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Development and Implementation of Motivated Strategies for a Learning Thinking Maps Tool Among Computing Students

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Abstract

This study emphasized the challenges in teaching and learning fundamentals of programming as a consequence of the lack of metacognitive awareness, which is associated with problem-solving abilities. These abilities can be enhanced through the use of thinking maps, but they are typically used only in school and under the supervision of a teacher. Additionally, the practice is conducted in a typical manner, with no interesting features incorporated into the process, and it does not promote the development of metacognitive awareness. Therefore, the purpose of this study is to produce a learning tool to train computing students using thinking maps in the multimedia environment to enhance their metacognitive awareness. The developed tool called Motivated Strategies Thinking Maps Tool (MoSTMaT) embeds multimedia principles as well as motivated strategies for learning theory to keep students motivated and able to learn in the self-regulated learning environment. The tool was developed using ADDIE instructional design model and was evaluated by the end user namely computing students. A set of questionnaires containing three parts was applied to measure the acceptance of students; 1) multimedia principles, 2) post-study system usability, and 3) motivated strategies for learning was applied to measure the acceptance of students. The result of this study indicated that students agreed that the multimedia application in the tool is suited for students' usage, has adequate information on thinking maps, a user-friendly interface, and is suitable to be used in the self-regulated mood. The implication of this study is the conceptual framework for developing MoSTMaT can be a guide for developing instructional tools in self-regulated learning. Furthermore, this study demonstrated that multimedia principles and elements had a beneficial impact on motivation and self-regulation among computing students.

Keywords: motivated strategies for learning, metacognitive awareness, thinking maps, computing students, instructional tool

INTRODUCTION

In today's technology-driven world, virtually all people have to deal with a vast amount of information from the internet and social media, which have drastically shaped their lifestyles and worldviews. Essentially, the development of websites and systems involves a variety of practitioners, such as designers, project managers, and, particularly programmers, who write appropriate programs using codes to meet customers' needs. In this regard, programmers should be equipped with strong problem-solving skills to solve complex and intricate problems. Malaysian Qualification Agency (MQA) clarifies that programming skills and proficient to learn other new programming languages is crucial in computing. Later, industrial training will cultivate students' maturity and gain experience in a working environment (MQA, 2015). These essential requirements are to provide experts (in computing) to be marketable. Malaysia government is eager to train students starting early stage (primary and secondary school) to cultivate skills needed in the future. The Ministry of Education (MOE) of Malaysia has launched an ambitious education blueprint to raise the levels of quality of Malaysian students to be an equality to those of developed nations by focusing on critical, creative, and innovative thinking skills (Ministry of Education, 2012). This study highlights the issues in the teaching and learning of programming at the tertiary level that entail students to have good problem-solving skills. In particular, this study focuses on students' metacognitive awareness, motivated strategies for learning (motivational beliefs and self-regulation), and an instructional design strategy that involves the use of thinking maps to help students develop strong metacognitive awareness and intrinsic motivation in self-regulation mode. Collectively, such factors can help students develop good metacognitive awareness that in turn help them learn programming efficaciously.

BACKGROUND OF RESEARCH STUDY

Fundamental courses on programming languages becoming essential at all levels of curriculum in education (Lawan, et al., 2019). In this regard, in the world of technology, facing 21st-century education, programming skills is currently relevant (Abesadze & Nozadze, 2020; Nelson, 2009). Thus, a proper understanding of programming languages is important that can only materialize when students have the essential cognitive ability to learn the subject matter efficaciously (Ambrosio P. A., et al., 2014). Admittedly, most programming students find learning programming extremely challenging, which stems from a lack of essential learning ability and motivation. Unresolved, students may eventually opt to quit learning the subject or perform poorly in the examination or dropout (Robins, 2019). In this regard, studies have been made to investigate the issues pertaining the challenge confronted by students during early phase of learning programming subject.

Metacognitive awareness does have significant effects on the successfulness of students in learning introductory programming course in university (Rum & Ismail, 2016). Moreover, metacognitive awareness have significance connection towards problem solving skills is agreed upon many researchers and it keeps on going to find suitable activities or tool to fit learners' condition (Guner & Erbay,2021; Mangaroska, et al., 2021).Indeed metacognitive awareness is crucial skills need to be acquired among computing students but then again these are the lack skills identified by many previous researches (Ismail, et al., 2006; Ismail, et al., 2010; Tseng & Weng, 2010 ; Hui & Omar, 2011; Rum & Ismail, 2016). Metacognition is the ability of learners to take control of what they know. From the learning perspective, the ability to take control of one's knowledge involves the ability to use a precise strategy in a correct situation, monitor learning, and replace the strategy with a new one if the former was ineffective or inefficient (Schraw & Dennison, 1994; Caliskan & Sunbul, 2011; Mitsea, et al., 2019). Metacognitive awareness also has close relations with problem solving skills. Guner and Erbay (2021) agreed through their study, that metacognitive awareness do have significant impact towards students' problem solving effectiveness. Based on the findings of Shraw and Dennison's (1994) study, metacognitive awareness can influence cognitive performance by enhancing the strategy being used. Cognition relates as a process of thinking and metacognitive knowledge is a process of a person knowing the thinking process (Hamiddin & Saukah, 2020).

