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The relationship between learning styles, creative thinking performance and multimedia learning materials

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Abstract

This paper reports the findings of a research which looks at the influence of learning styles on engineering students' creative thinking performance when multimedia learning tool is used. Taking into consideration the ubiquity of technology-based educational tool and its possible impact on students' creative performance, a multimedia learning tool was developed for a group of mechanical engineering students based on a specific subject. The purpose was to investigate the relationship between students' learning styles and their creative thinking after using the multimedia learning tool. The Torrance Test of Creative Thinking (TTCT) was used as the main instrument to measure students' creative thinking before and after the multimedia learning tool was administered. The Index of Learning Style (ILS) was also used to identify students' learning styles. The independent sample *t*-test and one-way analysis of variance were used to compare the TTCT scores with the learning styles dimensions. The findings indicate that active, reflective, intuitive and high visual students benefit creatively after using the multimedia learning tool.

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Keywords: Learning Styles; Creative Thinking; Multimedia Learning Tool

1. Introduction

The use of technology in education today is common with many new teaching and learning tools being introduced and used. Instead of using the conventional paper-based and static learning materials, educators are looking at manipulating and utilizing dynamic learning materials. Computer technology can be employed to transform texts and graphics, manipulate colours and audio and use other computer effects to create dynamic and animated representations of information [1]. This includes static graphics and texts using *PowerPoint* or animation and audio using *Flash* or *Media Player*. Representations of information can therefore be transformed from static and paper-based formats into dynamic representations [2, 1], which allow for new tools, materials and techniques to be used in teaching and learning processes.

The impact of technology in transforming education, and how people teach and learn are huge. However, the question of whether such impact can actually lead to meaningful learning; and whether traits such as creativity can be enhanced through these new types of learning materials is still being hugely researched and debated. This paper will therefore report part of a study that examined the impact of using multimedia learning materials on engineering

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students' creative thinking performance. This paper particularly focuses on the relationship between students' learning styles preference and their creative thinking when such learning materials are used.

2. Literature review

Multimedia learning research investigates the effectiveness of learning materials that use multiple information representations. Basically, multimedia learning refers to learning using materials or tools which consist of words and pictures [3]. In the context of this study, the scope of multimedia learning materials is defined as materials comprising multiple information representations, which development utilizes multimedia technology. In Malaysia, the use of static and paper-based learning tools is still the preferred method, but the use of computer-based multimedia learning materials is increasing, especially with the existence of the Internet, computer and multimedia technologies [4].

It is a fact that each person is unique and different from one another. As such, it is evident that there are people who are more creative or more intelligent than others. Apart from environmental and social factors that could influence creativity, there are also individual differences that could directly or indirectly promote or inhibit individual traits. In the educational context, one way to describe individual diversity is through learning styles. Researchers claim that students indeed have different levels of motivation, different attitudes and responses towards learning; and therefore, this affects their individual's preferences on how they learn [5, 6]. The proponents of learning styles research define this notion as "cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" [7]. There is a number of learning styles models, which put and define learning environment into different contexts, and the Felder and Silverman Model is the model that examines information processing learning preferences. This model focuses on information processing preference; a model which deals with the way students process, assimilate information and create new information and knowledge through experience [8]. It defines learning styles as "characteristic of strengths and preferences in the ways individuals have preferences in the ways individuals take in and process information" [8]. Therefore, the question is whether providing students with learning materials suitable with their learning preference is able to help enhance their learning experience and make them more creative.

Creativity is a multi-faceted construct and its complex nature makes it difficult to be defined and examined [9]. Other major researchers [10, 11] posited that knowledge is one of the essential elements needed for creativity. The depth of one's knowledge in one particular domain as well as the extent of general knowledge can help a person to generate creative ideas. With a deeper knowledge base, the association of information and knowledge across remote and divergent ideas can lead to creativity [9, 10, 11]. Moreover, creativity can be learnt and fostered, and one of the ways to foster creativity in the classroom is by changing the learning and teaching materials. With the ubiquity of technology, the question to be asked is whether learning materials presented using multimedia technology can enhance students' creative performance.

The development of the main material of this study utilized the Cognitive Theory of Multimedia Learning (CTML) proposed by Mayer [3]. CTML focuses on the cognitive model of information processing and hypothesizes that the design of multimedia learning materials needs to accommodate the way individuals learn, that is, how information can be processed so that knowledge can be constructed and meaningful learning can occur. CTML proposes that information representations in the learning materials should effectively manipulate the architecture of the cognitive system and should manage the load of the learning materials that can be imposed on the cognitive system. Effective and appropriate design of learning materials should especially manage cognitive load in working memory so that processing capacity can be increased [3]. Effective load of the learning materials ensure knowledge construction and can lead to meaningful learning and creative potential.

