2 Summary of Activity

A. *User Centered Design Approach (UCD)*

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 the previous section, 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, this study has discovered appropriate elements in the 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 consultation through UCD approach. This involves users and experts, in which their criteria are justified in Table 1.

TABLE 1 Criteria and Justification of Participants in UCD Cycles in the Construction 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 fulfil 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 three years.	The developers' participation is important to confirm on the technical part of the proposed model (i.e. development process and navigation specification).

Fig 3. UCD Approach (Getting Inputs and Comments from the LV learners)

Fig 4. UCD Approach (Having Discussion with Teacher)

In UCD approach interview with low vision learners has been conducted. Sample of courseware has been played to them (Fig. 3) in seeking their needs regarding the content design which related to information accessibility, navigationability, and pleasure aspects. Also, discussion with teachers (Fig. 4) has been carried out to further strengthen the information gathered from the low vision learners. Discussing with developers was also performed in finding out on part navigation specification and development process. In supporting the findings gathered from the UCD cycles comparative analysis were carried out which further details in the next subsection.

B. *Comparative Analysis*

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 study, both of them are named as model. In [9] [10] 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 2.

TABLE 2 Justification for Selecting Model

No.	TC	Justification
1.	[15]	This model is selected because it highlights the details regarding the courseware component.
2.	[8]	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.	[16]	It is targeted for learners with visual problems in learning mathematics, which is related with this study.
4.	[17]	This model recommends specific design guidelines, in which some of them are appropriate to be adapted in this study.
5.	[18]	This model represents basic components in designing a courseware.
6.	[16]	Description of the content in this model is comprehensive in terms of learning theory, interface guidelines, and development process.
7.	[19]	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.	[20]	Generic components of courseware are clearly presented in this model.
9.	[21]	This is one of the latest models that provide leaning contents based on individual learning style. This relates with this study when VI learners are more to audible and kinesthetic style.
10.	[22]	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.	[23]	Multiple characters provided in this model motivate this study to refer to it as guidance in developing characters for AC4LV.
2.	[24]	Learning theories and approaches adapted in this model were found related with this study. Also, the presentation of such components is of interest.
3.	[25]	This model emphasizes on interface layout, which is important to be considered in this study.
4.	[26]	This model suggests specific guidelines in terms of text size and color for low vision learners, which is almost tailored to this study.
5.	[27]	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.	[28]	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.	[29]	This model provides interesting features in terms of its function, which inspires this study in designing the content of AC4LV.
8.	[3]	Developed specifically for VI learners and proposes specific guidelines for developing AC for VI learners.
9.	[30]	Supports the disabled children in learning through courseware by providing scaffolding strategy in making sure the subjects could grasp the knowledge.
10.	[31]	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.

Study carried out by [32] apply the comparative analysis of existing models to gather features appropriate for a Reality Learning Media (RLM). The features of all compared models are put into a table, which separated in columns. The similarities and the differences of the features contain in the models are then plotted in the column. With that, information for all models for a certain features is seen on the same line, so that the decision is easy to form. In this study, the technique by [8], [32] is adopted. First, the models are presented in figures. Then, tables containing features follow [32], [33]. The results from the comparative study of two types of conceptual models (i.e. TC, and AC) are compiled and used as the input for developing the Conceptual Design Model of AC4LV. Having done UCD approach and comparative analysis component, elements, and design principles of Conceptual Design Model of AC4LV has been carried out. They are discussed in the next section.

3. Findings and Discussion

Derived from UCD cycles and comparative analysis there are seven main component of Conceptual Design Model of AC4LV. This section highlights the findings achieved in phase one and phase two of the study which are elements and design principles of AC4LV and the Conceptual Design Model of AC4LV.

A. Elements and Design Principles

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. It also involves expert consultation through UCD approach. Their comments are inline with early discussion on information accessibility, navigation ability, and pleasure as discussed in the first section. 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 III.

i) Audio

Provide auditory explanation:

Low vision learners and other types of VI depend 100% on audio to explain everything that appear on screen [34], [35] [36], [37]. 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 omitting 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 [19]. 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.

ii) Formatting Styles and Texts
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 styles:
Using multiple font styles especially on one screen may 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.
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.

iii) Graphics
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:
Provide 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.

