

Proposing the Components of Conceptual Design Model of ical4la using Comparative Analysis Method

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Abstract—This article discusses an ongoing study in determining the generic components for a conceptual design model of interactive computer-assisted learning that is specifically designed for low achieving (LA) children (iCAL4LA). These children need a specific learning support that can be used as an alternative material in their learning environment. In order to develop the conceptual model, this study extracts the common components from 15 strongly justified CAL studies. A comparative analysis has been conducted to determine the most appropriate components by using a set of specific classifications to prioritize the applicability. The results of the extraction process reveal 17 common components for consideration. Later, based on the pre-set justifications, 16 of them were selected as the proposed components for the Conceptual Design Model of iCAL4LA. In accordance, an initial model is proposed by considering those components.

Index Term—Interactive Computer-Assisted Learning; Low Achieving Children; Conceptual Design Model; Comparative Analysis Method.

I. INTRODUCTION

In educational setting, Computer-Assisted Learning (CAL) or computer-based learning assistance is a beneficial tool regardless of learners, subjects and learning environment [1,2]. The development of a CAL application can be implemented in various concepts and approaches based on general or specific learner requirements, especially for primary school children.

In Malaysian mainstream education context, underperforming children in primary schools are usually clustered in ranked-classes. The main reasons for ranking them include to properly and appropriately attending to them during teaching and learning process. However, these children feel demotivated during learning sessions, which leads to loss interest [3,4] as they face difficulties in grasping the fundamental concepts of reading, calculating, and writing [5-7]. These problems eventually deteriorate their academic performance in the future. This can be seen in Literacy and Numeracy Screening (LINUS) assessment records highlighted in National Key Report Area (NKRA) Lab Report by Performance Management and Delivery Unit (PEMANDU) [8]. Particularly, in 2008, they found that more than 54,000 pupils of year 1 and over 110,000 of year 4 had not reached the target for literacy and numeracy standard. Therefore, this study gives a proper attention for a special group of non-disabilities

children who have difficulties to acquire fundamental knowledge during learning process in class, which is known as Low Achieving (LA) children. The issue and problem of LA children have been investigated as reported in a preliminary study [9].

In accordance, with the leading issue of LA children's learning concern, support in a form of interactive CAL application [10,11] is urgently needed. It is important to stimulate learning interest of LA children for better learning experience. CAL is beneficial as it contains specific learning requirements, such as, the contents, learning concepts with adaptation of particular technique and learning approaches, which is customized based on the in-depth study. Many computer-based applications have been proposed to suffice the educational purposes for children and interactive multimedia is found as the most common concept.

However, they are not emphasized on the LA children learning requirements comprehensively. Even though Mohd Syah, Hamzaid, Murphya, and Lim [12], Rahmah, Hafiza and Tengku Nazatul Shima [13], and Wan Fatimah [4] proposed educational learning tools for remedial children, their applicability was in the different context of study. Therefore, a specific interactive CAL for LA children with comprehensive components is geared as the main intention of this study.

In line with that, the initial phase of proposing a Conceptual Model of Interactive Computer Assisted Learning for Low Achieving (iCAL4LA) children requires a systematic approach to extract the common components. This is the main focus of this paper, and the following sections explain those processes in detail.

II. CONCEPTUAL DESIGN MODEL

The main idea of a conceptual design model is based on the users' requirements, which consist of various appropriate components. The definitions of the components depend on the needed attributes and users' working environment, which determine the utilization of suitable technologies and theories [14]. Apparently, conceptual design model is an important initial task in delivering a useful and effective software or product [15], in which it can be used as a guideline by the software designer or developer in the implementation stage [16].

Based on the software’s user interface perspective, Mayhew [17] emphasized that conceptual model is a “general conceptual framework through which the functionality is presented” (p.80), which refers to detail design level. She stressed out the importance of understanding users’ mental model in order to develop a conceptual model.