Thinking maps have been shown in prior studies to be one of the most effective tools for improving students' metacognitive awareness (Hyerle, 2011). Derus and her colleagues (2012) also propose a visualisation tool to assist students in learning programming in a practical manner. There are eight different types of thinking maps that have been used in the teaching and learning process to help students increase their metacognition and cognitive capacities. Because they provide an effective medium for thinking, listening, speaking, reading, writing, and problem-solving, thinking maps can help increase self-regulated learning (Hyerle, 2011). Multimedia has become one of the most exciting and successful learning aids in recent years, and it has been used in a variety of settings. Mayer's cognitive theory in multimedia offered concepts and a comprehensive model, starting with broad principles: students learn more efficiently when they utilise both words and graphics in the learning process than when they use a test alone (Mayer 2009). Previous research on the relationship between metacognition and multimedia (Antonietti & Colombo, 2014) has shown that using multimedia in the classroom can help with metacognition in a variety of aspects and roles (Schwonke, et al., 2013).

Multimedia is delivered in an enthralling manner with the use of various presentations and the ability to give instructions through it, while metacognitive enables pupils to regulate, monitor, and assess their own learning (Shraw & Dennison, 1994). With the prevalence of multimedia in the modern day, integration of dynamic multimedia (Moreno, 2005) that enables interactivity and feedback is necessary for integrating the component of cognitive, metacognitive, motivation, and learners (Domagk, et al., 2010). Finally, the use of multimedia in the learning process demonstrates metacognitive improvement among learners (Antonietti, et al., 2015; Alemdag & Cagiltay, 2018; Mayer, 2009; Mayer, 2020). Based on relevant issues and theories that can assist to promote metacognitive awareness, self-regulation, and motivation among students, an objective of this study has been raised; to determine the acceptance of the developed tool by computing students.

LITERATURE REVIEW

Motivated Strategies for Learning

The researcher concentrated on motivated learning in this study, which is composed of two key components or constructs, namely motivational beliefs and self-regulation, both of which can be maintained or sustained by intrinsic factors (Pintrich, 1994). Motivational attitudes about the appropriate use of learning tools can have a major impact on students' metacognition when they seek to solve complex problems (McDowell, 2019). The relationship between motivational beliefs and metacognitive awareness, in particular, can support students in comprehending and utilising available information to accomplish desired goals.

In this study, we examined how participants' motivation to learn programming in a multimedia self-regulated learning environment is related to their incentive to learn. Pintrich (1994) identified three components of motivating beliefs: self-efficacy, intrinsic value, and anxiety. Numerous studies have demonstrated that students' learning outcomes are significantly impacted by their motivational beliefs (self-efficacy, intrinsic value, and anxiety) (Gbollie & Keamu, 2017). Admittedly, conventional learning systems are ineffective at encouraging students to learn more enthusiastically because they are primarily exam-oriented, encouraging pupils to learn solely for the sake of achieving high grades.

According to the literature, self-efficacy is positively connected with cognitive methods and self-regulation, both of which have an effect on students' academic achievement (Adesola, et al., 2018). Students with a high level of self-efficacy in self-regulation were able to employ appropriate cognitive strategies throughout learning, resulting in improved academic achievement. Numerous pedagogical and motivational factors have an influence on programming learning, including a lack of practice sessions and an inability to execute assignments independently (Rahmat et al., 2011). Self-regulated learning encourages learners to choose and employ suitable cognitive methods to aid them in sorting and organising information in order to solve a specific task. Learners who are capable of self-observation, self-evaluation, self-reaction, and self-reflection will eventually promote self-regulated behaviour (Ormrod, 2016).

Relations Motivated Strategies for Learning and Metacognitive Awareness

Metacognition is known as the ability of learners to take control of what they are learning and understand their own ability to learn. In this respect, metacognitive awareness is students' ability to select and use an effective method to monitor the learning process and adjust such a strategy if needed (Shraw & Dennison, 1994; Caliskan & Sunbul, 2011). Such a skill is also known as 'knowing about knowing' that helps learners become aware of the most effective technique to handle a particular challenge. In other words, metacognition entails learners to have good self-regulation, planning, and monitoring skills that are necessary for self-directed learning (Pang, 2010; Sweller, Mawer, & Ward, 1983; Novick & Holyoak, 1991).
Self-regulated learning encourages learners to choose and employ suitable cognitive methods to

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facilitate them in sorting and organising information in order to solve a specific task. Learners who are capable of self-observation, self-evaluation, self-reaction, and self-reflection will eventually promote self-regulated behaviour (Ormrod, 2016). According to Toshalis (2012), students must explore their minds independently while they study, which ultimately influences their self-motivation and thinking. Additionally, Agarwal and colleagues (2021) recognised that students require a high level of self-motivation in order to engage in more engaging and meaningful learning. In essence, self-regulated learning is a state of mind in which students study and make choices based on their abilities. Effectively, such type of learning equips students with the ability to choose their own motivation, set learning goals, and monitor and control their own learning, all of which need a high level of metacognitive awareness and cognition. Admittedly, any discussion of self-learning will involve the structure of techniques for cognition knowledge and regulation (Pintrich, 2002). Self-regulation is a volitional process that entails goal formulation, planning, and monitoring (Roeser & Peck, 2009). Self-regulated learning was determined to be the most relevant mode of learning to explore in this research based on this criteria, as metacognitive strategies involving planning and comprehension of such tactics have a major impact on students' self-regulated learning.