Follow the same rules of graphics and texts:

Use animations for graphics and texts when only necessary.

iv) Animations

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 desired information:

Do not animate every information at the same time. It is 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.

v) 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.

vi) 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.

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.

vii) Interface Layout

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.

viii) 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 [38]. 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.

B. The Proposed Conceptual Design Model of AC4LV

(i) 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 [19]. 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 3.

TABLE 3 Details of Structural Component

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.

Justification on Structural Component of AC4LV

Having done the comparative analysis, this study decides to maintain all the structural components (as listed in Table III) 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 was utilized in acquiring suggestions from teachers and low vision learners to determine the structural component of AC4LV.

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 [28],[29] 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 structural components is revised as resulted in Fig. 5.

(ii) Content Composition Component

Inside the structural component is content composition component, that further details all the components 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 pleasure aspects. These three aspects guarantee that the content of the courseware achieve the objective to be assistive. Composing content for AC4LV needs sufficient efforts since this study focuses on fulfilling the needs of low vision learners. 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 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 ([19]. 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 act as the basis to put across the pedagogical aspects in content delivery.

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.

(a) Multimedia elements

The selection of multimedia elements as one of the pedagogic component is inspired by the principles of Multimedia Learning Theory and Multiple Intelligence Theory. 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 mode. 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.

(b) 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 behaviorism and cognitivism theories.

(c) 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.

(d) 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.

(e) 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.

Human Entities

Human entities are categorized into (a) actor and (b) interaction.

(a) 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.

(b) 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, **Error! Reference source not found.** provides further detailed explanation on the content composition component in the context of this study.

Justification on Content Composition Component in AC4LV

As low vision has restrictions in visualization, this study considers that real objects, images, and video are 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 [31]. 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 [2], the acceptance of low vision learners on animation is not similar to sighted learners even though 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 [2], 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 [19]. 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 developers, 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 pleasure must be designed as part of the content. However the existing models do not include them.

Based on these arguments, content composition components are extended to include the assistive content which consists of information accessibility, navigationability, and pleasure 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 were represented as the model for content composition (see Figure 5) and have 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:

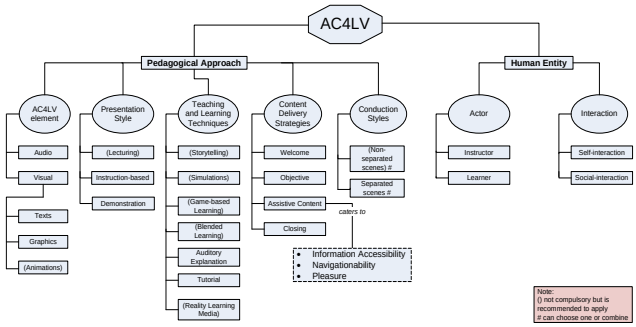

Fig. 5 Initial Concept of Content Composition Component

"*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".*

(Associate Prof. Dr. Daniel 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 and design principles 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.

(iii) Learning Theories and Approach

Among learning theories that act as the guide in constructing the design principles of AC4LV are behaviorism, cognitivism, constructivism, Multimedia Learning Theory, and Multiple Intelligence Theory. Also, Mastery Learning Approach, PBL, Active Learning, and Self-paced Learning are the learning approaches that influence the content design of AC4LV.

(iv) Development Process

To develop the AC4LV, the developers are recommended to refer to the three-phase activity recommended in the development process components. Going in-depth into the development process of AC4LV, it involves three phases, which are pre-production, production, and post production. In the first phase, 10 steps were implemented. In developing AC4LV it is important to involve users and experts before the development of AC4LV begins. At this phase, user requirements were identified by interviewing the teachers regarding the needs of LV learners in terms of the actual content of AC4LV. Also, the LV learners were involved to gather the input and comments in terms of the design of AC4LV. All this input are important in preparing the script and storyboard of AC4LV. Having finished the 10 steps in the pre-production phase, the development of AC4LV was started by utilizing Adobe Flash as the main development tool. Sound Forge was used to record and edit the sound, while Adobe Illustrator was utilized to design all the characters. In the post production phase, editing and quality checking were performed, which also involved real users and their teachers. It was done until they were satisfied and finally the AC4LV was packaged in the form of VCD or DVD prior to test the user experience.