Meanwhile, in the teaching and learning perspective, Churchill [18,19] describes conceptual model in learning object representation as a set of specific concepts, which is related to numerous attributes used to inform learning activities, especially in multimedia learning tool. He highlights the importance of a conceptual model to be embedded by a learning technology using graphical objects and textual representation by incorporating those elements with an interactive concept [20]. Inspired by a multimedia learning study initiated by Mayer [21], which includes interactivities and multimodalities, he emphasizes that a designer of a conceptual model must address three main issues of design; i) the presentation, ii) learning uses and iii) platform to convey it [19].

In accordance, this study gives consideration of those perspectives in proposing the conceptual design model of iCAL4LA.

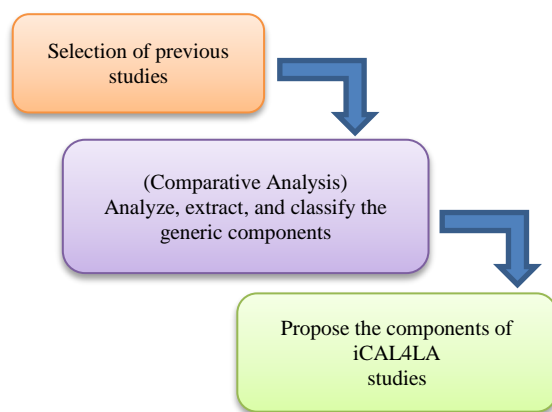


Figure 1: Summary of research activities

III. METHODOLOGY

In this study, comparative analysis is used to look into the distinct existing model in proposing the conceptual design model of iCAL4LA. According to Ariffin [14], every model consists of different features and characteristics, and it is important to analyze those components critically. Based on that, this study is conducted based on three main activities as seen in Figure 1. The first activity is the selection of existing studies that are in line with the focus of this study. The selection process relies on the appropriateness of those studies, which have been strongly justified in terms of their contribution in iCAL4LA model development. The extracted components were then tabulated and separated in columns to prioritize each component using comparative analysis method. The outcome of these activities is a set of proposed common components that are applicable for iCAL4LA.

IV. SELECTION OF PREVIOUS STUDY

Previously, many studies have been conducted to propose a conceptual design model by identifying relevant components of CAL courseware concept. It is important to justify the selection of the existing studies in order to determine its generic components, which becomes the main concern in proposing a new solution for LA children. In accordance to that, this section lists and justifies all selected models, which comprise of five conceptual design models of CAL (CDMc) and 10 CAL courseware (CALc), detailed in Table 1. The selection of those models is based on the specific justification as they contribute in the extraction of components for Conceptual Design Model of iCAL4LA. In order to get insight from different contexts of CAL courseware properties, some of the selected models also consider CAL for children with learning disabilities.

Table 1
Justification of model selection

Model	Justification
CDMc	
[14]	Reason of considering this model relies on its comprehensiveness as a conceptual design model for learning. Most of the components are explicitly relevant and appropriate to be adapted in this study.
[22]	This model elaborates the multisensory concept clearly in very a simple representation. However, the inclusion of learning technique and approach blended with multimedia elements significantly contribute to this study.
[23]	This model complements the shortage of other models, which exclusively outlines the specific design guideline for multimedia learning.
[24]	This model provides most of the common components by extensively describing the specific navigation and animation aspects that are significant to this study.
[25]	The application of this model relies on the implementation of the learning techniques (flash card) and multimedia learning concept that are applicable for LA children.
CALc	
[12]	The pedagogical approach (EIP) and learning theories are applicable to be prolonged in LA children learning concept.
[4]	This model is the only study that relates to LA children. It offers some user interface design guidelines for better enhancement of this study as both refer to the same target users.
[26]	This model includes the interaction design concept that is related to the main concern of this study.
[27]	This model is applicable in form of the concept of remedial learning treatment, which is related to LA children learning problem.
[28]	This model offers several creative and interactive elements in designing a multimedia learning tool, which are considerable for LA children learning assistance.
[29]	This model consists of interaction design components that are related to the main concern of this study. Those elements are applicable as guidance in designing iCAL4LA.
[13]	This model is useful to guide the color utilization, as it is one of the important elements to attract the LA children’s attention.
[30]	This model consists of numerous applicable components to be adapted in this study. It contributes to this study in terms of learning context, including instructional design and development process.
[31]	This model helps to determine the common components as it consists of several general concepts of learning courseware.
[32]	This model is quite complex. However, the adaptation of interaction control is applicable as it combines multimedia elements and learning approaches.

