Improving Reading Comprehension Skills Using Multimedia Storytelling with Mind Maps for Students with Learning Disabilities in Thailand

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Abstract—This study explores the innovative approach of integrating multimedia storytelling with mind maps to enhance reading comprehension for students with learning disabilities (LD). We developed a proposed mobile application and applied it to 36 students with LD from grades 4 to 6 in Bangkok, Thailand. Students were selected using a simple random sampling technique; the lottery method. Students were formally identified as having an LD caused by a reading related disability. The experiment was conducted under a Thai language learning course, following the indicators for reading comprehension skills. The sampling groups included two experimental groups and one control group. We evaluated the test results by comparing the learning outcomes for each sampling group. Students in the three groups practiced their Thai reading comprehension using the same Thai literature, but employing three different learning methods. The first experimental group used tablet PCs with the application installed including multimedia storytelling with mind maps. The second group used tablet PCs that only had multimedia storytelling installed, while the control group learned as the teacher read the stories and used hand-drawn mind mapping. The findings of the experiment clearly showed that the teaching approach using the application accommodated the learners' weaknesses and built upon their strengths in reading comprehension skills, while the results of the second and third group indicated that without interaction with the learning media students were less interested and focused on learning.

Keywords—reading comprehension, multimedia storytelling, mind maps, learning disabilities, mobile application

1 Introduction

Learning innovation has been the driving force behind a paradigm shift in 21st century global development of education. Effective learning tools, such as mobile learning applications, interactive multimedia, cartoon animations, and digital mind mapping, play an important role in enhancing the learning competencies of students across

classroom settings. This is especially true of students with learning disabilities (LD). This global trend in education has given priority to equality in education.

In Thailand, the Thai government released its 20-year national education plan (2017-2036). One of the key issues of this plan focuses on both formal and informal education, as well as life-long learning. Its goal is to create greater educational opportunities for everyone, especially children with LD, so that they can be educated equally [14]. This national education plan supports children with LD and offers them potential for development in the skills necessary for living and continuing to a higher-level education, providing equal opportunities to access various types of knowledge resources.

In recent years, there have been many research studies in Thailand that have focused on how to develop the skills and knowledge of children with LD. Based on a demographic survey of children with LD in Thailand in 2018, it was found that there were 329,274 students with LD. This represented 84.38 percent of the total number of students with disabilities [19]. The most common language problem for these children with LD was found to be reading comprehension. The evidence for this can be found in a report on the standard examination results in the primary level of the country [13]. Based on the data collections of previous studies [16], the findings show that students with LD at a primary level who are at grade 4-6 have the most reading comprehension problems.

Reading comprehension is one of the most important skills that allows children to learn and discover new knowledge from content both inside and outside the classroom. It is also the underlying basis for further study of other subjects. Students with LD who lack reading comprehension skills are unable to capture the main point or summarize the key ideas of reading passages assigned, such as news articles, short stories, and literature. It is clear that a student's reading skills have an impact on their ability to learn in subjects other than English, such as social studies, history, and science [13]. For that reason, teachers must focus on helping children with LD improve their reading skills.

In order to improve weaknesses in reading ability, this study examines a variety of effective learning tools that can be applied to classroom settings to help students with LD develop their reading comprehension skills [15], [22]. It finds that by applying mobile applications, such as multimedia storytelling, as a learning tool for reading in the classroom, this gives students a better opportunity to practice reading skills as opposed to simply using a teacher-centered approach. This study also shows that by implementing mind maps as a tool to help summarize key points, it allows students to draw the associated diagrams and pictures that help them to connect keywords, main ideas and secondary thoughts together. Using a suitably designed application enables students with LD to improve their performance in reading through enjoyable and engaging guided reading using a variety of stories [16]. The integration of multimedia, storytelling and mind mapping techniques to facilitate reading comprehension for children with LD is essential in enhancing brain development and critical thinking [2], [3].

There is currently no research that integrates all three techniques to be used as a learning tool for reading comprehension for children with LD [20]. Therefore, the

implementation of mobile applications in teaching and learning is an interesting area for research. This research aims to investigate and compare the results of the proposed learning method using the application with a further two learning methods to see whether the proposed application could improve children's reading comprehension performance. The instrument used in this research is the proposed mobile application with storytelling and mind maps for Thai students with LD in grades 4 to 6 (elementary school in Thailand) and the case studies are examined within a Thai language course.