(v) Instructional Design (ID) Model

The adaptation of ID model is important since this study is related to instructional design material. Based on the discussion in [9] 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. As the developer has to refer to ID models [9] [10] in developing the AC4LV, so the proposed model suggests four options of ID models which are ADDIE, Dick and Carey, ASSURE, and Morrison, Ross, and Kemp. By applying anyone of the suggested model, the development of AC4LV has to be supported with ARCS model.

Although there are some of the ID models (i.e. Dick & Carey model, and Morrison, Ross, & Kemp 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 models are also required as part of the component of instructional materials. Thus, this study extracts the applicable phase and process of the discussed ID models in designing the conceptual design model of AC4LV learners.

(vi) Technology

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 the interested users.

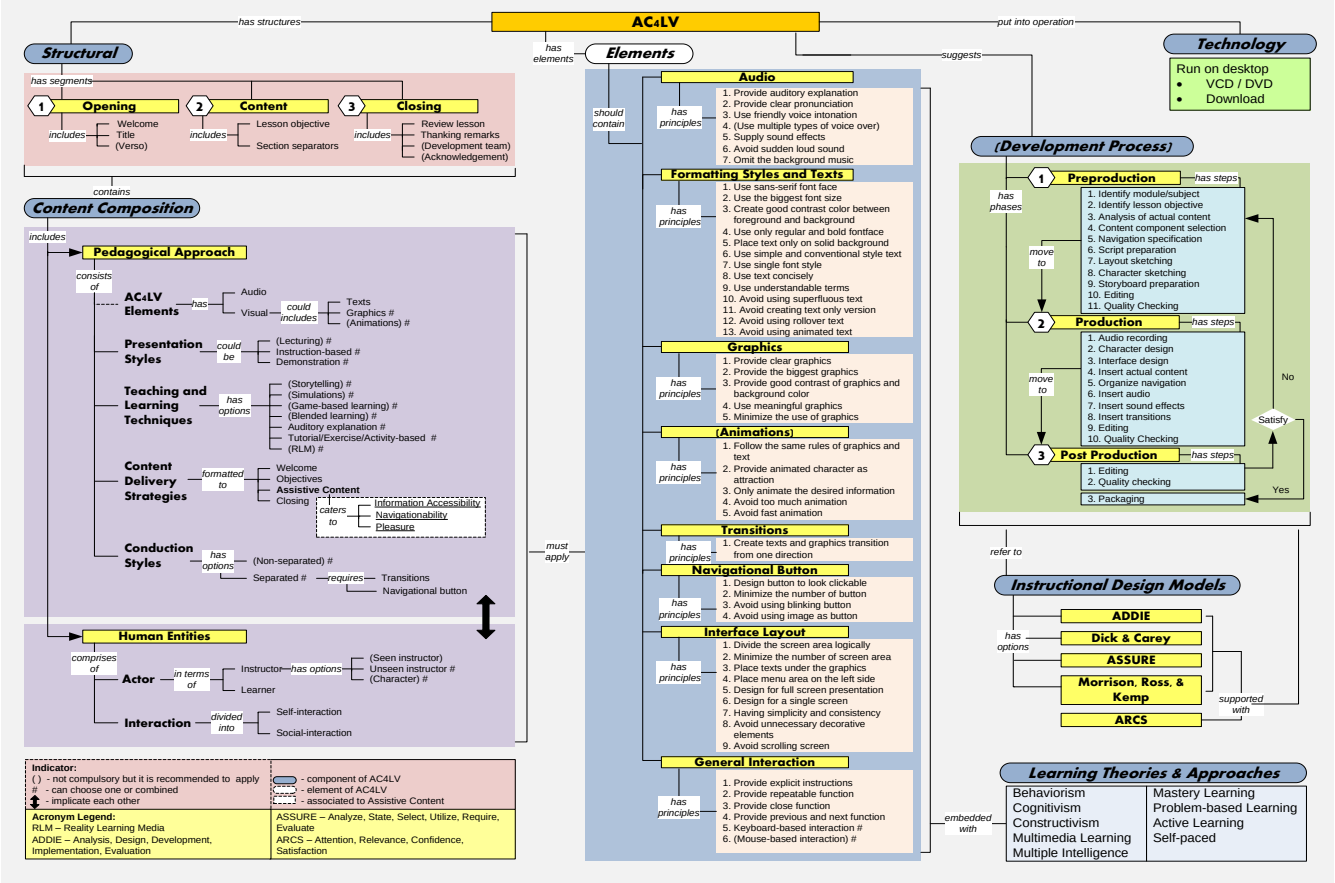

Fig. 6 Proposed Conceptual Design Model of AC4LV

4. Conclusion and Future Works

Overall, this study reports an ongoing project regarding the development of Conceptual Design Model of AC4LV. Document study, UCD approach, and comparative analysis have been carried out in identifying the components, elements, and design principles of the proposed model. Derive from those method seven main component of Conceptual Design of Model of AC4LV were proposed which are structural, content composition, development process, ID models, learning theories, learning approach, and technology. AC4LV elements is the core part of the proposed model in which it was formulated catering to the needs of low vision learners in learning activities which are information accessibility, navigationability, and pleasure aspects. Future works of this study is to validate the proposed model through expert review and prototyping method.