The justification in Table 1 explains that each model has its own significant impact. This can be seen as some of the models are related to this study in different contexts such as the application of learning theories, approaches, and techniques,

including the development process. Meanwhile, some of them merely contribute in very specific contexts such as user interface and interaction design guidelines. Particularly, they are significant to this study in determining and extracting the common components of Conceptual Design Model of iCAL4LA. Therefore, the following section describes the process as an initial activity of this study.

V. COMPARATIVE ANALYSIS

The initial step in proposing the common components in this study involved specific comparisons of the 15 studies. Conceptually, for this study, interactive CAL is divided into five main segments, which are design, content, user,

technology, and learning segments. These segments have been discovered based on basic component of CAL theoretical concept [33] that involves the user who interacts with the system supported with technology that consists of learning content with specific design and approaches. Learning content means lesson materials that are designed for the users in the digital form according to their levels. It consists of multimedia elements that enable the interactivity between users and the system[34],[35]. Based on the analysis of each study, the components were extracted and weighted in order to identify the degree of their applicability in appropriate segments using comparative analysis technique, which eventually lead to the results detailed in Table 2.

Table 2
Comparative analysis of common component of iCAL4LA

Category	CDMc					CALc										Total	%
	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10		
Design Segment																	
General	Y	Y	Y	Y		Y	Y		Y	Y		Y	Y	Y	Y	12	80%
Multimedia	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	15	100%
Navigational	Y	Y	Y	Y		Y	Y		Y	Y	Y		Y	Y	Y	12	80%
Interaction			Y					Y		Y	Y	Y			Y	6	40%
Content Segment																	
Content structure	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	14	93%
Content composition	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	14	93%
Development process	Y	Y							Y			Y	Y	Y	Y	7	47%
ID model	Y			Y	Y	Y	Y			Y	Y	Y	Y			9	60%
Learning Segment																	
Learning theories	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	14	93%
Learning approaches	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	15	100%
Learning techniques		Y			Y	Y	Y		Y		Y	Y	Y			8	53%
Learning styles		Y			Y		Y									3	20%
User Segment																	
Actor	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	15	100%
Audience	Y															1	6%
Technology Segment																	
Hardware	Y	Y	Y			Y	Y	Y	Y	Y			Y	Y	Y	12	80%
Software		Y				Y	Y	Y	Y	Y			Y	Y	Y	10	66%
Internet								Y	Y							2	13%

The next step is to classify the comparative analysis as a whole into segmented common components of iCAL4LA. In order to determine the applicable components of each segment,

this study follows the indicators in Table 3, which are adapted from [14, 36]

Table 3
Indicator for classification of component

Indicator	Description	Condition of classification
AM	All models	All models apply the component (100%)
MM	Majority of models	There are between, 8 to 14 models that apply the component (50-99%)
FM	Few models	There are between, 1 to 7 models that apply the component (1- 49%)
NM	No model	There is no model that apply the component (0%)
◆	Compulsory to apply	The component is compulsory to be applied when AM or MM appears in the row
◇	Recommended to apply	The component is recommended to be applied when FM or NM appears in the row