3. Purpose of the Study

It is the aim of this study to examine the effectiveness of learning tools which are developed using computer technologies on creativity. The main purpose of this study is therefore to examine whether learning styles can influence creative thinking performance when multimedia learning materials are used.

4. Methodology

4.1. Participants and research design

Mechanical engineering undergraduates (*N* = 32; 97% male) from a technical-based university voluntarily participated in this study. Participants were third-year students who enrolled in the Mechanism Design subject, and they were selected by means of non-random convenience sampling because students came into the semester as an intact group. This study used a one group pre-test post-test non-randomised design. The rationale for applying this research design is because there was only one group of students who enrolled for the subject; and since the main materials of this study (will be discussed section 4.2) required students who were studying the subject Mechanism Design, the stated research design was applied.

4.2. Materials

The main material used in this study was a multimedia learning tool (MLT) titled Mechanism Design. MLT is a self-paced multimedia program which was used by the participants during their tutorial in the lab. The MLT contains a number of multimedia clips, which content was developed based on a textbook titled *Machines and Mechanisms: Applied Kinematic Analysis* [12]. It comprises of five chapters following the subject's syllabus, which include: 1) Mechanisms and Kinematics, 2) Position and Displacement, 3) Velocity Analysis, 4) Acceleration Analysis, and 5) Cam Design and Kinematics Analysis. Each of the chapter consists of several multimedia clips. In total, there were 37 multimedia clips in the MLT, which is about 75% of the actual content covered in the subject syllabus. The MLT was designed and developed by applying the design principles of the Cognitive Theory of Multimedia Learning (CTML) [3]. Fig. 1 illustrates two screenshots where the MLT applied the signaling principle of the CTML. These two screenshots illustrate visual cues namely highlights which can be used in multimedia learning materials to signal help to students in making the organizational structure and content of the materials more explicit.

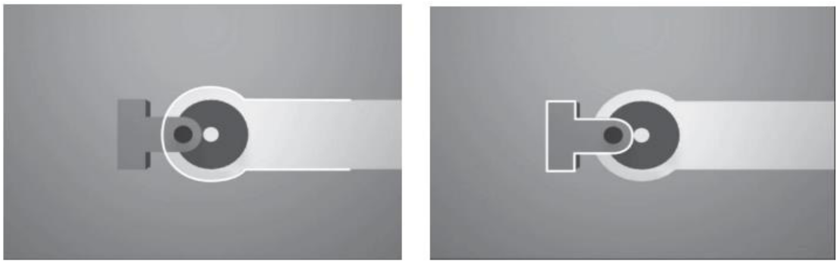
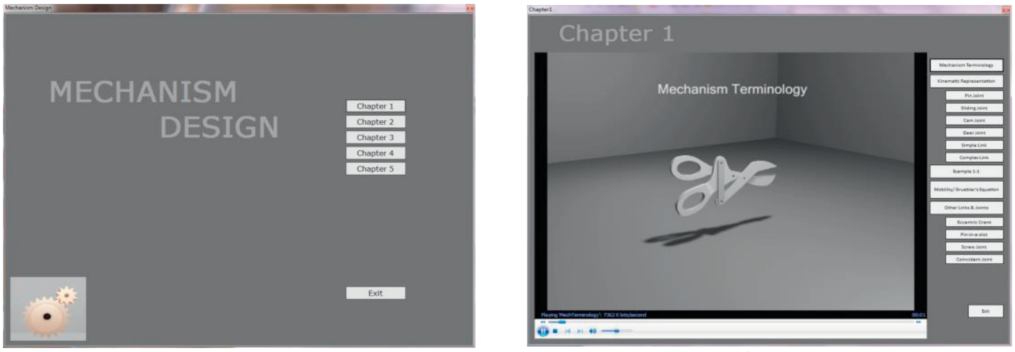


Fig. 1. Screenshot of the MLT

The development of the MLT started with the storyboard. Storyboards of each clip were written by the researcher with consultation with the subject lecturers and reference to the textbook [12]. Written storyboards were given to the lecturer for assessment, and accepted storyboards were given to the multimedia designers for development. Two computer engineering students were recruited to develop the MLT based on the accepted storyboards. Once a multimedia clip was completed, it was electronically sent to the lecturer for review and evaluation. Each multimedia clip was reviewed by the subject lecturer taking into account the following aspects: 1) the graphical design; 2) the narrated information; 3) the textual information and 4) the Mechanism Design concepts presented in the MLT. Once the lecturer approved the content of the multimedia clip, it was finalized and accepted for use in the study. All finalized multimedia clips were then compiled into a program named Mechanism Design. Microsoft visual studio was used to compile all the clips, which were programmed in *C++ clr*.