Acknowledgments

The researchers wish to thank to the Primary School of Jabi (Visual Impairment Integration) and Special Primary School of Alma (Visual Impairment) for their cooperation participating in this study. This study also has been financed by Universiti Utara Malaysia (UUM), Malaysia and Ministry of Higher Education, Malaysia. The authors gratefully acknowledge both of the credibility organizations'.

References

[1] A. M. Ariffin, A. Nurulnadwan, and S. Zatul Amilah, "Digital storytelling makes reading fun and entertaining," *Int. J. Comput. Appl.*, vol. 18, no. 1, pp. 20–26, 2011.

[2] A. Nurulnadwan, A. M. Ariffin, S. Siti Mahfuzah, and J. Mohd Saifullizam, "Preliminary investigation on creative educational content for visually-impaired (VI) learners," in *Advances in Visual Informatics*, 3rd ed., no. Vi, H. Badioze Zaman, P. Robinson, O. Patrick, T. K.Shih, and S. Velastin, Eds. Switzerland: Springer International Publishing, 2013, pp. 408–417.

[3] A. Nurulnadwan, M. R. Nur Hazwani, and A. M. Ariffin, "Visually impaired children's acceptances on assistive courseware," *Am. J. Appl. Sci.*, vol. 8, no. 10, pp. 1019–1026, 2011.

[4] A. Nurulnadwan, M. R. Nur Hazwani, E. Erratul Shiela, and A. M. Ariffin, "Assistive Courseware for the visually impaired based on theory of multiple intelligence and SECI model," *Am. J. Econ. Bus. Adm.*, vol. 3, no. 1, pp. 150–156, 2011.

[5] A. M. Nurulnadwan, A., Nur Hazwani, M.R., & Ariffin, "Assistive courseware for visually impaired," in *Lecture Notes in Computer Science,Visual Informatics: Bridging Research and Practice*, no. Vi, B. Z. Halimah, Ed. Berlin, Germany: Springer-Verlag Heidelberg, 2009, pp. 905–915.

[6] S. Bocconi, S. Dini, L. Ferlino, and C. Martinoli, "ICT educational tools and visually impaired students: Different answers to different accessibility needs," in *Universal Access in Human-Computer*