The Influence of Thinking Maps towards Metacognitive Awareness

According to Hyerle (2011), thinking maps can assist students improve their metacognitive awareness across a wide variety of subjects and level of age. Numerous novel learning aids have been developed in recent years to assist students in becoming more engaged and effective learners. Caliskan and colleagues (2011) discovered that using appropriate learning methods helped students raise their awareness of appropriate learning techniques, metacognitive awareness, and metacognitive knowledge, the latter of which includes declarative, procedural, and conditional knowledge (Schraw and Moshman, 1995). Additionally, this study demonstrated that enhanced metacognitive awareness resulted in improved students' learning outcomes. Metacognition, as defined by Flavell (1979), is a regulatory system comprised of knowledge, goals, and methods. Thus, metacognitive knowledge refers to the stored knowledge or ideas about oneself and others as cognitive agents, tasks, behaviors, or tactics, and how all of these factors interact to influence the outcome of any intellectual endeavor. Metacognitive experiences, in this context, are cognitive or affective experiences that involve any component of an intellectual endeavor.

To date, a number of strategies for promoting metacognition have been developed, including thinking aloud, thinking journals, thinking words (mnemonics), thinking maps, and thinking with reading. Each of these strategies can be used in the classroom and contributes to students' learning performance improvement (Kolencik & Hillwig, 2011). According to Hyerle’s (2011) extensive research, thinking maps have numerous educational benefits, one of which is the promotion of metacognition in learning, which enhances students' cognitive growth. His study shown that the usage of thinking maps improved self-regulation during learning, implying that thinking maps could be a powerful tool for mediating thinking, listening, speaking, reading, writing, problem-solving, and obtaining new knowledge.

CONCEPTUAL FRAMEWORK OF MOTIVATED STRATEGIES THINKING MAPS TOOL (MoSTMaT)

The tool's content is designed to offer users (students) with sufficient knowledge and suggestions, so equipping them with the skills to solve problems using thinking maps in the related subject of this research. The fundamental objective of the tool development is to assist students in grasping the concept of thinking maps, as well as how to effectively use each type of map for describing and explaining information structure. Additionally, when appropriate, the use of thinking maps may assist them in addressing challenges (on how to develop knowledge based on information stored in memory). The following formats were used to present the content of thinking maps: written notes, examples, tutorials with help functions or hints for completing activities, and, finally, video representations. Examples and lessons demonstrated a variety of different types of thinking maps. The program has made three recommendations for each clue in the tutorial in order to assist students in resolving the provided problems. Students must recommend the appropriate types of thinking maps to use in order to answer the questions at the conclusion of the questions.

MoSTMaT was developed combining the related and important theories which are motivational beliefs, self-regulated learning (MSL), multimedia principles including multimedia elements which insisting theories involved. Self-learning requires motivation, self-efficacy, and encouragement to continue learning, which is referred to as intrinsic value (Pintrich, 1994; Gbollie & Keamu, 2017). When combined with the motivation elements embedded in the tool, such as interactivity, feedback, and multimedia elements, self-learning mode can significantly increase a learner's motivation to engage in learning for a longer period of time and more effectively (Cleary & Zimmerman, 2004). Multimedia enables the creation of a variety of combination representations, including text and graphics, text and audio, and graphic and audio. Multimedia learning is associated with cognitive development, demonstrating how multimedia instructional materials can assist in the fast acquisition of knowledge (Sorden, 2013). Mayer (2010) proposed that effective text- and graphic-based learning occurs when learners select important images into visual working memory, organise them into pictorial models, and integrate them with prior knowledge.

By minimising unnecessary processing, regulating critical processing, and encouraging generative processing, MoSTMaT adheres to these principles. The tool incorporates extraneous processing principles such as coherence, signalling, and spatial and temporal contiguity. The purpose is to eliminate extraneous features from the tool's multimedia components so that students' cognitive ability for grasping the concept of thinking maps improves. In addition to texts, pictures, audio, and video, the tool includes multimedia components such as interactivity and feedback. In each example of thinking maps and tutorial guidance, an element of interactivity was used. Figure 1 shows the conceptual framework of the tool.

