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Artikel Asli/*Original Article*

Development of a Computer-Assisted Learning Courseware for Anatomy and Physiology of Swallowing

(Pembentukan Perisian Kursus Pembelajaran Berbantukan Komputer untuk Anatomi dan Fisiologi Penelanan)

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ABSTRACT

Knowledge of normal anatomy and physiology of swallowing is fundamental in the identification of individuals with or at risk for swallowing disorders. Learning anatomy and physiology however, is not an easy task thus, computer-assisted learning (CAL) approaches have been incorporated into the learning of the topics to enhance understanding. Although evidence exists on the benefits of using CAL in education, more studies are necessary in the field of swallowing. While courseware for the learning of anatomy and physiology of swallowing exist, they are not comprehensive. Therefore, this study aimed to develop a comprehensive CAL courseware for anatomy and physiology of swallowing. The current study used a designed-based research following the ADDIE (analysis, design, development, implementation, and evaluation) model to create a multimedia courseware, incorporating the use of text, still images, animations, audio narrations, and presented on a simple graphical user interface. The courseware was evaluated by 27 undergraduate students in terms of its usefulness, ease of use, and users' satisfaction. Results indicate that the participants were satisfied with the courseware and that they perceived the courseware as useful, easy to learn and easy to use. The study represents an initiative to investigate the use of CAL in the subject and to establish the basis for further work which includes assessment on the learning outcomes from the usage of the CAL courseware. It is hoped that the use of this courseware in teaching and learning of anatomy and physiology of swallowing can enhance students' knowledge and understanding of the area efficiently and effectively.

Keywords: Anatomy; physiology; swallowing; computer-assisted learning; ADDIE model

ABSTRAK

Ilmu berkaitan anatomi dan fisiologi penelanan merupakan asas kepada penilaian dan pengendalian masalah penelanan. Namun begitu, penguasaan ilmu anatomi dan fisiologi bukanlah suatu tugasan yang mudah. Oleh itu, pendekatan pembelajaran berbantukan komputer (PBK) telah diterapkan ke dalam pembelajaran topik tersebut untuk meningkatkan pemahaman. Walaupun perisian kursus untuk pembelajaran anatomi dan fisiologi penelanan wujud, ianya adalah tidak menyeluruh, dan meskipun wujudnya bukti manfaat penggunaan PBK dalam pendidikan, lebih banyak kajian diperlukan dalam bidang penelanan. Oleh demikian, kajian ini bertujuan untuk membangunkan sebuah perisian PBK yang menyeluruh bagi anatomi dan fisiologi penelanan. Kajian ini merupakan suatu kajian berasaskan reka bentuk yang dilaksanakan berpandu kepada model ADDIE ('analysis,' 'design,' 'development,' 'implementation,' dan 'evaluation'), bagi menghasilkan sebuah perisian kursus multimedia yang menggabungkan penggunaan teks, imej pegun, animasi, dan pengolahan audio ke atas antara-muka pengguna grafikal yang mudah. Perisian ini kemudiannya dinilai oleh 27 orang pelajar ijazah sarjanamuda dari segi kesesuaian, kemudahan, dan kepuasan penggunaan. Hasil kajian menunjukkan bahawa pelajar berpuas hati dengan perisian kursus tersebut dan mereka berpendapat bahawa ianya berguna, mudah dipelajari dan mudah digunakan. Kajian ini merupakan suatu inisiatif untuk mengkaji kegunaan PBK dalam subjek ini dan sebagai asas kepada kajian lanjutan yang merangkumi penilaian hasil pembelajaran daripada penggunaan perisian kursus PBK. Adalah diharapkan penggunaan perisian kursus ini dalam pengajaran dan pembelajaran anatomi dan fisiologi penelanan dapat meningkatkan pengetahuan dan pemahaman pelajar secara efisien dan efektif.

Kata kunci: Anatomi; fisiologi; penelanan; pembelajaran berbantukan komputer; model ADDIE

INTRODUCTION

The speech-language pathologist (SLP) carries out assessments and manages individuals with swallowing disorders (American Speech-Language-Hearing Association [ASHA], 2001; Canadian Association of Speech-Language Pathologists and Audiologists [CASLPA], 2007; Royal College of Speech and Language Therapists [RCSLT],

2009). Professional associations in speech pathology across the world have developed guidelines that stipulate the pre-requisite skills required to practice, in which they set out the minimum skills, knowledge base and professional standards across key areas of the profession which SLPs are required to meet (e.g., ASHA 2007; College of Audiologists and Speech-Language Pathologists of Ontario [CASLPO] 2007; Irish Association of Speech & Language Therapists [IASLT] 2012; Speech Pathology Australia [SPA] 2001). It is well documented that knowledge of anatomy and physiology of swallowing, the ability to conduct an oral, pharyngeal, and laryngeal examination, and the ability to identify normal and abnormal structures and functions, are among the required competencies to provide dysphagia (swallowing disorders) services.