Interaction. Applications and Services, C. Stephanidis, Ed. Germany: Springer Berlin Heidelberg, 2007, pp. 491–500.
[7] R. Raisamo, A. Hippula, S. Patomäki, E. Tuominen, V. Pasto, and M. Hasu, "Testing usability of multimodal applications with visually impaired," *MultiMedia, IEEE*, vol. 13, no. 3, pp. 70–76, 2006.
[8] A. M. Ariffin, "Conceptual design of reality learning media (RLM) model based on entertaining and fun constructs," (Doctoral dissertation, Universiti Utara Malaysia, 2009), 2009.
[9] A. Nurulnadwan, A. M. Ariffin, J. Mohd Saifullizam, and S. Siti Mahfuzah, "A comparative analysis on conceptual design model of Assistive Courseware (AC) for visually-impaired learners (AC4VI)," *Aust. J. Basic Appl. Sci.*, vol. 8, no. 4, pp. 75–80, 2014.
[10] A. Nurulnadwan, A. M. Ariffin, and S. Siti Mahfuzah, "Critical analysis in proposing a conceptual design model of assistive courseware for low vision (AC4LV) learners," *Int. J. Comput. Appl.*, vol. 92, no. 10, pp. 18–25, 2014.
[11] A. P. Freire, S. Carlos, D. M. B. Paiva, and M. A. S. Turine, "Using Screen Readers to Reinforce Web Accessibility Education," pp. 82–86, 2007.
[12] T. Gowases, R. Bednarik, and M. Tukiainen, "Text highlighting improves user experience for reading with magnified displays," *Proc. 2011 Annu. Conf. Ext. Abstr. Hum. Factors Comput. Syst.*, pp. 1891–1896, 2011.
[13] O. Hameed, J. Iqbal, B. Naseem, O. Anwar, and S. Afzal, "Assistive technology-based navigation aid for the visually impaired," *Proc. 2006 Int. Symp. Pract. Cogn. agents Robot. - PCAR '06*, p. 192, 2006.
[14] J. Khadka, B. Ryan, T. H. Margrain, J. M. Woodhouse, and N. Davies, "Listening to voices of children with a visual impairment: A focus group study," *Br. J. Vis. Impair.*, vol. 30, no. 3, pp. 182–196, Sep. 2012.
[15] M. Mazyrah, W. A. Wan Fatimah, M. N. Shahrina, and S. Suziah, "A conceptual framework for english language courseware using storytelling approach : Case study in University Teknologi Petronas," *Inf. Technol. Symp.*, pp. 1–6, 2008.
[16] Z. Zuraini Hanim and W. A. Wan Fatimah, "Application of design and learning theories in multimedia courseware development , ' Li2D ,'" *Natl. Postgrad. Conf.*, pp. 1–5, 2011.
[17] D. Churchill, "Conceptual model learning objects and design recommendations for small screens key concepts and issues," *Educ. Technol. Soc.*, vol. 14, no. 1, pp. 203–216, 2011.
[18] N. A. Nik Siti Hanifah, R. W. Tao, and J. Ping, "Immersive environment courseware evaluation," *Procedia Soc. Behav. Sci.*, vol. 15, no. 2011, pp. 1667–1676, 2011.
[19] A. Efendioğlu, "Courseware development model (CDM): The effects of CDM on primary school pre-service teachers' achievements and attitudes," *Comput. Educ.*, vol. 59, no. 2, pp. 687–700, Sep. 2012.
[20] M. Rossafri, "The design, development and evaluation of an adaptive multimedia learning environment courseware among history teachers," *Procedia Technol.*, vol. 1, no. 2012, pp. 72–76, Jan. 2012.
[21] Ö. Özyurt, H. Özyurt, A. Baki, and B. Güven, "Integration into mathematics classrooms of an adaptive and intelligent individualized e-learning environment: Implementation and evaluation of UZWEBMAT," *Comput. Human Behav.*, vol. 29, no. 3, pp. 726–738, May 2013.
[22] I. Garcia and C. Pacheco, "A constructivist computational platform to support mathematics education in elementary school," *Comput. Educ.*, vol. 66, no. 2013, pp. 25–39, Aug. 2013.
[23] K. Ellis, "Multimedia for primary school children learning sign language," *Proc. 21st Annu. Conf. Aust. Comput. Interact.*, 2009.