VI. RESULTS AND DISCUSSION

The results of the comparative analysis were then transferred in a tabular form, which is listed as segments, common components, classification of component, and applicability in iCAL4LA. The applicability of each component that initially was found in the existing models is labeled using two types of indicators, representing compulsory and recommended conditions. Particularly, there are 17 common components that

have been extracted from 15 models. As seen in Table 4, 12 of the components are devoted as “compulsory to apply”, while the other five are “recommended to apply”. Only one component is excluded from this study. It clearly shows that to propose a comprehensive courseware, those components (compulsory) are vital. Therefore, based on this stage of analysis, the compulsory components must be included in the Conceptual Design Model of iCAL4LA. Further elaborations of each component in the core segments are provided below

Table 4
Summary of generic components in existing models

Segment	Common Component	Classification	Extraction	iCAL4LA
Design	General design	MM	◆	◆
	Multimedia design	AM	◆	◆
	Navigational design	MM	◆	◆
	Interaction design	FM	◇	◆
Content	Content structure	MM	◆	◆
	Content composition	MM	◆	◆
	Development process	FM	◇	◇
	ID model	MM	◆	◆
Learning	Learning theories	MM	◆	◆
	Learning approaches	AM	◆	◆
	Learning techniques	MM	◆	◆
	Learning styles	FM	◇	excluded
User	Actor	MM	◆	◆
	Audience	FM	◇	◇
Technology	Hardware	MM	◆	◆
	Software	MM	◆	◆
	Internet	FM	◇	◇

Note: ◆ → Compulsory to apply ◇ → Recommended to apply

A. Design Segment

In design segment, the only interaction design is found as a recommended component, and the rest are compulsory to apply. It obviously shows that the lack of the previous models in highlighting this component as the gap to this study. Therefore, in order to provide suitable design components that are specifically proposed for LA children, this study includes interaction design as “compulsory to apply”. The general design, multimedia design, and navigation design components are consistent with the same classification condition.

B. Content Segment

The content segment consists of four common components that can initially be proposed in constructing the Conceptual Model of iCAL4LA. They are content, structure, composition, structure, development process, and ID model. Based on the comparison results, the development process component is only found in few models, which means it is applicable to be recommended as one of the common components.

Generally, development process refers to phases in constructing the courseware content. It is conducted in step by step activities. Meanwhile, ID model refers to the instructional approach in developing any learning material. In a real practice, both are applicable to be utilized in developing a learning courseware. Therefore, this study decides to maintain the result of comparative analysis with the inclusion of ID Model. Besides that, any other development process can be used by the developers based on their preference. Regardless of any development methodology that the developers choose, the

content, structure and content composition must become their main guidance in developing the learning content of iCAL4LA.

C. Learning Segment

Learning theories, learning approaches, learning techniques, and learning styles are the most common components extracted from this analysis. The first three components are classified as “compulsory to apply”, as they are important to be embedded in a learning material from an educational perspective. However, learning styles that refer to learners’ learning preference is only implemented in few models. It shows that in proposing a CAL courseware, learning style is not compulsory as the learning content can be designed to address the different types of learning characteristics. Therefore, this study decides to discard learning style as one of the components.

D. User Segment

The user is the main human entities that interact with the iCAL4LA which can be further subdivided as external (audience) and internal (actor) users. The concept of audience and actor has been introduced by [1] as human entities of RLM. However, only the actor component is applied by all models, and it shows the importance of this component to be included as iCAL4LA common component. In order to address the characteristic of LA children as the users of iCAL4LA learning content, this study decides to maintain audience component as “recommended to apply”.

E. Technology Segment

The technology segment remains important, as CAL is a digital learning assistance that can facilitate learning process. Regarding this segment, the main concern of this study is to deliver and expose iCAL4LA content in a convenient way at either schools or homes. Basic requirement of an educational CAL is hardware and software components that serve as its platform. In addition, the Internet is required for a web-based CAL. Therefore, this study maintains the hardware and software components as “compulsory to apply” and the Internet component as “recommended to apply”.