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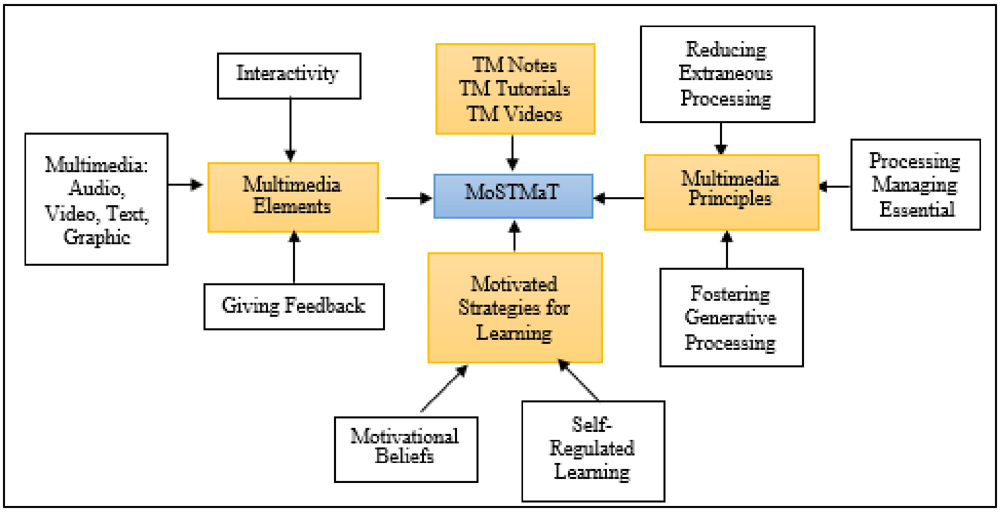

Figure 1: Conceptual framework of MoSTMaT

RESEARCH METHODOLOGY

Development of MoSTMaT

The development of MoSTMaT consists of five phases namely analysis, design, develop, implement and evaluate (ADDIE). The model covers all main and complete cycle to produce an instructional tool. It comprises processes from analysing information until evaluation of the tool.

The Instructional Design

The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model has been chosen to develop the tool in the research. This model is generic, simplified instructional design model to the AECT's (Association for Education Communication and Technology) learning standards (Wang, et.al, 2009). The use of the model to develop the tool to ensure that all the objectives that are aimed in the research will be achieved and will contribute to the field of educational technology and multimedia. Every phase is connected to each other and this will facilitate the further process to be more systematic. Further details for each phase will be discussed in the following section. Molenda (2015) stated that ADDIE is a shorthand term for any process-based approach to instructional material development. He also suggested that the acronym is nearly synonymous with the word instructional design, and that it encompasses a variety of distinct design frameworks. Figure 2 shows the phases of the ADDIE model.

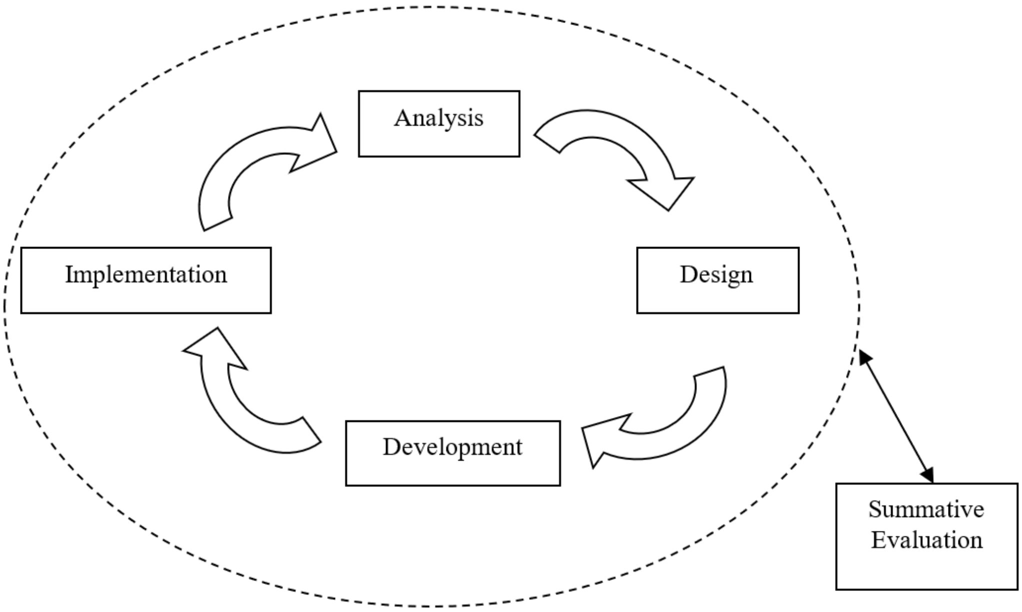

Figure 2: The ADDIE Model Phases

Analysis phase

During analysis phase, the designer identifies the learning problem, the goals and objectives, the audience's needs, existing knowledge, identify environment and delivery method, instructional strategies, and any other relevant theories and characteristics. The analysis also considers the instructional strategies, assessment strategies and summative evaluation, any constraints, and the timeline for the project.

User

Participants that were using the tool are students in a computing course. The involved participants are students who had prior knowledge about programming languages so that they would understand better the difficulties working with programming languages through developing systems. The student did not have background knowledge or any exposure related to thinking maps.

Delivery Method

The whole framework shows the tool overall including all the components inside the tool. The theory that was embedded in the tool is motivated strategies for learning which are implemented when participants use the tool. The motivated strategies for learning theory were implemented in the tool by Paul Pintrich (1994) which has two major elements namely motivational beliefs and self-regulate

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learning. The features that help self-regulation theory in the tool that would help keep a self-learning environment should be implemented much better. These are the elements that will be emphasized during the development of the tool.

