

Development of The “ThinkHOTS” Software Based on Thinking Maps To Increase Higher-Order Thinking Skills

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Abstract—The weak performance of Malaysian students in the Trends in Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) indicates a very low mastery of higher-order thinking skills (HOTS) among them. The i-Think program, which introduces eight types of thinking maps, was introduced to increase and cultivate the thinking skills of students and teachers. In line with the implementation of the programme, a Computer Aided Learning (CAL) software named “ThinkHOTS” was developed. This software covers Form 1 KBSM Mathematics topics of Round Number, and Number Pattern and Sequence. The software was developed based on a cognitive theory, and each question in the software uses all sorts of thinking maps and focuses on weaker students, although it is still suitable for use by all Form 1 students. “ThinkHOTS” was developed based on the ADDIE model using the Macromedia Authorware 7.0, Adobe Photoshop CS6, Adobe Flash CS6, and Sony Sound Forge 9.0. The majority of the respondents agreed that the contents of “ThinkHOTS” software was in sync with the KBSM Mathematics syllabus, easy to use, suitable as a Teaching Tool (ABM) for learning and teaching, and helped students understand mathematical concepts. From a technical perspective, a majority of the respondents agreed that the illustrations and explanation of the teaching materials were clear and easily understood, and the “ThinkHOTS” software was complete with a user manual. The combination of the thinking maps application and multimedia elements makes students’ learning experience more interesting and encourages them to use HOTS.

Keywords— *thinking map, higher-order thinking skills, multimedia*

I. INTRODUCTION

The education transformation in the Malaysian Education Blueprint (PPPM) 2013-2025 has given emphasis on the higher-order thinking skills (HOTS) concept which is expected to produce a generation that is able to think critically and creatively. Thinking skill is one of six main characteristics aspired by the Ministry for students to compete at a global level. The Ministry of Education Malaysia (MOE) and the National Innovation Agency of Malaysia (AIM) launched the i-Think program in order to increase and cultivate thinking skills among students to produce creative, critical and innovative students. “i-Think” means innovative thinking, which is a quality that every student should possess. Eight types of Thinking Maps were introduced in the i-Think program. Thinking Maps is not a new curriculum; it is a thinking tool that allows teachers to deliver the syllabus in a more meaningful manner. The i-Think-based learning comes from learning through thinking maps that are widely used in other countries. Learning via thinking maps was introduced in 1988 by the founder David Hyerle who came up with eight thinking maps: the circle map, the bubble map, the double bubble map, the tree map, the flow map, the multi-flow map, the bridge map, and the brace map. Each of the thinking maps is based on specific basic cognitive processes. According to [1], the circle map is used to define knowledge according to context, the bubble map is used to express descriptive qualities, the double bubble map is used to compare and contrast, the tree map is used to show the relationship between the main idea and

supporting ideas, the flow map is used to sequence and order events, the multi-flow map is used to analyse cause and effect, the brace map is used to identify part-to-whole relationships, and the bridge map is used to illustrate analogies and their relating factors.

Learning in the 21st century should put greater emphasis on learning using thinking maps with the implementation of the i-Think program in schools. In a study conducted by [2], it was found that learning using thinking maps improved students' academic progress and increased HOTS on their learning content. It is clear that learning using thinking maps is closely related to HOTS as it is a visual thinking tool that stimulates and sharpens HOTS. This was proven in a study by [3] in which 85% to 90% of students said that thinking maps were effective tools in their learning process and stimulated HOTS. Thinking maps are widely used in other countries with positive results toward learning. In a study carried out by [4], the usage of thinking maps yielded positive results towards the students' academic language and learning development. Their attitude, motivation and thinking also improved after implementing thinking maps in their learning [5]. In the six-month research project, it was found that thinking maps provided a visual representation of the students' knowledge and allowed both teachers and students to reflect their learning.

In the KBSM Mathematics Curriculum, the seventh objective is to emphasise the usage of appropriate technologies to build concepts, master skills, solve problems and explore mathematics. Moreover, PPPM 2013-2025 acknowledges the importance of the usage of technology in education. Computer Aided Learning (CAL) techniques, such as interactive multimedia software, can be used as a teaching tool in the PdP process. The usage of such software can assist teachers and students to increase HOTS and improve their knowledge on technology. According to [6], multimedia software provides students with a more interesting learning experience because they can understand them in a better way. Thus, interactive software based on thinking maps – combined with multimedia elements – was developed to entice the students, especially those who are weak in Mathematics. According to [7], even though the learning materials are presented in a sophisticated way, those learning materials will not have high educational values without pedagogy principles. It is hoped that integrating multimedia elements into activities based on thinking maps in the interactive software will make learning mathematics more interesting and stimulate their HOTS.