Hence, knowledge related to anatomy and physiology of the head and neck is extremely important for guidance in the processes of assessment, diagnosis and intervention in swallowing disorders. This knowledge provides vital foundation to the SLP's quality of practice and therefore is important to be well assimilated in the early stages of training. However, learning anatomy and physiology is not an easy task as it requires students to utilize at least two different learning skills: (i) the acquisition of a large and complex technical vocabulary, and (ii) the development of an ability to interpret and understand three dimensional relationships within the human body (Tallitsch et al. 2012). Therefore, it is important to employ methods which facilitate learning.

Computer-assisted learning (CAL) defined as 'any use of computers to aid or support the education or training of people' (Daintith 2004), has become a common place in medical education and a feature of medical training programs since the mid-1980s. Research has shown that computer training is particularly well suited for visually intensive, detail-oriented subjects, such as anatomy and physiology. This is because it allows text to be combined with still and moving graphics, with the display of this information controlled by the learner (Toth-Cohen 1995). The nature of CAL therefore allows visually rich and interactive environments, to be incorporated to anatomy and physiology laboratories and classes to enhance learning (Goldberg & McKhann 2000; Moos & Marroquin 2010; Paalman 2000).

Multimedia technology in CAL combines different types of media, such as text, image, sound, animation, and video, to be used as digital teaching materials to enhance teaching and learning (Giller & Barker 2006). Stimulating multimedia presentations play an effective role in the delivery of information with its ability to draw attention and increase involvement of students in learning (Schraw & Lehman 2001). The use of computer technology also has the potential to motivate students, help students to connect various sources of information, and give educators the extra time to help students in the classroom (Moallem 2003; Roblyer et al. 2004; Wilson & Lowry 2000). Two conclusions drawn from meta-studies on CAL are that learners generally learn more using CAL than they do with conventional ways of teaching as measured by higher post-training test scores (Andrews et al. 1992; Fletcher 1999; Gee et al. 1998; Kallinowski et al. 1997; Kulik 1994; Perciful & Nester 1996; Potts & Messimer 1999; Summers et al. 1999; Toth-Cohen 1995), and that learners using CAL generally do so in less time than those using traditional approaches (Kulik & Kulik 1991; Lyon et al. 1992; Orlansky & String 1979).

Currently there are computer softwares and applications available in the market which aid learning of anatomy and physiology of swallowing and also some which aid understanding of swallowing and swallowing disorders. However, on review of the currently available softwares and applications; videos and animations presented in these softwares and applications are contained to the 'overview' of the normal and/or the disordered swallowing. This may cause important features in each phase of swallowing to be easily missed, as how each anatomical structure functions and is coordinated to form a chain of events during the normal swallowing process is not animated in detail. Consequently, learners could find themselves learning the anatomy and physiology separately; making the learning process dreary when learners fail to understand that learning the subject is about conceptual and relational understanding, and not about lists of names and terminologies.

In a study on student perceptions about learning anatomy, it was found that students often saw anatomy as being content driven and so they focused on surface approaches to learning that relied on rote memorization (Notebaert 2009). In contrast to surface approaches, deep approaches to learning were geared toward engagement of the material through intrinsic interest where learners worked to maximize learning through the use of cognitive learning strategies (Biggs et al. 2001). The delivery of the subject needs to move away from identification of structures individually to identification of structures in relation to one another for students to utilize deeper approaches to learning (Notebaert 2009).

In view of the shortfall in the currently available software, this study aims to develop a multimedia courseware for anatomy and physiology of swallowing which provides detailed animation of each phase of the normal swallowing process in addition to graphics, texts, and audio narrations, combined and presented on a simple graphical user interface; in an attempt to help learners learn about the anatomy of swallowing and the physiological functions conveniently in a connected and meaningful manner.

METHODS

This design-based research used the ADDIE (analysis, design, development, implementation, and evaluation) model created by the Centre for Educational Technology at

Florida State University (Branson et al. 1975). This widely used methodology for developing new training programs is composed of five steps as detailed below.