Content

The content of the tool is thinking maps notes, tutorials and videos. Thinking maps tutorials are provided in the tool and users can access the tutorials during answering exercises. The note refers to notes about thinking maps. The content of examples and tutorials are basically a daily routine to make students can think of the ideas for answering the questions easily in purpose to make them understand the concept of thinking maps. The button or hyperlink of the notes is designed as the shape of thinking maps itself. It also comes with names and functions of the map. For example, circle maps are for defining context appears on the screen. The notes consist of an explanation about the use of the map. Different colours are used to highlight the important point to make it visualize by students while reading the notes. The image of maps also has been labelled to make sure that students are aware of the use of proper information that should be put into the maps in detail.

Software

During the development of the tool, there are four software that were used to create the tool. The whole tool was developed in Adobe Flash Professional CS6 and to create thinking maps. Editing and creating videos using Sparkol to make them more interesting. Sound Forge Pro used to edit and record audio while Adobe Premiere Pro CS6 is used for video editing. Graphic and design editing was done using Adobe Photoshop CS6.

Design phase

This phase needed a systematic process of specifying learning objectives. Content and strategies for an individual unit of instruction are identified, detailed storyboards and prototypes are often made, and the look and feel, graphic design, user interface and content are determined here. The interface for the tool is designed simple and easy to access. The navigation for notes, thinking maps tutorials and videos can be accessed along the way while using the tool. The colour used is not too bright, size and colour of the letters can be read easily. Figure 3 shows one of the interface designs for the tool.

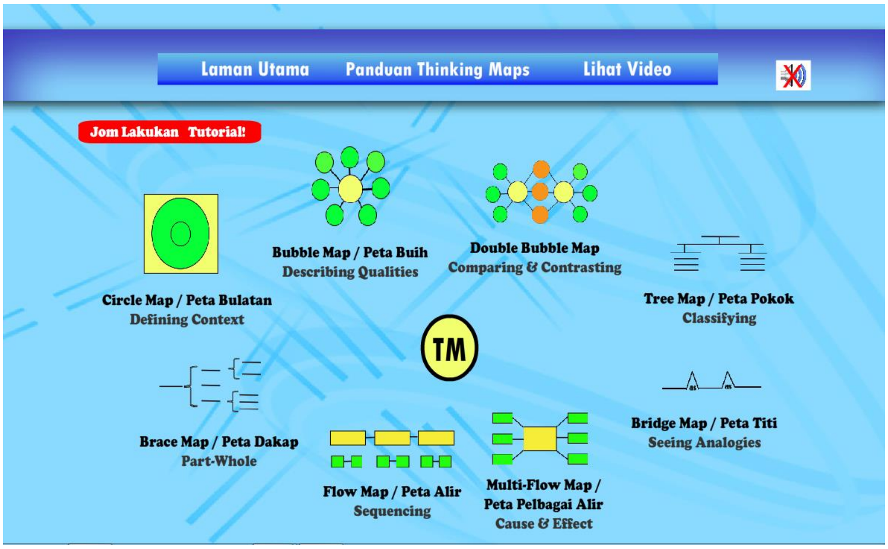

Figure 3: Interface for Thinking Maps Guide

Inside thinking maps guide interface, there are buttons (which presented in every type of thinking maps) including name of the maps so that it can make user easier to users to understand briefly about every type of the maps. On the upper left side of the interface, there is button for tutorial if user wanted to test their knowledge about thinking maps by answering few questions using thinking maps. By clicking one of the buttons; as for example double bubble map in Figure 4, notes regarding the types of maps will be appear. Starting with the name of the map in English and *Bahasa Malaysia*, followed by the image of the maps, notes about it on the right side of the map and the function of the map (in blue colour text). The bubbles of the maps are in different colour which indicates that the different function of the bubbles. For example, the bubbles in the middle are to state the similarities of both compared ideas. Meanwhile, bubbles on the right and left side are for differences between the two ideas. According to the functions of the maps, it is most suitable to be used when there are two or more ideas need to be compared and differentiates. On the upper right sight of the interface there is 'example' button which direct users to see the example on how to use the map.

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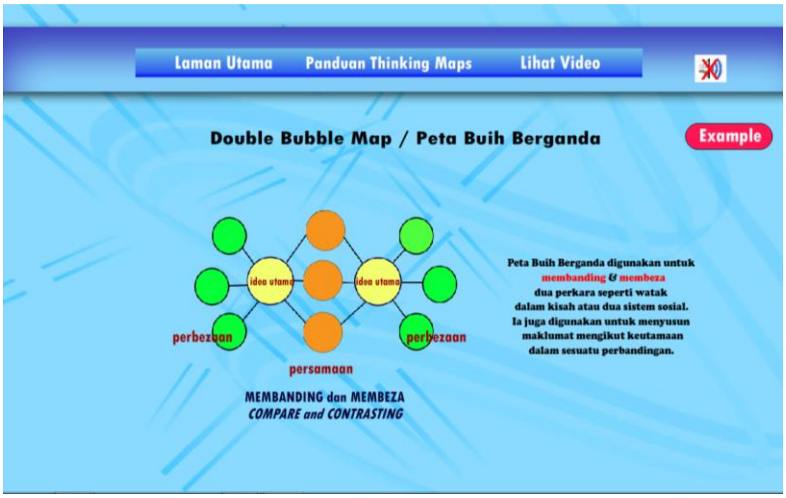

Figure 4: Interface for Thinking Maps Notes

After user clicking example button, this interface (Figure 5) will come out. The figure shows the example on applying double bubble map including examples of information that suitable to be filled in the bubbles. Different colour used for differences and similar information between these two ideas to make sure that student having clear visual about the correct information should be in specific bubbles.