II. RESEARCH METHODOLOGY

In order to develop the learning multimedia software, the researchers chose to use the ADDIE design model. The selection of this model was based on its clear component segregation and tallied with the developmental needs. Apart from that, the ADDIE model also provided design phases which were simple but clear and concise. This model was the basis for other instructional design models and it also had its own advantages [8]. The ADDIE model contained five main phases which were the analysis phase, design phase, development phase, implementation phase and evaluation phase. The "ThinkHOTS" software development process based on the ADDIE model is summarised in Fig. 1.

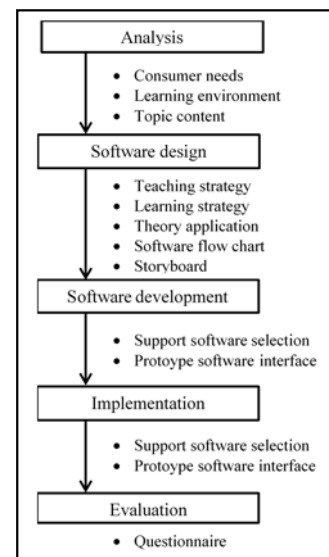


Fig. 1. Research Methodology

A. Phase 1: Analysis

In this phase, researchers built an understanding on the needs of the software users, learning environment, software content, the goals of the software, and the strength and weakness of the software. The cause of the students' problems were identified, whether formally or informally, so that the problems would be solved with the software. This software specifically focused on Form 1 students who were weak in mathematics. However, in general, the target group for this software was all Form 1 students. The topics chosen were Chapter 1 (Round Numbers), and Chapter 2 (Number Pattern and Sequence) from the Form 1 KBSM Mathematics syllabus.

B. Phase 2: Design

The design phase was implemented after the needs analysis process was completed. According to [8], this phase also explained the overview of the design, the structure, the media type and the technology involved. These aspects were very important to ensure that the topic and the subject content were suitable for the user. The researchers used thinking maps as they were very useful in explaining complex facts. In this phase, the general overview of the software that was about to be developed would be shown in a visual method. The visual design methods used were flowcharts and prototype interface sketch using storyboard.

C. Phase 3: Development

Development refers to the process of developing and producing the "ThinkHOTS" software. This software was developed and produced by integrating existing applications such as authoring, graphics, audio, video and others. In this phase, prototypes were developed based on the information gathered from previous phases especially during the design phase. In developing "ThinkHOTS", the main softwares used were Adobe Photoshop CS6, Adobe Flash CS6, and Sony Sound Forge 9.0. The combination of these softwares complemented each other.

D. Phase 4: Implementation

The “ThinkHOTS” software was presented in its actual form to 30 users to test its effectiveness and smoothness. In this way, the researchers were able to identify problems that were overlooked during the design and development phase. This in turn allowed the researchers to improve the weak aspects of the software in order to improve its quality before it was officially released.

E. Phase 5: Evaluation

The evaluation phase involved getting feedbacks, opinions and reviews from users. This process was completed by 30 respondents who were future mathematics teachers. The evaluation process was useful to ensure that the software was effective and enabled the researchers to evaluate the suitability of the software’s design, content, text, colour and audio. This process also tested the smoothness of the “ThinkHOTS” software such as the navigational buttons.

III. RESEARCH FINDINGS

Discussed below are the parts developed in the “ThinkHOTS” software.

A. Software Title Display

Title display is the main display that users first see when they open the software. The display has background music that increases motivation for students to explore the software.



Fig. 2. Software Title Display

B. Login Screen Display

Then, students are taken to the login screen before they start their lesson. On this screen, the students need to fill in their names in the space given. There is an image of a field as the background and a teacher on the login screen.

C. Preparatory Display

After the welcome screen is displayed, students are directed to the preparatory display. On this display, students are asked, “Are you ready to start learning with Miss Mira?” The “Yes” button is for students who are ready to explore and the “No” button is for students who feel otherwise. Students are free to choose any options based on their readiness. If they click “Yes”, they are taken to the montage display, but if they click “No”, they are directed to the exit page. The background image of this screen is a field with houses and rainbows in order to motivate students. The colours used on this screen are bright and colourful so that students are more excited to keep exploring [9].