ANALYSIS

The analysis stage is the 'goal-setting' stage. It involves identifying the target audience or learners to determine their learning needs. The goal of the design was determined based on needs and literature analysis. A survey of 44 SLPs conducted in 2004 revealed that there were critical limitations to dysphagia services in Malaysia with SLPs reporting a lack of skills and confidence in managing the disorder (Sharma et al. 2006). More recent research has also highlighted that there continue to be significant issues regarding the SLPs levels of training, knowledge, skill and confidence in dysphagia management (Mustaffa Kamal et al. 2012). Malaysia-trained SLPs were found to have received limited hours of formal education relevant to dysphagia and minimal opportunities to receive mentoring/supervision prior to beginning independent practice as compared to international standards (Mustaffa Kamal et al. 2012). These factors were seen as impacting their preparedness for clinical care of this population.

In light of the evidence indicating that Malaysian clinicians lack confidence, knowledge, skill and clinical training in managing dysphagia, there is a crucial need to improve the current undergraduate training in the subject. Also, as knowledge of the anatomy and physiology of the head and neck is extremely important in the overall management of swallowing disorders, and as CAL has shown to be well suited in learning such subjects; this study explored the use of CAL in learning anatomy and physiology of swallowing. Hence through preliminary analysis, it was determined that the goal of the design was to develop a multimedia courseware for learning anatomy and physiology of the normal swallowing process, which can be used by undergraduate students as a CAL tool to acquire basic knowledge and also by practicing clinicians to refresh their knowledge on the subject.

DESIGN

The design stage involved the complete design of the courseware. In the design stage, the focus was on the learning objectives, courseware content, and media selection. The learning objectives and content were identified based upon the learning outcomes for the subject of anatomy and physiology of swallowing from universities course modules and from anatomy and physiology reference books available in the market. Since the study focuses only on the anatomy and physiology of the normal swallowing process, the courseware covers topics on basic structural anatomy; muscles and innervation; phases of swallowing; and the coordination of respiration and swallowing. The specific learning objectives and contents are summarized in Table 1. As multimedia courseware weaves different types of media into the learning environment; graphics, animations, videos, texts, and sounds were incorporated in this courseware. By using multimedia, a large amount of information can be passed across to the users, and high interest can be created in the users. Furthermore, different media can be tailored towards different objectives outlined for the lesson (Blythe-Lord 1991; Kemp & Smellie 1989; and Wittich & Schuller 1973). The different types of media were chosen based on its functionality and suitability for each of the learning objective (Table 1).

DEVELOPMENT

Development is the process of authoring and producing the materials, corresponding to specifications determined from the analysis and design stages. This stage sees the creation of storyboards, graphics, audio files and programming involved in the development. It involved the production of graphics and animation according to storyboard specifications; audio narrations according to scripts, and the programming according to graphical user interface storyboard specifications. Storyboard and outline of the courseware interface was first created using PowerPoint® (Microsoft®). The courseware content was organized and structured in a manner that aids understanding of relation between the physiological functions and the anatomical structures and muscles involved, as depicted in Figure 1. Several others software packages were used in the courseware development process. Adobe After Effects® (Adobe® Systems), Adobe Photoshop® (Adobe® Systems), and Autodesk 3ds Max® (Autodesk®) were used in the production of graphics and animation; Speech Application Programming Interface Text-To-Speech Application (SAPI 5.3 TTSApp) (Microsoft®) was used in the production of audio narrations; and Visual Studio® (Microsoft®) and Visual Basic® (Microsoft®) were used in programming.

At the end of the development stage, 29 coloured two dimensional (2D) still images were produced. An example of a still image is as shown in Figure 2. Each of these images shows and highlights either the important features of a structure or the muscles which are involved in swallowing. A total of 10 colourful three dimensional (3D) animations with duration ranging from 18 to 129 seconds were produced. These animations were used to illustrate each of the phases of swallowing in detail, and some to show specific processes such as velopharyngeal closure, pharyngeal constriction, pharyngeal shortening, hyolaryngeal excursion, and the coordination of respiration and swallowing. As for the audio narration, text-to-speech application - SAPI 5.3 TTSApp were used to generate audio narrations used in the courseware. In addition to the brief texts displayed on the interface, these narrations function to explain each structure elaborately in terms of its function, muscles and nerves innervations. Audio narrations were also used in the animations, describing each event in the animation concisely. The voices of Microsoft® David and Microsoft® Zira (in SAPI 5.3 TTSApp) were used at a rate of speech of 125 words per minute (WPM). The full list of images, animations, and audio narrations produced in this

stage, is shown in Table 2. All these materials were then put together onto a simple graphical user interface using Visual Basic programming language, to ensure convenience and maximized usability. A snapshot of the graphical user interface is shown in Figure 3.