Figure 5: Interface for examples of Thinking Maps

Figure shows interface for doing some tutorials. There are eight tutorials provided in the tool. Each tutorial is for each type of thinking maps. The questions given in the tutorials are comprising daily routine activities of a student to create easier situation for the students to think of the content. The focus is more to ability to choose proper types of thinking maps based on problem given. There are three hint or help given to guide students to answer the questions and choosing the correct and appropriate thinking map. The third hint will reveal the proper thinking map that student should use to answer the question. There is a silent button (on the top right) if the audio cause disturbance during answering the tutorial (Figure 6).

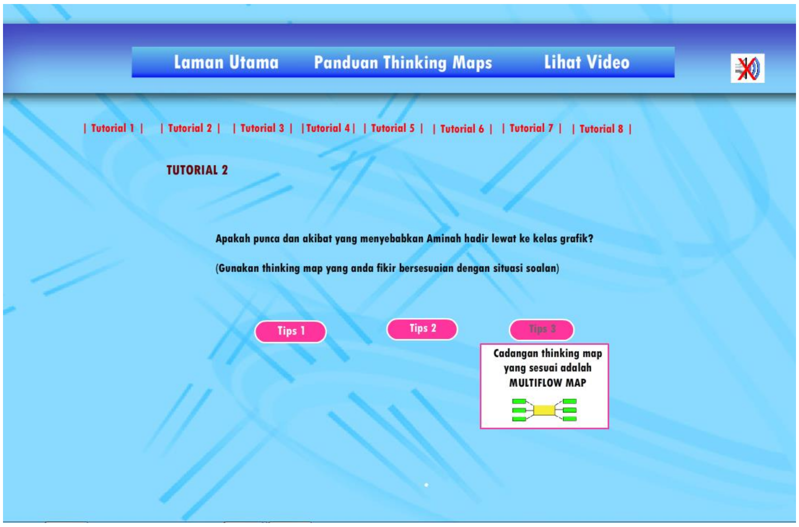

Figure 6: Hints for guiding users to answer the questions

Figure 7 shows the interface for tutorial videos. There are three separate videos which can be played, pause and stop function to make it easier for students to focus and do repetition on what they wanted to learn. Inside the videos, students will explore the elaboration of thinking maps with different examples in different environment of learning (audio and visual representation). Total of thirteen minutes of videos separated by three videos to make it easier to students to search information in the videos pertaining the types of maps that they want to learn.

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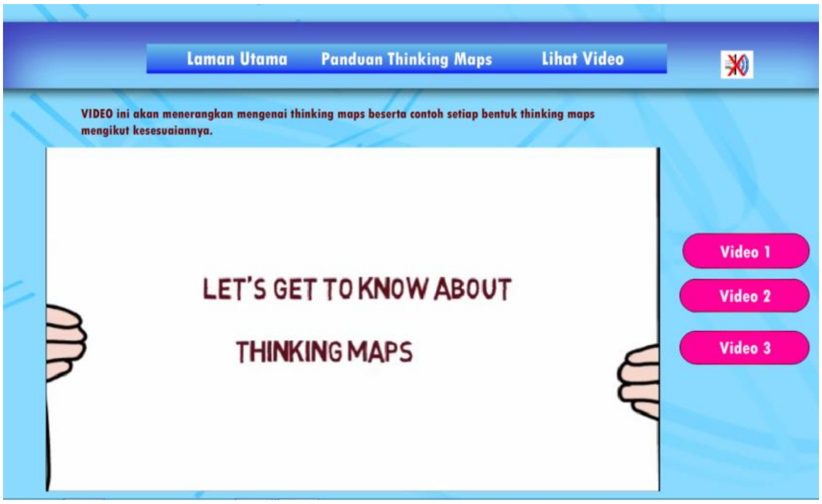

Figure 7: Interface for videos

Development phase

The development phase will combine the actual creation (production) of the tool and its content to create a multimedia tool that contains guidance on how to use each form of thinking map most effectively and creatively in a multimedia environment. The development process comprises audio recording, video editing, design creation, and editing in order to create a fully functional multimedia application. The tool is divided into three main sections: notes with examples of various sorts of thinking maps, lessons with assistance or hints, and videos. Students can choose from the following navigation buttons: main page, thinking maps notes, and videos. The tutorial is included in the notes so that users can practise after reading the instructions on thinking maps.