Research question: How effective are the three different learning methods for reading comprehension of Thai literature? The three methods include learning with a proposed mobile application including multimedia storytelling with mind maps, a proposed mobile application including multimedia storytelling without mind maps, and traditional learning, where a teacher reads a story from a book to the entire class and the students hand-draw a mind map to summarize the main points of the story told.

2 Literature review

This study reviews related literature and the most recent research in order to develop the best learning modules in reading comprehension for students with LD. Accordingly, these modules have been applied to state of the art technology to enhance the learning efficiency and suitability for learners in a 21st century classroom setting, as shown in the following sections.

2.1 Learning disabilities

Learning Disabilities (LD) are caused by defects that occur within a child's brain due to injury, genetics, environmental factors, or living conditions. These incidents leave the central nervous system unable to fully function. Even though most students with LD have the basic features of sensory structures the development of cognitive strength is low and unable to perform the tasks we would expect children to accomplish and therefore, these children face difficulty in meeting age and grade level expectations [9].

Learning disabilities are caused by neurologically based processing problems that are observed as difficulties in acquiring knowledge and involve deficits in learning basic skills, such as reading, writing, math and reasoning, listening, and speaking. Because LD children have one or more abnormalities in their basic learning psychology process, this disorder can manifest in problems of listening, thinking, speaking, reading, writing and computation. Students with LD may also express behavioral problems, like a lack of social awareness, or difficulties interacting with others [7]. The National Joint Committee on Learning Disabilities (NJCLD) define LD as a deficiency that has various types of disabilities which clearly demonstrate a difficulty in understanding and using skills in listening, speaking, reading, writing, reasoning and or math skills [8].

In Thailand, a study of children indicated that in 2016-2018 there were approximately 329,000 children between the ages of 7 to14 who had LD [19]. These findings revealed that most of the children identified with LD encountered difficulties with reading. This reading disorder is often known as dyslexia where children had problems with identification or character recognition. This made learning vocabulary difficult and affected their reading comprehension. As a result, it was difficult for learners to summarize the key concept of articles or short stories.

[19] From the Bureau of Special Education Administration for 2018, it was found that the number of children with LD began to increase at primary school level (Primary 4 - Primary 6), which had the highest number for all ages. According to the researcher, of the interviews with teachers who taught this group of children having more than 15 years' experience, four teachers concluded that many children begin to show a clear LD when they enter elementary school level. Therefore, every school requires a medical team to identify and consult with children for further treatment.

2.2 Reading comprehension

Reading comprehension is a basic skill that is necessary for all types of reading ability. However, if students are unable to attain a basic level of reading comprehension, they will not be able to progress to a higher level. Reading comprehension is needed to enable students to search for knowledge and summarize important points of content in order to read effectively.

A lot of research has found that reading comprehension is a problem for Thai children, including children with LD. Students who have a suitable level of reading comprehension can understand the material they are reading. They can then start learning and discovering new knowledge [21]. The most important factors forming the basis for reading comprehension are understanding the meaning of words and practicing listening to short stories, such as Thai literature.

There are materials that can be used to help with reading comprehension problems of children with LD, for instance, "The Oxford Handbook of Reading" [17]. Several methods of learning can be applied. Firstly, students can underline important words or keywords within a given story. Later, students can add more details to those words. Secondly, repetitive reading can be utilized, where initially teachers read stories to the children and then students read the story by themselves. Finally, the use of drawings and images that relate or express the main idea of the story can be used to help students understand the text [19].

This study reviews research papers covering a variety of teaching styles and concludes that when instructors are able to track and monitor the results of each student in each chapter, they can effectively adjust the teaching process to suit the development of reading comprehension for each student [1], [6], [11].

2.3 Multimedia storytelling

Multimedia is the introduction of various media elements that come together in a systematic manner consisting of text, still images, animation, sound and video through

a computer system to convey meaning by focusing on the interaction between media and learners to communicate ideas to learners effectively. Accordingly, the previous research suggests that the cognitive theory of multimedia learning in terms of redundancy principle alone could not promote the motivational aspects of teaching and learning, especially for catching the attention of children with LD [10]. This weakness is compensated by the benefits of Multimedia storytelling (create appeal, attractiveness and enthusiasm). Consequently, it stimulates the 3 cognitive systems related to the human learning process, namely the memory sensory system, the memory system in the period of working or short-term memory, and long-term memory.

When students receive information in the form of sound or images, the data will be remembered for a short time as sensory memory. Audio for some will be remembered in the working memory. These groups in the form of images and sounds become knowledge. They may also be combined with previous knowledge of the long-term memory or combined with other knowledge groups (if any). Therefore, presentation through both the optic nerve in the form of text and image as well as the auditory nerve in the form of sound is more beneficial to learning than using only one form.