Fig. 3. Preparatory Display

D. Main Page Display

The main page display is the display that shows the main menus of “ThinkHOTS”. On this screen, students are able to choose any link to continue their learning process. The main menus on this page are menus of Chapter 1 and Chapter 2, and the home and power buttons.



Fig. 4. Main Page Display

E. Control Button Display

Control buttons are very important in a software as a medium of interaction between users and the software. Users are free to explore every part of the software using the control button. There are six types of navigational control buttons in this software: enter, main page, exit, next, yes and no.

F. Navigational Control Button

Navigational control buttons are very important in a software. It controls the users’ journey so that they are properly guided in their software exploration. In fact, user-friendly and interactive navigational buttons makes software highly likeable among users. There are three important navigational buttons on each software screen: main page button, exit button and next button. Each button is marked symbolically for users’ convenience to explore other menus. These buttons are placed on top, in the middle or at the bottom of the page depending on suitability.



Fig. 5. Navigational Control Button

G. Chapter Menu Display

Chapter menu display is the learning content design display. This display is also important in the “ThinkHOTS” software to achieve its objectives. This is due to the fact that the learning content is the main intention and the pivotal goal

of the software development. The content included should be suitable and focused to increase HOTS among the students.



Fig. 6. Chapter Menu Display

H. Question Display

Question display is divided into two chapters: one for Chapter 1 and one for Chapter 2. The questions are constructed using the i-Think map to increase HOTS among the students.

I. Question List Display

This display lists down questions in Chapter 1 and Chapter 2 in the form of navigational buttons as shown in Fig. 7. This display allows students to choose the questions they prefer to answer, leaving them free to plan their learning journey.



Fig. 7. Question List Display

J. Question Instruction Display

This display provides clear instructions to students. For example, if they are in the Chapter 1 question list menu, the students are directed to the instruction display for Question 1 in Chapter 1. An example of the display is shown in Fig. 8.