[24] A. Norfarhana, W. A. Wan Fatimah, and P. A. Emelia Akashah, "Multimedia design and development in ' Komputer Saya ' courseware for slow learners," *Second Int. Conf. Comput. Res. nad Dev.*, pp. 354–358, 2010.
[25] E. Morfidi, N. M. Papachristos, and T. A. Mikropoulos, "Teachers' implementation of a hypermedia application for children with severe learning disabilities," *2010 Int. Conf. Intell. Netw. Collab. Syst.*, pp. 267–273, Nov. 2010.
[26] D. G. Sampson and P. Zervas, "Technology-enhanced training for people with disabilities: The eAccess2Learn framework," *2010 Int. Conf. Intell. Netw. Collab. Syst.*, pp. 244–251, Nov. 2010.
[27] Y. J. Seo and H. Woo, "The identification, implementation, and evaluation of critical user interface design features of computer-assisted instruction programs in mathematics for students with learning disabilities," *Comput. Educ.*, vol. 55, no. 1, pp. 363–377, Aug. 2010.
[28] M. Siti Zaharah and M. Z. Nor Azan, "Accessible courseware for kids with hearing impaired (MudahKiu): A preliminary analysis," *2011 Int. Conf. Pattern Anal. Intell. Robot.*, pp. 197–202, 2011.
[29] K. S. Savita and A. P. Nur Athirah, "Malay sign language courseware for hearing-impaired children in Malaysia," *World Appl. Sci. J.*, vol. 12, pp. 59–64, 2011.
[30] L. Y. Rahmah and T. P. Tengku Nazatul Shima, "Reading activities using the scaffolding in MEL-SindD for down syndrome children," *Procedia - Soc. Behav. Sci.*, vol. 35, no. December 2011, pp. 121–128, Jan. 2012.
[31] L. Y. Rahmah, A. Hafiza, and T. P. Tengku Nazatul Shima, "Affective Engineering of Background Colour in Digital Storytelling for Remedial Students," *Procedia - Soc. Behav. Sci.*, vol. 68, pp. 202–212, Dec. 2012.
[32] M. Ariffin Abdul and S. Norshuhada, "Conceptual design model of Reality Learning Media (RLM)," *1st Int. Malaysian Educ. Technol. Conv.*, pp. 353–360, 2005.
[33] A. Cut Nora, A. M. Ariffin, A. Nurulnadwan, and A. B. Rozana Mastura, "Multiple intelligence ensures usability of digital storytelling for preschool children," *Proceeding Int. Conf. Adv. Sci. Eng. Inf. Technol.*, pp. 117–123, 2011.
[34] P. Roth, L. Petrucci, T. Pun, and A. Assimacopoulos, "Auditory browser for blind and visually impaired users," *CHI '99 Ext. Abstr. Hum. factors Comput. Syst. - CHI '99*, pp. 218–219, 1999.
[35] H. Donker, P. Klante, and P. Gorny, "The design of auditory user interfaces for blind users," *Proc. Second Nord. Conf. Human-computer Interact. - Nord. '02*, p. 149, 2002.
[36] R. F. Cohen, V. Haven, J. a. Lanzoni, A. Meacham, J. Skaff, and M. Wissell, "Using an audio interface to assist users Who are visually impaired with steering tasks," *Proc. 8th Int. ACM SIGACCESS Conf. Comput. Access. - Assets '06*, p. 119, 2006.
[37] J. Sodnik, G. Jakus, and S. Tomažič, "Multiple spatial sounds in hierarchical menu navigation for visually impaired computer users," *Int. J. Hum. Comput. Stud.*, vol. 69, no. 1–2, pp. 100–112, Jan. 2011.
[38] J. Fraser and C. Gutwin, "A framework of assistive pointers for low vision users," *Proc. fourth Int. ACM Conf. Assist. Technol. - Assets '00*, pp. 9–16, 2000.
[39] B. Andharini, D.C., & Ari, "Personalized learning path of a web-based learning system," *Int. J. Comput. Appl.*, vol. 53, no. 7, pp. 17–22, 2012.
[40] Y. Yang, H. Leung, L. Yue, and L. Deng, "Generating a two-phase lesson for guiding beginners to learn basic dance movements," *Comput. Educ.*, vol. 61, no. 166, pp. 1–20, Feb. 2013.