The layout concept of the MLT is similar to a book with a brief content page, sub-titles column and the content in multimedia form. The program was installed on each computer in the computer laboratory, and participants accessed the tool by double-clicking the icon on the desktop. The content page of the MLT appeared as depicted in

Fig. 2(a). The contents page listed all five chapters of the MLT with an *Exit* button. Single clicking on the *Chapter* button would lead students to the MLT's chapter page as illustrated in Fig. 2(b). The Chapter page of the MLT contained the *Viewing Screen* and the *Column List* on the right, which identified all multimedia clips of the chapter. By double-clicking one of the multimedia clip buttons, the Viewing Screen would play the clip.



(a) (b)

Fig. 2. (a) Screenshot of the MLT contents page; (b) Screenshot of the MLT chapter page

4.3. Instruments

The Torrance Tests of Creative Thinking (TTCT)

The Torrance Tests of Creative Thinking (TTCT), the verbal forms, was used to measure participants' creative thinking performance. The TTCT verbal form measures creative thinking through written tasks. Participants were given scenarios, and they were required to write their answers. The TTCT verbal form generates scores on three elements of creative thinking which are: 1) Fluency, the number of interpretable, meaningful and relevant responses; 2) Flexibility, variety of categories of relevant responses and 3) Originality, responses which are unexpected, unusual, unique or statistically rare [13]. It consisted of Forms A and B; Form B was used in the study.

The Index of Learning Styles® (ILS)

The Index of Learning Styles® (ILS) is based on the Felder-Silverman Learning/Teaching Style Model [5, 8], and has its basis in the engineering sciences. It was developed to assess engineering students' learning styles in four dimensions: active-reflective, sensing-intuitive, visual-verbal and sequential-global.

1. Active-Reflective Learners
   This refers to how students process information. Active learners prefer active experimentation, an indication that they like to work in groups and express opinions freely. Reflective learners prefer reflective observation, an indication that they like to work by themselves or at most with only one person.
2. Sensing-Intuitive Learners
   This refers to what kind of information students prefer to perceive. Sensing learners observe and gather data through senses; therefore, they like facts, data, experimentation and detailed information. Intuitive learners use speculation, imagination and hunches; hence, they prefer theories, principles, complications and innovations.
3. Visual-Verbal Learners
   This refers to which modalities of information representation students can effectively perceive. Visual learners prefer and remember information presented in pictures, diagrams, graphs and demonstration whilst verbal learners prefer words and sounds.
4. Sequential-Global Learners

This refers to how students progress towards understanding. Sequential learners need to understand by taking in information in continual steps. Global learners are divergent thinkers, and they see information in a big picture.

Results of the ILS generated student's preferences for all four dimensions, and the degree of preference. ILS was used to profile students' diversity, and to identify whether the impact from using the MLT on students' understanding and creative thinking could be influenced by their learning styles. ILS was used rather than other existing learning styles instruments because it was developed, tested and used within the literature of engineering education [5]. Since the scope of this study involved engineering students, the ILS was a suitable instrument to measure students' learning styles.

4.4. Procedures

The study was conducted in seven weeks. In the first week, prior to the use of the MLT, the ILS was given to the students to assess their learning styles. The participants attended a two-hour lecture and a two-hour tutorial every week. During the tutorial, participants were given access to the MLT and they could use and refer to the MLT as supplementary reading materials. They used the MLT during the tutorial for seven weeks. In the seventh week, in a separate session, the TTCT-Verbal Form B was administered to measure their creative thinking performance.

5. Results

5.1. Students' learning styles preference

Using the Index of Learning Styles (ILS), analyses of engineering student learning styles were categorised in four dimensions: 1) active-reflective; 2) sensing-intuitive; 3) global-sequential and 4) visual-verbal. The distribution of the learning styles is displayed in Fig. 3.