TABLE 1. Learning objectives, contents, and media used

Learning Objectives	Contents	Media
Students will be able to identify the anatomical structures and to explain its function in swallowing.	• Salivary glands • Lips • Mandible • Teeth • Tongue • Oral Cavity • Cheeks • Pharynx • Larynx • Valleculae and pyriform sinuses • Esophagus	• Coloured graphic • Audio narration • Text
Students will be able to identify the muscles involved in swallowing and to describe the functions of the muscles and its innervation.	• Muscles of the lips • Muscles of mastication • Intrinsic and extrinsic muscles of the tongue • Muscle of the cheeks • Pharyngeal muscles • Intrinsic and extrinsic muscles of the larynx • Muscles of the esophagus	• Coloured graphic • Audio narration • Text
Students will be able to describe the events in the phases of swallowing.	• Pre-oral anticipatory phase • Oral phase • Oral transit phase • Pharyngeal phase • Crico-esophageal phase • Velopharyngeal closure • Pharyngeal constriction and shortening • Hyolaryngeal excursion	• 3D animation • Audio narration
Students will be able to explain the coordination of respiration and swallowing.	• Coordination of respiration and swallowing	• 3D animation • Audio narration

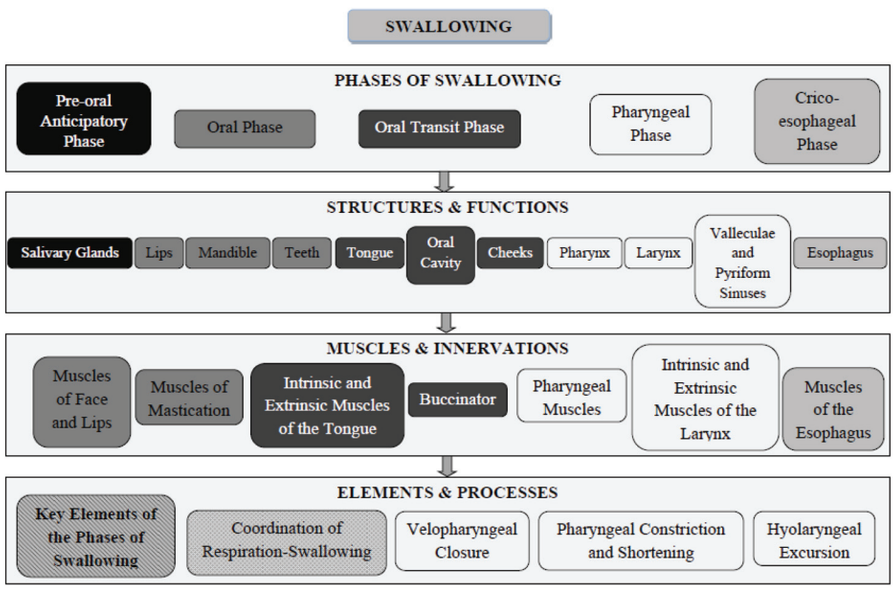

FIGURE 1. Contents in the courseware were organized according to the phases of swallowing. Topics on each anatomical structure and its functions were organized under the swallowing phase(s) which the structure is involved in, followed by topics on muscles and nerve innervations of the anatomical structure. Topics on key elements of each phase of swallowing and topics on specific processes were organized under the swallowing phase which it is related to.

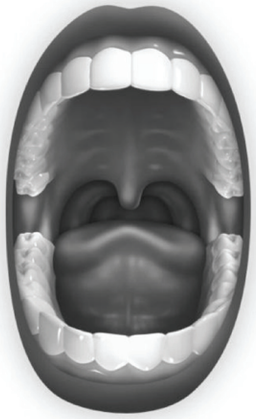

FIGURE 2. A sample of image used in the courseware – anterior view of the oral cavity

TABLE 2. Materials produced (images and animations with audio narration)