Multimedia storytelling is the presentation of storytelling through multimedia in various contexts. Cartoon graphics, animation, and sound effects with multimedia features stimulate interest in the memory of children and help promote their reading comprehension skills, including children with LD. [12], [18]. Multimedia storytelling helps create appeal, attractiveness and enthusiasm for learning [22].

2.4 Mind maps

Mind Maps are a graphical expression of ideas, which contain the main topic or main concept placed on the center of the diagram. The main concepts are branched out from the center radiantly. The Mind Maps technique can be applied to many situations, for instance, summarizing meeting minutes, memorizing a lesson learned, business planning, and organizing main concepts [5]. Mind maps are also a conceptual management tool that brings together the skills of both hemispheres of the brain using data coherence and imagination to make notes with images, symbols, associated lines, keywords, and colors. Mind maps are a well-known visual language, proven to help the brain remember and organize the thinking system.

Research suggests that for children with LD unable to learn due to structural abnormalities in the brain or brain damage, for instance, [11] mind mapping can improve patients care and quality of life. Drawing mind maps also helps people with dementia by practicing their neurocognitive skills, planning daily activities, recalling past information, and with their overall creativity. However, if injuries are not severe, the brain and central nervous system can still work very well. Therefore, applying mind maps to teaching and learning with this group of children can help children to think systematically and improve memory [4].

Recently, mind maps have become an important tool to help learners with reading problems. Learners can visualize the relationship between the main idea and secondary thoughts on the subject that is read. It can help learners understand the subject that is read according to the author's intent. It also helps to solve the problems of reading,

comprehension, and understanding for the learners [1]. As stated in [11], it is suggested that using a mind map helps to express ideas that show the relationship of ideas and keywords and allows students with LD to clarify what they have read. More importantly, the mind mapping practice can be conducted in a reading comprehension class for more student-centered learning where students can draw relationships of the major subjects and extract important ideas out of the given story. Mind maps also help to increase the efficiency of memorizing stories.

2.5 Mobile application

A mobile application is a computer technology innovation, currently used in teaching and learning, which is essential for learning in the 21st Century for IT skills. It improves learning for children with LD because students study spatial independence, is cheaper than a computer, and children can use their own devices which is attractive to learners as well.

Previous studies related to students with LD have shown that applications with interactive multimedia through mobile platform technology is a very effective teaching and learning tools that create more interest and concentration on the content than other forms of learning media. Therefore, using a mobile application and multimedia technology to help enhance the learning process for students with LD is essential for enhancing learning skills [20]. Furthermore, the studies found that learning through a multimedia mobile application with mixed media improves the academic achievement of LD students [15]. In addition, multimedia in the form of storytelling can promote the classroom practice of reading comprehension skills very effectively as well [22].

3 Research methodology

This research employed a truly experimental research design where a pretest-posttest only design method was conducted. This experiment was conducted within a Thai language learning course, regarding the indicators for reading comprehension of students with LD from two experimental groups and one control group. Those groups included: 1) an experimental group that used the proposed application which provided both multimedia storytelling with mind maps; 2) an experimental group that used the proposed application which offered only multimedia storytelling; and 3) a control group where the teacher read stories and students used hand-drawn mind mapping. The samples were selected using a simple random sampling technique; the lottery method. The samples were students with LD who were studying in primary school at grades 4 to 6, where normal students and students with LD were in the same classroom. There was a total of 36 students. The schools are located in Bangkok, Thailand. All students received a screening test from a doctor and they were diagnosed as having LD, particularly in reading comprehension. The students were assigned into one of three groups, two experimental and one control, with 12 students in each group.

3.1 An instructional design

The study developed a prototype reading comprehension application named "Tales Maps". The proposed application was operated via android based mobile devices, such as a smart phone or tablet with Android version 5.1 or better. The proposed application provides multimedia storytelling with a focus on user interface design that encourages interaction and allows students to practice reading comprehension skills using the mind maps technique as an exercise that stores each student's scores. The prototype aims to teach students with LD about reading comprehension. The application contains a short story based on Thai literature in the form of multimedia storytelling and mind maps. This study has integrated these two techniques into the proposed prototype system in order to enhance the teaching methods that facilitate reading comprehension for primary school students.