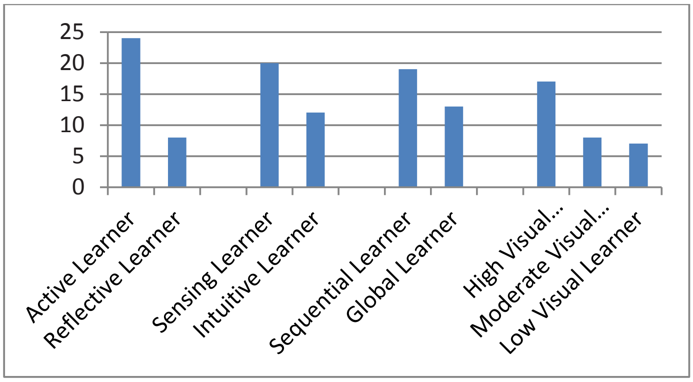


Fig. 3. Students' Learning Styles in Four Dimensions

The bar chart shows that the number of active learners is considerably higher than that of reflective learners, and similarly, the number of sensing and sequential learners is considerably higher than intuitive and global learners. This pattern is similar with the general engineering students' learning styles of the active-reflective, sensing-intuitive and sequential-global dimensions as reported in the engineering education literature [5]. On the other hand, for the visual-verbal dimension, none of the participants identified themselves as verbal learners, which makes 100% of the participants as visual learners. This is again similar with the findings of the engineering literature where engineering students were found to incline towards being visual learners. Therefore, for this particular dimension, the distribution of participants learning style preference considered the strength of students' preference for visual learning materials, differentiating between high, moderate and low visual learners. Fig. 3 shows that the number of high visual learners is greater than the other two levels.

5.2. Learning styles, creative thinking and multimedia learning materials

Analyses of the influence of learning styles preferences were conducted on the students' TTCT scores. This is to explore whether particular learning styles preferences may be more strongly associated with students' creative thinking performance benefiting from using the MLT.

Two different statistical techniques were used:

1) An independent-samples t-test was conducted to compare the TTCT scores for three learning styles dimensions: active-reflective, sensing-intuitive and sequential-global. This is because for these three dimensions, the students were divided into two different groups of learning styles preferences.
2) A one-way analysis of variance (ANOVA) was performed to compare the TTCT scores for the visual learners since for this dimension; the students were divided into more than two groups.

The independent variables were students' learning styles preferences, and the dependent variables were the post-test scores of the TTCT elements measured as Fluency, Flexibility and Originality.

5.2.1. Independent-samples t-test

For the active-reflective dimension, the independent-samples t-test results showed that there was no significant difference in the TTCT scores for active and reflective learners for any of the creative thinking elements: Fluency – $t(30) = -1.34$, $p > .05$ (two-tailed); Flexibility – $t(30) = -1.27$, $p > .05$ (two-tailed), and Originality – $t(30) = -1.48$, $p > .05$ (two-tailed). The mean scores and standard deviations for active and reflective learners of the creative thinking elements are presented in Table 1.

For the sensing-intuitive dimension, there was also no significant difference in the TTCT scores for sensing and intuitive learners for any of the creative thinking elements: Fluency – $t(30) = -1.48$, $p > .05$ (two-tailed); Flexibility – $t(30) = -1.19$, $p > .05$ (two-tailed); and Originality – $t(30) = - 1.60$, $p > .05$ (two-tailed). The mean scores and standard deviations for sensing and intuitive learners of the creative thinking elements are presented in Table 1.

Similarly for the sequential-global dimension, there was no significant difference in the TTCT scores for sequential and global learners for any of the creative thinking elements: Fluency – $t(30) = .002$, $p > .05$ (two-tailed); Flexibility – $t(30) = -.40$, $p > .05$ (two-tailed); and Originality – $t(30) = .25$, $p > .05$ (two-tailed). The mean scores and standard deviations for sequential and global learners of the creative thinking elements are presented in Table 1.

Although main results did not reach significance, the mean scores do indicate that learners preferring reflective or intuitive styles have a slight advantage over learners preferring active and sensing styles for all the creative thinking elements. However, there is no clear advantage for learners with global or sequential preferences. Issues relating to visual learning styles were explored using a different statistical technique.

Table 1. Mean Scores and Standard Deviations of the TTCT Results Comparing Students' Learning Styles for Active-Reflective, Sensing-Intuitive and Sequential-Global Dimensions

Learning Styles		Fluency	Flexibility	Originality
Active	*M*	83.67	84.38	89.33
(n = 24)	*SD*	11.20	13.02	11.87
Reflective	*M*	94.88	97.88	104.63
(n = 8)	*SD*	22.68	29.18	28.34
Sensing	*M*	83.20	84.35	88.80
(n = 20)	*SD*	15.24	14.61	13.47
Intuitive	*M*	91.92	93.42	100.42
(n = 12)	*SD*	18.30	23.90	22.98
Sequential	*M*	86.47	86.70	93.84
(n = 19)	*SD*	16.30	19.32	18.01
Global	*M*	86.46	89.31	92.15
(n = 13)	*SD*	14.31	18.67	19.16

5.2.2. One-way analysis of variance (ANOVA)

For visual learning preferences, ANOVA was used because there were more than two groups of learners' preferences. For the different levels of visual learners, the ANOVA results showed that there were no statistically significant differences for any of the creative thinking elements: Fluency, F (2, 29) = .47, p = .63, Flexibility, F (2, 29) = .43, p = .66 and Originality F (2, 29) = .48, p = .63. The effect size, calculated using eta squared for all the creative thinking elements was .03, and there were also no statistically significant differences within groups. The mean scores and standard deviations for different levels of visual learners in relation to of the creative thinking elements are presented in Table 2.