Media Type	Contents
Coloured images with audio narrations	• salivary glands • lips • muscles of the face and lips • mandible • temporalis and masseter muscles • lateral and medial pterygoid muscles • teeth • tongue • taste and general sensations of the tongue (innervation map) • intrinsic muscles of the tongue (frontal section) • intrinsic muscles of the tongue (lateral view) • extrinsic muscles of the tongue • oral cavity • buccinator muscles • pharynx (sagittal section) • pharyngeal muscles • larynx (bone and cartilages) • hyoid bone • thyroid cartilage • intrinsic muscles of the larynx • extrinsic muscles of the larynx • hyolaryngeal excursion • valleculae and pyriform sinuses (posterior view) • valleculae and pyriform sinuses (superior view) • esophagus • esophageal muscles
Animations with audio narrations	• overview of a swallowing process • pre-oral anticipatory phase • oral phase • oral transit phase • pharyngeal phase • crico-esophageal phase • velopharyngeal closure • pharyngeal constriction and shortening • hyolaryngeal excursion • coordination of respiration and swallowing

IMPLEMENTATION

The implementation stage reflects the continuous modification of the program to make sure maximum efficiency and positive results are obtained. It is the process of installing the project in the real context. In this study, 27 second-year undergraduate students of Audiology and Speech Sciences programs at Universiti Kebangsaan Malaysia (UKM) were given the opportunities to try out the courseware. The students had completed a course in anatomy and physiology the previous semester, and had basic knowledge in topics of anatomy and physiology of swallowing. These students were chosen as participants of the implementation stage as they had had experience in an anatomy and physiology course conducted through conventional lecture-based instruction. With that, these students were felt to be most suitable for the evaluation of the courseware, since they had experienced the difficulties of learning the subject through the conventional method and would be able to critique the courseware developed. All participants were required to provide written consent for the study. Ethical clearances were received from the Research Ethics Committee of Universiti Kebangsaan Malaysia.

In the implementation stage, the courseware was first installed into 27 desktop computers in a multimedia lab within UKM. The students were then ushered to the lab and were allocated two hours to try out the courseware on the desktop computers. Students were instructed to explore the functions and go through all the contents as listed on the menu in the courseware within two-hour duration. The students were supplied with a mouse (to point and click on various elements of the graphical user interface and to navigate around within the courseware) and a set of headphones (to allow students to listen to the audio narrations privately).

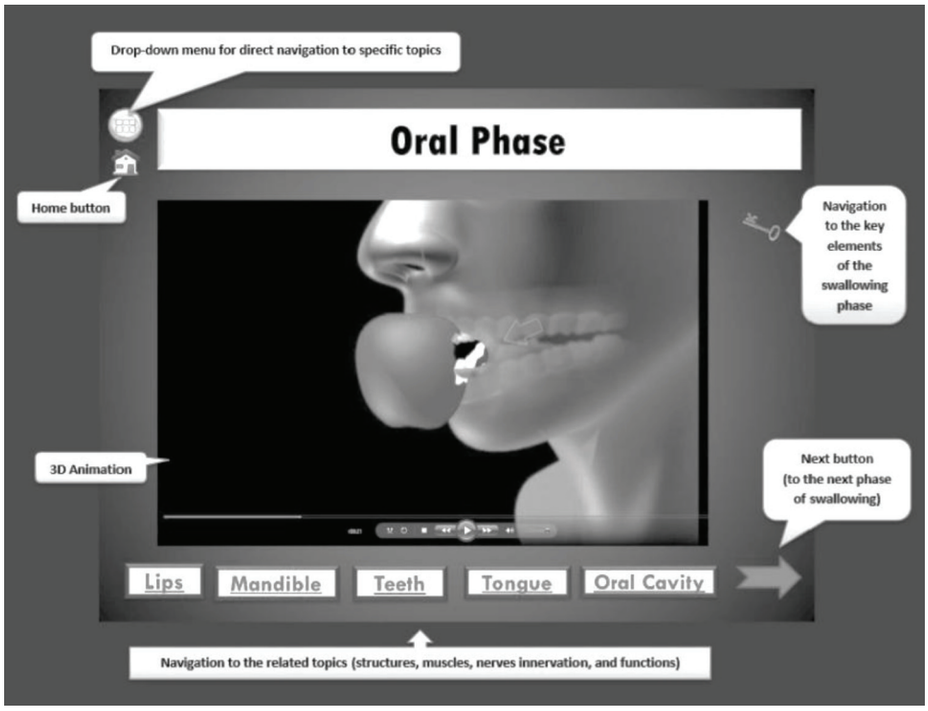

FIGURE 3. Sample of a content page showing animation of the oral phase of swallowing. Links to topics on anatomical structures involved in the phase placed under the animation video – provides easy navigation and direction to related topics to aid understanding of relation between the physiological functions and the anatomical structures and muscles involved.