Our hypothesis is that the proposed application can improve reading comprehension skills of students with LD. This research examined several teaching models, various practical theories, and research from reading comprehension perspective, particularly in Thai language. Consequently, we introduced the integration between multimedia storytelling and mind map techniques as a major contribution to the design concepts.

In the development of this application, the researcher applied 3 experiments to students with LD in a single trial. This consisted of a One–To–One tryout, for observing and interviewing with the intention of analyzing the weaknesses of reading comprehension by adapting the contents of the story to be more concise and adjusting the cartoon images and sound of narration to serve the needs of the students. After that, we applied the experiment to a small group tryout of 9 students. A second round of observations and interviews to check the weaknesses of the students with LD was then conducted. At this stage, the user interface, such as buttons, were edited and modified in terms of size and color, size of labels and text in order to be more readable. Finally, we interviewed 5 experts, including 3 experienced Thai language teachers who teach LD students, 2 IT professionals in the field of application development, and asked them to evaluate the quality of the research tools including the proposed application and questionnaires, which have details on the following aspects.

Multimedia storytelling is based upon Thai literature. The stories used in the proposed prototype application are from dramatized literature in a Thai language study learning book. The stories are in accordance with the Core Education Curriculum 2008, Thai language learning area, Primary level Grade 4 to 6. Three dramatized literatures were chosen by a group of Thai language teachers. These consisted of a story of Phra-Ruang, a story of Sang-thong, and a story of Khun Chang Khun Phaen, which all have story-lines and characteristics of Thai literature. After that, the three stories were brought to experts in Thai language teaching to be adapted and made more concise and easier to understand. These adapted texts were then applied to all learning methods. Each story consists of sub-menus including a spelling menu, vocabulary menu, reading menu, and a reading menu with mind maps.

Multimedia storytelling is located in the section on reading. Each story contains no more than ten scenes, because children with LD often have unstable behavior with

some having attention deficit hyperactivity disorder; therefore, each scene design should not have a story that is too long [3]. The story is designed in the form of multimedia storytelling, with images, animations, sounds and text in the story section [10]. The sound is read as a karaoke style, where the subtitle appears in bold and color according to the narration. Students can turn the narration sounds on or off, as shown in Figure 1.

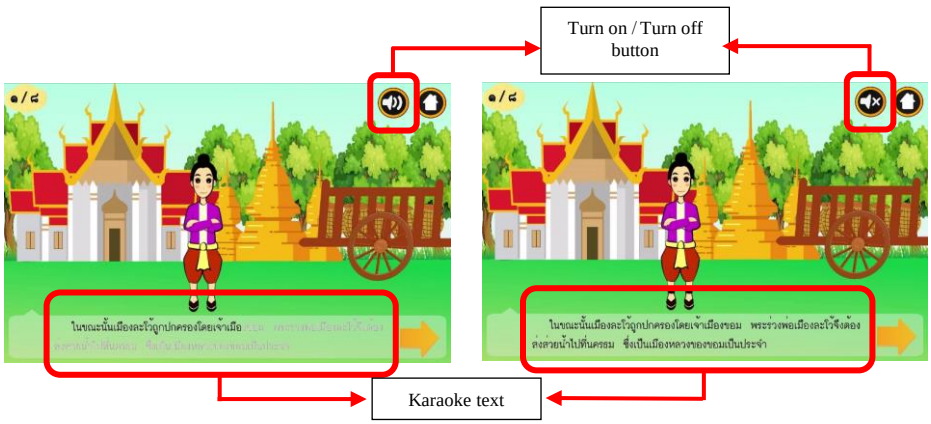

Fig. 1. The proposed multimedia storytelling application

Mind maps are in the menu as reading with mind maps and this function encourages learners to review the content from each reading of the Thai literature. Mind maps are separated into each Thai literature and each scene provides practice for reading skills, capturing the main points of each literature. Using mind maps to review and summarize the main points of each Thai literature, helps students revise their understanding of the story. The proposed application allows students to repeat the mind map exercises as many times as they wish. The prototype also lets students re-read the Thai literature at each scene and then move forward to see mind maps for each corresponding scene. At this stage, students are required to select a word or short sentence by clicking on the touch-screen to choose which word colored in blue is from the story. After that they have to drag the word to fill the correct blank space in the mind maps provided. On each branch, there is a hint to help learners. When the student has completed each task, they click OK and then the answer is checked and the score is inputted into the student record. Learners can choose to see solutions in the next order where there is a summary of each student's score, where the teacher can see the students' development in the following order, as shown in Figure 2.