F. The Conceptual Design Model of iCAL4LA

In addition, based on the result of comparative analysis, this study initially proposed the model as illustrated in Figure 2. It comprises all internal and external of generic components in iCAL4LA that were discovered in the previous stage. The relationship of each segment and component is represented and mapped by using computer folder, arrows, and boxes. The segments are notated using open folders which link them to their components. Each component is indicated with thick line box for “compulsory to apply” and thin line box for “not compulsory but recommended to apply”, which represents its classification in iCAL4LA.

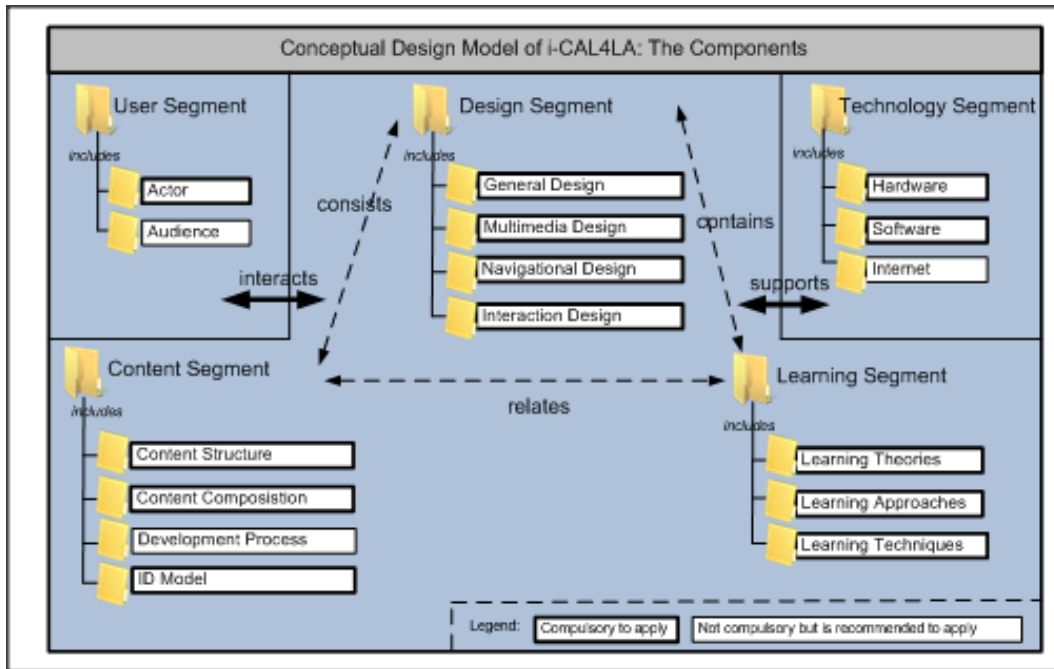


Figure 2: The initial conceptual design model of iCAL4LA

VI. CONCLUSION AND FUTURE WORKS

Overall, this article reports the on-going research in proposing the Conceptual Design Model of iCAL4LA, which requires an extensive study of the components. The comparative analysis process is solely depended on the extraction of 15 existing studies that comprise 10 CALc and five CDMc. The extracted components have been segmented into five core components of CAL, which are design, content, learning, user, and technology segments. Based on the comparative study, 17 common components have been determined initially.

However, based on the delimitation of this study, only 16 components remained as proposed components for Conceptual Design Model of iCAL4LA. This activity is conducted as an early phase in proposing the components. In line with that, an initial conceptual design model of iCAL4LA is proposed. Basically, it serves as an abstraction of the model that requires further study to determine the elements. Prior to that, consultation session needs to be conducted in order to confirm that the proposed components are applicable within the LA

children’s learning environment. Therefore, in the future works, involvement of content experts, software developers, and instructional designers are crucial. They need to confirm and justify the applicability and suitability of the proposed components for Conceptual Design Model of iCAL4LA.

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