EVALUATION

Evaluation is the process of determining the suitability of the materials/courseware. It is an essential component of the ADDIE process to determine what works and what does not, and the reason(s) why. Evaluations were done at two points in the study for the purpose of formative evaluation and summative evaluation. A formative evaluation is a continuous effort that aims to monitor the ability of a program to achieve its goals and objectives so that any deficiency in the program can be detected as early possible and appropriate intervention can be performed to the program so that it achieves its goals and objectives (Clark 1995). While summative evaluation is a method of evaluation at the end of a program to see the results of the program (Scriven 1967).

In this study, formative evaluation was carried out in the development stage after the formation of still images, animations, texts, and audio files. Three lecturers from Speech Sciences program UKM and one lecturer

from Department of Biomedical Engineering, Universiti Malaya (UM) were involved as subjects for the formative evaluation. These lecturers were chosen as evaluators based on their experiences as instructors in the field of speech sciences and swallowing, and in biomedical engineering, particularly in development of computer-based system/ tool.

During the formative evaluation, the media files produced and the storyboard arrangement for the graphical user interface were presented to the lecturers (n = 4) involved. The lecturers were asked to evaluate and give feedback on the media files produced and the graphical user interface based on the content and organization of topics in the courseware, ease of use, clarity and accuracy of images, videos, and audio files, as well as the manner and the content of labels. Based on the feedback given by the panel, improvements have been made to several stills images and images in the animation, sequences of events in an animation video, pronunciation of several terms in audio files, and the manner and contents of labels.

Summative evaluation was performed at the end of the implementation stage by means of evaluation of usability. Usability describes the ease with which a technology interface can be used and has been defined as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (Abran et al. 2003). The usability of user interfaces is an important element that needs to be considered when designing CAL resources. A poorly designed user interface imposes an additional, extraneous, cognitive load and impedes learning as users struggle with the interface as well as with the challenges of the content presented. Reducing such an extraneous cognitive load can lead to large gains in learning efficiency (Sweller 1994).

Therefore, at the end of implementation, an evaluation of usability was done. Students who participated in the implementation stage were given 30 minutes to complete a questionnaire pertaining to their experiences and perceptions towards the module after trying out the courseware for two hours (in the implementation stage). These students have completed a course in anatomy and physiology through conventional lecture-based instruction in the previous semester, and so it is anticipated that they evaluate the courseware by comparing it to their experiences through conventional method of instruction.

The questionnaire which was set online on a survey engine, included 28 (7-point rating scale) questions adapted from the Usefulness, Satisfaction, and Ease of use (USE) questionnaire (Lund 2001); and one open-ended question. The question items in the USE questionnaire were revised, whereby minimal changes were made to the wording in questions 1, 4, 5, 8, and 12 to be more aligned with usability of the courseware for learning the subject. The adapted questionnaire was distributed to a panel of experts which consisted of five academicians and clinicians, to ensure the suitability and appropriateness of language, content, and question items in achieving the objectives. Appropriate changes were made based on the experts opinions.

The questionnaire consisted of four parts with parts I to III made up of 7-point rating scale items. The rating of the 7-point Likert scale questions range from 1-strongly disagree to 7-strongly agree (with 2-disagree, 3-somewhat disagree, 4-neither agree nor disagree, 5-somewhat agree, and 6-agree). Part I included eight items pertaining to perceived 'Usefulness' of the courseware. Part II comprised 13 questions on the 'Ease-of-use' of the courseware. While part III included seven items regarding their 'Satisfaction' with the courseware. Part IV was an open-ended question on what they disliked about the courseware.

RESULTS

Analysis of the courseware evaluation revealed that all students agreed that the courseware is useful, easy to use, easy to be learnt, and that they were generally satisfied with it. These were demonstrated with all 28 items receiving mean scores of 6 and above (refer Table 3). Mean scores of 6 and above indicated that in average the students either agreed or strongly agreed to the statements pertaining to the courseware being useful, easy to use or to be learnt, and were satisfied with it.

Specifically, with regard to usefulness, students felt that the courseware helped them to be more effective in learning and to be more productive. They felt that it was useful, it made learning easier, saved them time, helped them understand the subject better, met their needs in learning, and it provided them adequate information. It was shown that the users strongly agreed that the courseware would be a useful tool to aid their learning and understanding of the subject (Table 3).