Implementation Phase

While putting the strategy into effect (implementation phase), a procedure for training the learner was constructed, which was then used to train distributed to student group. Materials were supplied or dispersed to the student group in a controlled environment. Before implementing the tool, the researcher initiated instruction with the participants.

Evaluation phase

This phase implementing summative evaluation. Evaluation towards the tool was conducted to seek the efficiency of the tool, the interactivity, feedback and the usage of multimedia principles to gain motivation as well as applicable in self-regulated learning environment. The tool was evaluated by two experts in instructional technology development for summative evaluation. Evaluation from the end user (students) was also carried out in intention to seek the usability of the tool, the appropriateness of multimedia implementation in the tool. A total of 34 students were selected to assess MoSTMaT. The researcher given an explanation relevant to the objectives of the assessment before the assessment questions were given to the students.

RESULT

Motivated Strategies Thinking Maps Tool Assessment

To correspond to the research objective; to determine the acceptance of computing students towards the developed tool, the responses from respondents indicating that the use of MoSTMaT was acceptable and can be applied in their learning processes. Firstly, expert evaluations were conducted as it relates to well-produced courseware. Two experts, namely lecturers with more than 5 years of experience were selected to conduct the assessment. Evaluation was performed using modified evaluation tool from Che Soh (2012), which originated from the software evaluation guide by Robyler (2006). Refinement of the tool is done based on the comments from the experts. The tool's evaluation outcomes obtained from experts found that the tool's navigation buttons were simple to follow. The implementation of fragments into the video's multiple segment content enables students to learn in a state of easy input reception. The examples provided are simple to comprehend to follow, even more so when interactivity and feedback are included to assist students in analysing the problem including receiving a suggested solution to the question. However, experts discovered that certain interfaces are less suited to the use of colours. It has been altered in accordance with expert appropriate recommendations. Following changes made in response to expert recommendations. Subsequent evaluation was performed to the appropriate students to assess their ability to use the developed tools. This assessment consists of five steps: selecting students, describing the assessment procedures and tool use, monitoring students while they use the tool, evaluating student feedback, and refining the software.

Later, a questionnaire to test the summative evaluation of the instructional tool was evaluated by end user divided into three sections. Section A measuring the application of multimedia elements and principles, section B was to determine the usability of MoSTMaT and section C to seek the implementation of suitable elements based on motivated strategies for learning namely motivation and self-regulated learning embedded in the tool. The instrument originally developed by Jiang (2017) consists of embedded multimedia principles which possess 0.77 of Alpha Cronbach coefficient. It is chosen to be used in the evaluation since it has all criteria of cognitive theory of multimedia learning which needed to be evaluated in terms of the use of multimedia principles in the tool to encourage learners engaged. Jiang (2017) indicated that the principles of cognitive theory of multimedia learning can be employed as an effective and reliable technique for evaluating the suitability of multimedia courseware design. Usability test from Post-Study System Usability Questionnaire version 3 by Lewis (2002) consists of 14 questions encompasses the usability and understandable while using the tool. Section C questions were based Cho (2004) and Pintrich and DeGroot (1990) where it expresses the design strategies to promote motivated strategies in learning through the developed tool. Table 1 shows the unit of measurements of the questionnaire.

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Table 1: Unit of measurement for assessment for developed tool questionnaire

Section	**No of items**		**Alpha Cronbach**	**Mean N=34**	**SD**
A (Multimedia Principles) (Jiang, 2017)	26	Coherent principles	0.766 Mean Part A 3.64 SD .283	2.98	.24
		Signaling principles		4.20	.52
		Redundancy principles		4.26	.51
		Spatial contiguity principles		3.08	.56
		Temporal contiguity principles		3.88	.52
B (Usability) Post-Study System Usability Questionnaire version 3 – PSSUQ	14	System Usefulness	0.946 Mean Part B 4.12 SD = 0.50	4.20	.53
		Information Quality		4.14	.48
		Interface Quality		4.02	.62
C (Motivated Strategies for learning) (Cho, 2004, Pintrich 1990)	8	Motivational Beliefs	0.927 Mean Part C 4.17 SD = 0.54	4.14	.56
		Self-Regulated Learning		4.20	.57

The findings from section A indicated that the tool's implementation of multimedia principles is adequate and does not impose undue burdens on students. Furthermore, all three sections of the results indicating high mean values which supporting or agreed to the statement in the questions. According to the results, the multimedia concepts used in the application were suited for usage by students, are simple to follow, and assist in the understanding of thinking maps. In addition, according to data collected from students about system usability, students believe that the software or tools developed are simple to use, contain adequate information to allow the usage of thinking maps, and have a user-friendly interface. Part C demonstrates that students discovered that the design strategy used to boost the effectiveness of MSL in the tool through the use of multimedia offers the atmosphere and aid necessary for students to use the produced tool.