Table 2. Mean Scores and Standard Deviations of the TTCT Results for Different Levels of Visual Learners

Learning Styles		Fluency	Flexibility	Originality
High Visual	*M*	87.82	88.18	95.53
(n = 17)	*SD*	13.70	18.58	17.00
Moderate Visual	*M*	88.00	91.50	93.13
(n = 8)	*SD*	18.65	21.20	23.20
Low Visual	*M*	81.43	82.43	87.43
(n = 7)	*SD*	16.21	18.15	16.11

Generally, the analysis of the relationship between the TTCT scores and learning styles preference dimensions indicated that there were no statistically significant differences in the influences of any of the learning styles dimensions on any of the creative thinking abilities. This implied that students' learning styles did not influence their creative thinking abilities when using the MLT. However, the mean scores indicate that reflective, intuitive and higher visual learners have a slight advantage over the active, sensing and low visual learners for all the creative thinking elements.

6. Discussion

Generally, the results presented in section 5 show that there were no significant effects of learning style preferences on students' creative thinking after using the MLT. The mean scores, however, indicated that the MLT might have positively affected reflective and intuitive learners as well as learners with a high preference for visual learning materials more than they affected active and sensing learners, and learners with a low preference for visual learning materials. The mean scores might suggest the possibility that high visual learners, reflective learners and intuitive learners seemed to gain more from using the MLT than other types of learners. Within the information processing context, the literature has shown that learning styles can influence how students acquire and process information, understand problems and generate ideas, which will determine their decisions, actions and creations [14]. Learning styles can also influence cognitive processes of creativity; this influence depends heavily on the types of learning materials given to students.

This study found that the mechanical engineering students were mainly active, sensing, sequential and high visual learners; similar to the findings by [5] and [15] on engineering students' learning styles. However, students who may have benefited more from using the MLT both in their creative thinking and product making were reflective and intuitive learners whose learning style preferences are less dominant in the field of engineering. The other group who appeared to benefit were high visual learners who are very dominant in the engineering field.

One possible explanation for the benefit gained by high visual learners is the use of graphical and dynamic representations of information. Due to their high preference for graphics oriented learning materials, it is possible that high visual learners were able to create informational representation better. Such learners would have required less mental effort to perceive the information, and it is also possible that they were able to construct the required knowledge necessary for creativity. Researchers [16] found that high spatial ability participants performed better in transfer and creative problem tasks when the animations were temporally coordinated. In another study, Mayer and his colleague [3] found that pictorial scaffolding, a design feature which was suitable for visuospatial thinking was able to help high spatial learners better.

Using a similar argument, intuitive learners were able to gain advantage from the MLT more than sensing learners because of their preferences for the use of imagination in processing information. The MLT may have allowed intuitive learners to visualise the motions of the mechanisms, which enabled them to be more imaginative. One study [17], which focused on learning materials that instructed students to imagine, claimed that this could lead to meaningful learning and called this the imagination effect. In addition, reflective learners benefited from the MLT use more than active learners. One possible explanation for this finding is reflective learners' preference to work and reflect individually on what they learnt. Since the use of the MLT required students to use the MLT individually, and to have a one-to-one interaction with the computer, reflective learners would find this learning environment more suitable to their preferences and styles.

Finally, there were no conclusive results differentiating sequential and global learners for the creative thinking test, but global learners scored higher than sequential learners on all product creativity criteria. A possible explanation for the creative thinking results is the subject matter of the content of the MLT itself. Mechanism Design deals with logic and sequential process of mechanisms, which may have been more suitable for sequential learners. Therefore, global learners may have been able to assimilate to the differences in the group, think divergently and help the group with the product more than sequential learners.

7. Conclusion

The discussion above has indicated that understanding and accommodating the design of the learning materials to students' learning styles could help students with their understanding. By considering learning styles in the context of information processing, students are able to deal with information representations in the learning materials which could further enhance their creative thinking performance. However, since statistical analyses did not reach significance levels, the results are inconclusive. Future studies should address this issue.

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