With regard to the ease of use, students felt that it was user friendly, easy to use, simple and flexible. Navigation from one part to another was easy. They found using it effortless and could use it without written instructions. They also did not highlight the presence of any inconsistencies as they used the courseware and believed that users would like it. Students strongly agreed that it was easy to learn to use the courseware. This was indicated with each of all the items regarding the ease of learning the courseware (items 18-21) showing mean score above 6.50 (strongly agree). They had easily learnt to use it and became skillful quickly. It was also easy to remember how to use it correctly.

Students reported to be satisfied with the courseware and indicated their intentions to have a personal copy in addition to recommending it to their friends. They found using it was fun and it was pleasant to use. They also agreed that it has an attractive presentation and the courseware worked the way they wanted it.

When asked about what they disliked about the courseware, some students commented that they liked everything about the courseware and had no dislike (n = 10, 37%). Other students commented on the audio narration,

TABLE 3. Mean and standard deviation of each 7-point rating scale item

	Questions	Mean	S.D.
	Part I: Usefulness		
1	It helps me be more effective in learning.	6.70	0.61
2	It helps me be more productive.	6.30	0.67
3	It is useful.	6.63	0.49
4	It helps me to understand the subject better.	6.89	0.32
5	It makes learning easier.	6.63	0.49
6	It saves me time when I use it.	6.41	0.69
7	It meets my needs in learning.	6.52	0.58
8	It provides me adequate information.	6.56	0.58
	Part II: Ease of use		
9	It is easy to use.	6.63	0.57
10	It is simple to use.	6.52	0.89
11	It is user friendly.	6.26	0.90
12	It is easy to move from one part to another.	6.04	1.02
13	It is flexible.	6.11	0.80
14	Using it is effortless.	6.15	0.77
15	I can use it without written instructions.	6.07	1.11
16	I don't notice any inconsistencies as I use it.	6.11	0.75
17	I believe users would like it.	6.52	0.51
18	I learned to use it quickly.	6.67	0.48
19	I easily remember how to use it.	6.81	0.40
20	It is easy to learn to use it.	6.59	0.50
21	I quickly became skilful with it.	6.56	0.51
	Part III: Satisfaction		
22	I am satisfied with it.	6.44	0.58
23	I would recommend it to a friend.	6.56	0.64
24	It is fun to use.	6.48	0.80
25	It works the way I want it to work.	6.37	0.88
26	It has an attractive presentation.	6.56	0.70
27	I feel I need to have it.	6.59	0.80
28	It is pleasant to use.	6.63	0.57

content and/or the graphics. Some students reported that the intonation of the audio narration was rather monotonous (n = 6, 22%) while some preferred a slower rate of speech (n = 2, 7%). Several other students (n = 5, 19%) suggested the inclusion of quizzes, mind maps, acronyms, fun facts, more images and more animations into the courseware. Several other students stated that they would prefer the use of 3D images or real images (n = 3, 11%); and a different colour themes for the interface of the courseware (n = 1, 4%).

DISCUSSION

In this study, a multimedia courseware was produced following the ADDIE processes, and incorporating use of images, animations, audio narrations, and text, on a simple graphical user interface layout. Analysis of evaluation conducted at the end of the courseware development showed that the students agreed on the usability of the courseware in terms of usefulness, ease of use, and satisfaction.

With regard to usefulness, the students felt that the courseware is a useful tool to aid their learning and understanding of the subject. Review of literature showed evidences of increased learning gains with increased test scores when CAL tools were utilized to support teaching and learning of anatomy and physiology (Chopra et al. 2012; Elizondo-Omaña et al. 2004; Goldberg & McKhann 2000; Paalman 2000; Pereira et al. 2007). The multimedia nature of this courseware offered learners access to information in a variety of formats, which included text, still images, animations, and audio presentations, which promotes multisensory learning. A simple advantage of multisensory learning is that it can engage individuals with different learning styles, for example, some people are 'visual learners' and others 'auditory learners' (Shams & Seitz 2008). Treichler (1967) stated that people generally remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they see and hear. Furthermore, stimulating multimedia presentations presents highly interesting and relevant information that engages learners (Schraw & Lehman 2001). Thus, various presentations of material in a multimedia environment engages individual into learning and consequently improving learning outcome. Computer and their associated software present great opportunities

for motivating students, encouraging independent learning and for improving the quality of educational programs (Westwood 2008).