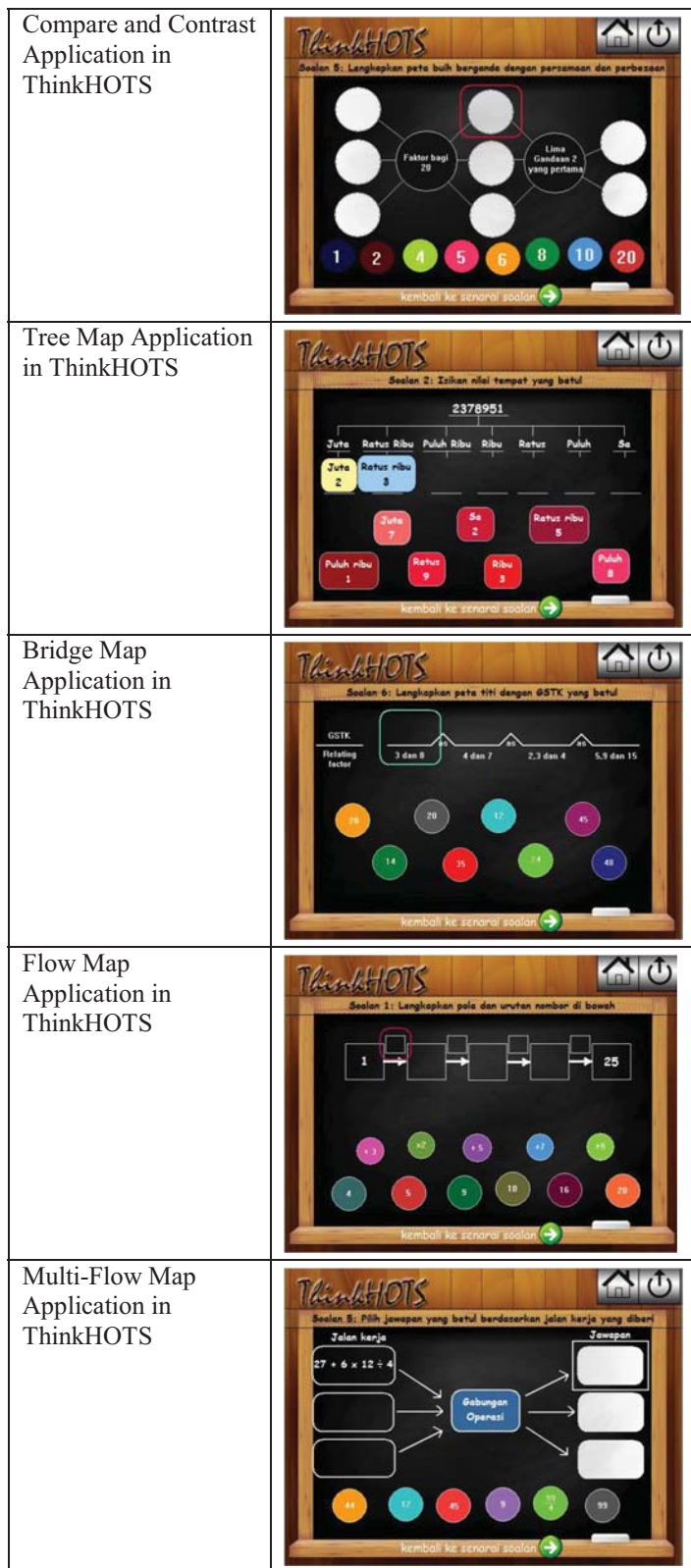
Fig. 8. Question Instruction Display

K. Question Display Based on the Thinking Map Type

Each question in the “ThinkHOTS” software uses the “drag & drop” technique. If they choose the right answer, the selection will stay at the position it is placed. But if they drag the wrong answer, the selection will return to its original location. The researchers used almost all types of thinking maps in the i-Think program, except the brace map. This is because the brace map was not suitable in Mathematics for chapters on Round Numbers, and Number Pattern and Sequence. Some thinking maps were used for more than one question depending on the suitability of the question and concept. An example of usage for each thinking map is shown in Table 1.

TABLE I. QUESTION DISPLAY BASED ON THE THINKING MAP TYPE

<p>Circle Map Application in ThinkHOTS</p>	
<p>Bubble Map Application in ThinkHOTS</p>	



getting the solution to continue using the software right up till completion.

The implementation phase occurred after the software was ready. In this phase, the completed software was shown to future Mathematics teachers who were Year 4 students of the Bachelor of Science and Education (Mathematics) degree. They were provided ample time to explore the “ThinkHOTS” software to evaluate a few aspects. The software was tested by 30 respondents. They were given a questionnaire that was verified by experts of Mathematics and multimedia. The evaluation was done on the content prepared, the application of the thinking maps to increase HOTS, and also the technical aspects such as the suitability of photos and audio used, whether the software was easy to use, and others. The items in the questionnaire used the five-level Likert scale: 1=Strongly Disagree, 2=Disagree, 3=Not Sure, 4=Agree, and 5=Strongly Agree. Research findings are shown in Table 2.

TABLE II. USER OPINIONS ON THE THINKHOTS SOFTWARE

Item	Statement	Mean
1.	Contents in the “ThinkHOTS” software are concise.	4.07
2.	The “ThinkHOTS” software is developed according to the KBSM Mathematics syllabus.	4.00
3.	The questions provided can help weaker students master certain Mathematics concepts.	4.07
4.	The questions provided cover the whole topic.	3.87
5.	The questions used are suitable to test the students’ understanding level, especially the weaker ones.	4.07
6.	The use of thinking maps in the “ThinkHOTS” software helps students understand certain Mathematics concepts.	3.90
7.	The use of thinking maps in the “ThinkHOTS” software stimulates the students’ interest to learn.	3.90
8.	The use of thinking maps in the “ThinkHOTS” software increases the students’ Higher-Order Thinking Skills (HOTS).	3.87
9.	The “ThinkHOTS” software is a suitable teaching tool (ABM) for KBSM Mathematics.	4.07
10.	The use of “ThinkHOTS” as ABM is very effective in the PdP for weaker students.	3.83
11.	The “ThinkHOTS” software helps weaker students master Mathematics concepts.	4.03
12.	The “ThinkHOTS” software is suitable for the PdP process.	4.30
13.	The “ThinkHOTS” software can generate students’ HOTS.	4.03
14.	The usage of “ThinkHOTS” software can stimulate the students’ interest to learn.	4.23
15.	The “ThinkHOTS” software is suitable for all students, especially the weaker ones.	4.03
16.	The “ThinkHOTS” software is suitable to be used by all teachers.	4.03