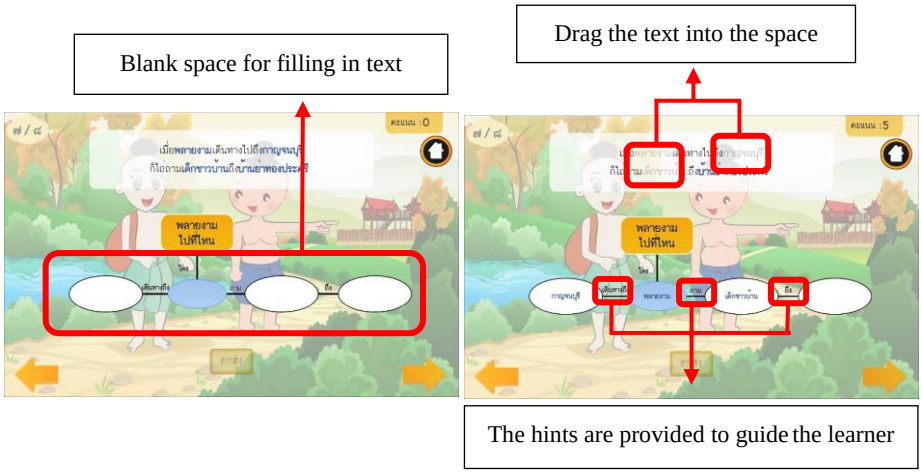

Fig. 2. The proposed mind maps application

The screen design of the proposed application presents an introduction screen that welcomes the learner before beginning the lesson. In order to identify each student correctly, at this stage the student is asked to enter some personal information to be used for data collection to identify and collect scores when doing the tests. Students must fill-out information such as their name and gender. This data is automatically stored into the students' database. The stored data of each student is presented on the main menu each time when they log-on to the application. When each student's score is stored in the database system, the teacher is able to check the progress and improvement of each student through the online database system that is connected to the application. The tracking of progress in learning through the online scoring system is another important aspect of the system because students with LD need a teacher who can keep track of their academic performance at all times.

3.2 Research procedure

The proposed prototype application aims to support the improvement of reading comprehension skills for children with LD. The experiment was applied to a sample of36 students with LD in the subject of Thai reading comprehension. The sample groups were organized into three separate groups, including two experimental groups and one control group. The sample students were carefully selected, all studying in grades 4 to 6. In addition, most of them presented similar characteristics based on their learning achievement score in Thai language courses in the first semester of the academic year2018 . The student achievement scores of all the students were ranked in descending order.

Table 1. Numbers of samples divided into three groups to enter the experimental plan

Sample group	Module for developing reading comprehension skill	Number of students
Experimental group 1	Application including multimedia storytelling with mind maps.	12
Experimental group 2	Application including only multimedia storytelling.	12
Control Group	Traditional method of teaching reading comprehension for students with learning disabilities.	12
	Total (students)	36

In this experiment, the three sample groups had to do a test to measure their level of reading comprehension in Thai language. For the process of creating a test, this research relied on five experts who are Thai language teachers. These five experts were required to validate the content IOC (Item Objective Congruence) and the average values at 0.85. At the same time, the proposed test was analyzed for its difficulty (P) and discrimination (R) of the test by using items with difficulty values between 0.2-0.8 Finally, the value of discrimination (R) was more than 0.2 and the test items created up to 25 questions.

For the experiment, we asked students from three groups to take a pretest. The pretest consisted of 25 questions. After that, students in experimental group 1 and experimental group 2 used the proposed prototype application. The data from this activity was stored in the database. The students in the control group learned the same lesson as other two groups, but through a traditional teacher-centered learning style. The teacher taught the students by reading the Thai literature to them. After the students had finished listening to the story, they drew relevant images and mind maps to summarize the story. The control group spent more than 100 minutes; more than the other two groups. Experimental group 1 spent about 38 minutes and experimental group 2 spent approximately 12 minutes. Finally, the three groups took the exam based on the reading comprehension perspective.

4 Findings

Table 2 shows the results of the comparison between the pretest and posttest data collected from the three sample groups as mentioned above. The statistics used include mean score (Mean), standard deviation (SD), t-value, and p-value. Table 3 demonstrates the variance analysis results of the three groups using One - Way Analysis of Variance (Anova). Table 4 presents the comparison's results of multiples of the three groups using Comparisons Multiple Analysis of Variance (LSD), accordingly.