According to the Technology Acceptance Model (TAM) developed by Davis (1989), perceived usefulness and ease of use influence attitude towards usage, which impacts behavioural intentions, which in turn impacts the actual usage. Therefore, another important aspect in courseware usability evaluation is the ease of use. Results show that the students agreed that the courseware was easy to use and learning to use the courseware was "a breeze." Minimal basic computer skills were needed to operate the courseware. The users found that they had easily learned how to use it quickly and became skilful with it.

Given the changes in the digital world over the last decade, students of the current generation anticipate the use of technology in advancing their learning, which calls for a need to change from the conventional passive learning methodologies to an active multisensory learning methodology (Prensky 2001). The evaluation analysis confirms that the students were satisfied with the courseware and they felt the need to have it and would also recommend it to their friends. Students also found it fun to use and agreed that it has an attractive presentation; it works the way they want and is pleasant to use. Affective dimensions such as aesthetics, fun, and flow are receiving increased attention as it was reported to enhance user motivation and ensure pleasurable user experiences. A study by Miller (2011) reported that students working in an online environment with enhanced aesthetic design had reduced cognitive load, increased motivation, and increased performance compared with those working with a low-aesthetic interface.

Although the majority of the students responded that they liked everything about the courseware, a number of students had commented on their dislikes. Eight students had commented on the audio narrations. In this study, text-to-speech (TTS) application was used to generate narrations. Computer or TTS generated voice was chosen over human voice due to factors such as consistency, quality, cost, and time. Although TTS generated voice sounded less natural compared to real human voice; TTS voice is much simpler to produce, uses less resources, and eliminates problems with controlling rate of speech, pronunciations, and maintaining sound quality; with low chances of error, low cost and time saving. With only a small number of students commenting on the intonation being monotonous, the research team decided to maintain the narration using TTS generated speech. Nevertheless, slight modification to the intonation could be possible with altered positions of pauses or with edition to the scripts.

Two students expressed that they would prefer a slower rate of speech. Notwithstanding that English is a medium of instruction for science and technology courses in public higher education institutions in Malaysia (Jacobson 2001; Zaaba et al. 2011); this issue might have arisen due to language barrier, as the students were non-native speakers of the language. A slow speech rate with pauses allows a listener extra time for the processing of speech (Murphey et al. 2003). However, when speech rate is too slow, it can lead to listeners having difficulty maintaining attention effectively (Berlyne 1960) and can result in weakened comprehension (Mastropieri et al. 1999). The optimal rate of speech for teaching is between 100-125 WPM, a rate which provides time to create understanding and to take notes (Wong 2014). In this study, the rate of 125 WPM was used. Considering the adverse effects of speech rate which is too slow, the option to reduce the speech rate was disregarded. Instead, future refinement of the courseware may consider the use of subtitles to assist students who may have difficulty following through the audio narrations.

Limitations of the current study include the absence of data on its effects on users' performance. This study only focused on the courseware development processes and did not investigate differences in performance before and after using the courseware, or the differences in performance between a control and an experimental group. It was also not the intention of the authors to evaluate the courseware based on the learning objectives of the topic even though it might give additional value to the study. As the ultimate goal of developing new learning methodology is to have increased learning outcome, these points should be considered in future investigations.

For future improvement, the courseware could be enhanced with the inclusion of quizzes and test, as means of self-assessments. Employment of mind maps and fun facts should also be considered, as suggested by students in the study. It is also recommended that this courseware to be integrated into web-based platform so as it can be accessed easily anywhere.

The present study represents an initiative to investigate the use of CAL in the subject of swallowing. Future research directions include to assess the learning outcomes from the usage of the courseware and further to investigate the effects of CAL on skills and confidence in clinical reasoning and decision making in the field of swallowing and swallowing disorders.

CONCLUSION

The development of engaging CAL materials for students and professionals in the health sciences is often resource intensive. It therefore becomes critical to evaluate and optimize these materials to maximize their educational impact. Results of the present study show that the multimedia courseware produced was perceived as useful, easy to use, and satisfied the users. Nevertheless, further investigation on its effects on performances and learning outcomes is needed. It is hoped that the use of this courseware in teaching and learning will increased students' knowledge and understanding on anatomy and physiology of swallowing. Ultimately, the implications of improved learning method and training in swallowing would help to improve dysphagia management services.

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