Based on the results of the section A, the applicability of the tool's use of multimedia principles has a high reliability value of 0.766, and the section A mean value is 3.64, with a standard deviation of .283. The principles with the highest mean value in subsection A are redundancy principles with 4.26, followed by signalling principles (4.20), temporal contiguity principles (3.88), spatial contiguity principles (3.08), and finally coherence principles (2.98). The result indicating that multimedia principles implemented into the tool was suitable and adequate to help them in understanding the concept of thinking maps. Section B is about the usability of the tool, with a mean value of 4.12 and a standard deviation of 0.50 indicating that students believed that the generated tool was uncomplicated to use. The mean value for system usefulness was 4.20, followed by information quality (4.14), and interface quality (4.02). Section C to seek the acceptance of students towards the implementation of motivated strategies for learning theory into the tool showed that students were accepting the application very well, based on the mean value of 4.17 for overall of section C. The implementation of self-regulation was successfully agreed by students by the results of mean value, 4.20 and 4.14 for motivational beliefs. Through these results, it is agreed that students were accepting the way of motivation and self-regulated elements embedded into the tool and they were adapting the use of the elements very well in self-learning environment.

DISCUSSION

Based on reflections from students, it shows that overall MoSTMaT was acceptable and applicable to their learning processes. Based on the results of the evaluation, students agreed that MoSTMaT is simple to use independently and that it provides motivation to remain engaged throughout the learning process. MoSTMaT's usage of multimedia assists users in locating information easily, and the descriptions are basic and straightforward.

This work suggesting that students need motivational values in learning which helping them to keep on going to meet the goal; understanding and learn new knowledge. Students must have a strong sense of self-motivation in order to study more effectively and meaningfully (Agarwal, 2021). In despite of that, motivation is something requiring to be nurtured and encourage aim to give satisfaction in learning and driven from, within a learner. Multimedia stands up as a tool (in this study) which proven to be a good motivator to these learners to keep on engaging in learning. The tool was developed based on self-regulation theories as well as motivational features (multimedia principles and elements) to encourage students to prefer learning and doing activities provided in the tool and gaining knowledge about thinking maps at the same time.

Multimedia is the use of multiple media simultaneously at a time. It can be one media, two or more media at the same time depends on a learner. Learning using multimedia meaning exposing learners to several medias, for example, text, graphic, audio and video during learning has been proven practical to enhance teaching and learning process (Abdullah, et al., 2021). Study by Puspitarini & Hanif (2019) agreed that learning through media is better than using books and lecture in classroom The use of video-based instruction can boost students' engagement and proficiency in the classroom (Ishak, et al., 2021). Motivation can be derived from intrinsic or extrinsic meaning that it can resulting from surrounding factor such as parents, family, friends or a fun learning environment. Atmosphere during learning especially in self-learning does testing oneself as learners trying to figure out whether the learning is on the right track, keeping momentum of learning and also finding the right decision for a problem given. Students was accepting the multimedia usage in the tool which implementing the principles of signalling, redundancy which gaining high mean value through the responses. Students agreed that it increases their self-efficacy by lowing anxiety feelings by doing exercises and tutorials with guidance which enabling them to learn in more convenient ways. Furthermore, hints and notes provided influencing them in making decisions before answering problem given. These activities will impact on their intrinsic motivation to keep engage as well as keeping them to learn more through the tool.

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Self-regulation theories were embedded into the tool by creating environment which allowing students to explore the content and all features delivered in the tool. While exploring, the brain will catch up information that they need and store it in the brain. After some time, they will answer some tutorials and questions regarding thinking maps and application of it with information that they already know, simple questions such as “Describe about your pet”. This kind of examples will give some simple brainstorming information to them to get the idea of how to use appropriate way of each type of thinking maps. These exercises will help them to face much complicated problem in the future using thinking maps. These is called cognitive strategy use which learners need to have information and learn how to organize it and turn it into something useful and answering problem occurs

CONCLUSION

The tool is primarily based on Pintrich's (1990) theories, with additional strategies from Cho (2004) and Schunk (2005). When these concepts are combined with multimedia principles (Mayer, 2009) and elements such as videos, graphics, stimulating buttons, and appropriate colour use, learners' ability to comprehend thinking maps is enhanced while they remain engaged in the learning process. Self-learning strategies and elements of motivational beliefs embedded in the tool may be the optimal combination for enhancing the learning process and increasing learners' engagement with technology-based learning while also increasing students' metacognitive awareness and motivated learning strategies.

Embedding motion multimedia in MoSTMaT encouraging users; computing students in this study, to have self-regulated learning experience by having interactivity, feedback given through exercises, audio, video, text, graphic through the tool’s experience. The design development tool also considers MSL and multimedia principles, which assists in establishing the state of the interface in terms of words and pictures that are suitable for usage with the tool. Appropriate positioning and sequence interface will give students a better understanding of how to use an appropriate thinking map based on a given situation. As long as the learner is not constantly overwhelmed with extraneous processing or excessively distracted by important processing, motivational elements can enhance student learning by supporting generative processing (Mayer, 2014). As conclusion, through collaboration with multimedia elements and principles, multimedia learning environment will able to arouse motivation during learning incorporating the suitable representation through MoSTMaT. It also functioning as a guidance for students on how to use every single type of thinking maps appropriately to help them, not only gaining effective work of using thinking maps in their learning process, but also increasing ability in critically thinking during facing any questions regarding problem solving, eventually leading towards improvement of metacognitive awareness to score throughout computing courses.

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