L. Score Display

After the students complete all the questions, the score display will appear. The scores are derived from each of the answers given. The scoring evaluates the students’ effort in

17.	The “ThinkHOTS” software is able to create a fun learning environment.	4.07
18.	The “ThinkHOTS” software is easy to use.	4.17
19.	The steps in the software are easily followed.	4.13
20.	The language used is clear and easily understood.	4.20
21.	The software’s illustration and explanation are clear and easily understood.	4.07
22.	The “ThinkHOTS” software is complete with user instruction and guide.	4.17
23.	The instructions in the “ThinkHOTS” software are clear and adequate.	4.17
24.	The “ThinkHOTS” software uses the font type and size that are clear and easy to read.	4.10
25.	The colour scheme of the software is suitable.	4.03
26.	The audio used is clear and suitable (it does not affect the student’s concentration).	4.03
27.	Usage of images helps stimulate the student’s interest.	4.03

IV. CONCLUSION

From the learning and teaching aspect, the thinking maps used in the “ThinkHOTS” software allow teachers and students to cultivate the use of thinking maps in the PdP process. Furthermore, the usage of multimedia in the software makes the PdP process more meaningful and more effective [10, 11]. Multimedia is a powerful tool that is able to change the way we conceptualise knowledge and perceive reality, the education system, and the business world. The exploration, perusal and topical choices in this software not only gives students a wider access to information, but also allows them to understand the meaning of specific concepts more deeply. From a technical point of view, this software has exciting and fun elements from a combination of audio and visual such as music, video, images, and navigation system. In the “ThinkHOTS” software, there is an interactive feature that users can connect to the computer, and the computer can respond accordingly. Users can surf their own information on the computer, associate related topics and do not need to go

through pages in a linear fashion. In a nutshell, the development of the “ThinkHOTS” software has undergone a meticulous planning process. This software is merely a medium to help students increase their HOTS, and help them understand Mathematical concepts in a better way. However, the effectiveness of the “ThinkHOTS” software depends on the willingness and ability of the users in exploring the software.

REFERENCES

- [1] D. Hyerle, and C. Yeager. *A Language for Learning: Thinking Maps Incorporated*. North Carolina; Thinking Maps. Inc, 2007.
- [2] D. Long, and D. Carlson. *Mind the Map: How Thinking Maps Affect Student Achievement*. *Networks Journal*, vol. 13, no. 2, pp. 1 – 7, 2011. Fall Publisher.
- [3] M.K. Ball. *The Effects of Thinking Maps on Reading Scores of Traditional and Nontraditional College Students*. Doctor Philosophy, The University of Southern Mississippi, Hattiesburg, 1998.
- [4] E. López. *The Effects of a Cognitive Model, Thinking Maps, on the Academic Language Development of English Language Learners*. Degree Ed. D., St. John Fisher College, Rochester, 2011.
- [5] S. Curtis. *Inviting Explicit Thinking: Thinking Maps Professional Development: Tools to Develop Reflection and Cognition*. Master’s Thesis, Antioch New England Graduate School, Keene, 2001.
- [6] Rozinah Jamaludin. *Teknologi Pengajaran*. Kuala Lumpur: Utusan Publication and Distributor Sdn. Bhd, 2003.
- [7] Baharuddin Aris, Rio Sumarni Shariffudin & Manimegalai Subramaniam. *Reka Bentuk Perisian Multimedia*. Johor Bahru: Penerbit Universiti Teknologi Malaysia, 2002.
- [8] Jamalludin Harun & Zaidatun Tasir. *Pembangunan Perisian Multimedia : Satu Pendekatan Sistematis*. Kuala Lumpur: Venton Publishing, 2001.
- [9] Jamaluddin Harun & Zaidatun Tasir. *Asas Multimedia dan Aplikasinya Dalam Pendidikan*. Bentong: PTS Publications, 2003.
- [10] R.A. Wahab, A.H.B. Abdullah, M.S.B. Abu, M.B. Mokhtar, N.A. Atan, *A case study on visual spatial skills and level of geometric thinking in learning 3D geometry among high achievers*. *Man in India*, 96 (1-2), 2016, pp. 489-499.
- [11] A.H. Abdullah, & E. Zakaria, *The effects of van hiele's phase-based instruction using the geometer's sketchpad (GSP) on students' levels of geometric thinking*. *Research Journal of Applied Sciences, Engineering and Technology*, 5(5), 2013, 1652-1660.