Table 2. Comparison of the pretest and posttest scores between the two experimental groups and one control group

Group	N		Mean	SD	df	T	p	
Experimental group 1	12	Pretest	7.42	3.17	11	-19.281	.000*	p<.05
		Posttest	17.33	2.99				
Experimental group 2	12	Pretest	7.50	3.11	11	-4.444	.001*	p<.05
		Posttest	10.33	2.83				
Control Group	12	Pretest	7.50	3.00	11	-.958	.359	
		Posttest	8.08	2.27				

Based on the comparative analysis of the mean of the pretest and posttest scores, the we found that the mean of the posttest scores of both experimental group 1 and 2 were significantly higher than the mean of the pretest scores. On the other hand, there was no significant difference in the average score of the posttest and pretest scores of the control group. The results imply that using an application including multimedia storytelling with mind maps and an application with only multimedia storytelling helped students to gain a higher learning achievement in improving reading skills for students with LD when compared to the traditional learning method.

Table 3. Variance analysis results of the three groups using one - way analysis of variance (Anova)

	Sum of squares	Df	Mean square	F	p	
Between groups	558.500	2	279.250	37.729	.000*	p<.05
Within groups	244.250	33	7.402			
Total	802.750	35				

Table 4. Comparative results of multiples of the three groups using Comparisons multiple analysis of variance (LSD)

(I) Group	Mean (Posttest)	(J) Group	Mean difference (I – J)	p	
Experimental group 1	17.33	Experimental group 2	7.000	.000*	p<.05
		Control Group	9.250	.000*	p<.05
Experimental group 2	10.33	Experimental group 1	-7.000	.000*	p<.05
		Control Group	2.250	.051	
Control Group	8.08	Experimental group 1	-9.250	.000*	p<.05
		Experimental group 2	-2.250	.051	

The results of the analysis of variance confirm that the average score in the posttest of all three groups is not equal (see Table3). Furthermore, the comparisons of multiple results show that the mean score is significantly different between the experimental groups 1 and 2 and between experimental group 1 and the control group (see Table4). This means that experimental group 1 using an application for multimedia storytelling with mind maps had the highest average score. Unlike the other 2 groups, the experi-

mental group 2 using an application including multimedia storytelling and the control group using the traditional learning method had no difference in the average score.

5 Discussion and conclusion

The research results clearly show success from using the proposed prototype application multimedia storytelling with mind maps in helping to support the learning of students with disabilities, especially in the development of reading comprehension. Students with LD have a better learning achievement in the subject of reading comprehension when using the proposed prototype application that integrates the mind maps technique. In this study we utilized mind maps as a visualization tool that was designed to encourage learners to summarize the main ideas and knowledge from readings from Thai literature. The summarization begins with the main ideas or keywords as the main branches and then extends each main idea to its associated secondary level (sub-ideas) systematically. Asking students to draw mind maps based on the story is a technique that helps students to understand more about the stories that they read and more importantly, our findings prove that students with LD can achieve higher scores in the reading comprehension test. The mind maps tool is a powerful visual tool that stimulates a students'brain for learning, and empowers the memorization of stories [11].

In addition, the findings show that the use of a proposed prototype application with multimedia storytelling helps stimulate the learning of students with LD in reading comprehension [10] and has the potential to impact the students' perception. Interactive multimedia can arouse and motivate learners rather than offering only one-way communication, according to the cognitive theory of multimedia learning. Due to the potential use of multimedia applications, this technique not only focuses on multimedia storytelling but provides strong interaction, which allows students to interact with various types of media including graphic images, sounds, and texts. This approach can stimulate and increase the learner's attention, especially students with LD [22].

The proposed prototype application is designed to allow students to turn-off any voice narrative sounds for those who prefer a mostly visual learning style. However, for students who prefer an audio learning style, they can turn-on the voice narration at any time. Therefore, receiving information is at the convenience of individual preferences. This approach suits learners who need to consume different types of media. This technique is adapted from the redundancy principle in multimedia learning which results in the learning process performing at its best [10] and affects the reading comprehension skills for students with LD [12], [18].

Finally, future research studies should aim to apply the techniques of integrating mind maps and multimedia storytelling to support students with LD, as well as students with special needs in other required skills for the 21st century, to include creativity, critical thinking and problem-solving. The opportunity for students with LD to improve their learning skills can allow them to study at a higher level and as a result they can become one of the forces in developing the country.

6 Compliance with ethical standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the research ethics review committee for research involving human research participants in the health sciences group. Chulalongkorn University, Thailand, has approved studies constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP).

Informed consent: Informed consent was obtained from all individual participants included in the study.

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