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ASSESSING THE RELATIONSHIP BETWEEN STUDENTS' LEARNING STYLES AND MATHEMATICS CRITICAL THINKING ABILITY IN A 'CLUSTER SCHOOL'

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Identifying students' learning styles in class can help teachers plan a strategy for adapting the best teaching method to help them understand. The objective of this study is to identify the potential relationship between the students' preferred learning style (visual, auditory and kinesthetic) and their critical thinking in mathematics. A set of questionnaires consisting of 14 questions and critical thinking problems were distributed to sixty-two 17-year-old students at a cluster secondary school in Pahang, Malaysia. The quantitative data collected were analyzed using descriptive statistics, Spearman's Rank Correlation Coefficient, and ANOVA and t-test. The findings indicate that the most popular learning style is visual (71%), followed by auditory (22.6%) and kinesthetic (6.5%). Further, the preferred learning style and critical thinking are not significantly related. Based on this study, the teachers can identify their students' learning style and make adjustment to provide various teaching methods consistent with the students' learning style in the future. It is also will help the students to build self-confidence and plan their study strategy.

***Keywords*:** cluster school, critical thinking, learning style, mathematics

1. Introduction

Everyone is unique in their particular way, not only physically but also emotionally, attitude, and thought. Learning style and critical thinking are essential elements in learning and enhancing an individual's professional competence. Learning styles refer to how a person acquires, retains, and retrieves knowledge. It also refers to individual behavioral action as managing information methods, starting with arranging, synthesizing, analyzing, and keeping information (Andreou et al., 2014). Due to the fact that each student's ability to receive and process information differs, students receive information in a variety of ways (Purwanto et al., 2020).

There are many types of learning preferences since people learn differently. According to Yenice (2012), learning style is a concept that indicates the choice of an individual in the process of learning, which may include environmental (noise, heat), emotional (motivation, responsibility), sociological (alone or in a group) and physical factors (visual, auditory, kinesthetic). Learning styles have been studied exhaustively by many scholars since their introduction in the 1970s (Coffield et al., 2004). However, numerous studies are still conducted on learning styles by linking them to other aspects of teaching and learning (Dutsinma and Temdee, 2020; Jepri et al., 2019; Syahra et al., 2020). Among others, studies investigate the correlation between learning styles and multimedia teaching materials (Weng et al., 2018), description of inference (Aljaberi and Gheith, 2019), study habits and academic performance (Magulod Jr., 2019), and students' personality (Seyal et al., 2019).

A study by Beatrice (1995) categorizes learning styles into three different domains, namely visual (V), auditory (A), and kinesthetic (K) learners. Visual learners learn by seeing and observing, visualizing, and enjoy drawing. They respond well to slides, posters, diagrams, charts, and computer graphics. Smart lecture notes are essential for visual learners. Auditory learners depend on hearing and speaking as their primary method of learning. They like to read aloud, speak in class, and use verbal reports. Auditory learners learn best when listening to recorded lectures, repeating facts loudly, and participating in group discussions. Kinesthetic learners learn better by moving, physical activities, and hands-on approaches.

Felder and Silverman (1988) proposed four learning style domains: active-reflective, sensing-intuitive, visual-verbal, and sequential-global. The study has indicated that most college students are visual learners. Ahmad et al. (2011) found that both high achievers and students with an average academic performance show strong preferences on visual learning style. However, high achievers are more visual and intuitive compared to the other group. Different disciplinary background influences the learning style preference. Engineering students express a significantly strong preference for logical learning style over visual, verbal, aural, physical, or solitary learning styles. In contrast, students with social backgrounds express a stronger social learning style than a logical learning style (Hill et al., 2016).

Individual differences require a different mode of instruction and most effective in the process of learning. Knowing the students' preferred learning style is essential to the teachers because they may not share the same preference. Another model of learning style by Myers and Dyer (2006) in their research categorizes the learning style into four groups: Concrete Sequential (CS), Abstract Sequential (AS), Abstract Random (AR), and Concrete Random (CR). According to Myers and Dyer (2006), CS is naturally task-oriented and structured. AS relies on intellect and logic, AR is concerned with feeling and emotion, while CR relies on intuition and instinct in their thinking process.

Learning and thinking are two processes that complement each other. Critical thinking requires a higher level of cognitive skills. Critical thinking is a rational reflection that refers to individual abilities to interpret given information, recognize issues, assume and analyze evidence (Andreou et al., 2014). In solving mathematics questions using critical thinking skills, students should know how a formula works, what is the concept used to derive the formula, what is the logic behind the formula, what to do to solve the question, analyze all the related aspects, they can elaborate the concept and the solution (Krulik and Rudnick, 1995: "Tips for Teachers," 2013). They are not supposed to simply guess or use the formula to find the solution without showing any related reasons.

Critical thinking has a pivotal role to play in learning mathematics. It has been acknowledged as a crucial component that students must acquire (Aini et al., 2019; Firdaus et al., 2019; Kholid et al., 2020). It has also become the main factor in differentiating students who understand the subject and those who do it without knowledge. Besides that, critical thinking applied in mathematics helps students be more creative and increase their ability to solve problems in different situations (Mailisman et al., 2020). According to Purwanto et al. (2020), since each student's ability to receive and process information differs, the learning style of each student influences their ability to think critically in mathematics.

Critical thinking has become a beneficial skill to acquire and is considered a vital skill for students to succeed in their future (Firdaus et al., 2015). Critical thinking skills help them decide on the significance of the information they obtain (Jepri et al., 2019). Besides that, critical thinking will be helpful in students' learning. One main reason is that critical thinking makes students think in-depth since it involves evaluating and judging (Innabi and Sheikh, 2006). Thus, the objective of this study is to determine the potential relationship between students' learning style and their critical thinking in mathematics.

This study used six null hypotheses as follows:

H_1: There is no significant difference between the male and female learning styles.

H_2: There is no significant difference between the male and female levels of critical thinking.

H_3: There is no significant difference between visual and auditory learners in the critical thinking test score.

H_4: There is no significant difference between visual and kinesthetic learners in the critical thinking test score.

H_5: There is no significant difference between auditory and kinesthetic learners in the critical thinking test score.

H_6: There is no relationship between learning style and critical thinking.

2. Method

The theoretical framework of this study is within the three domains of learning styles proposed by Beatrice (1995), namely Visual (V), Auditory (A), and Kinesthetic (K) learners. This study chooses this learning style model since the questionnaire matches respondents' age and thinking level. The students' learning styles were identified by assessing their responses to each question in the learning style inventory with three choices. For critical thinking in mathematics, 10 questions are given and five critical indicators are considered which are interpretation, analysis, evaluation, inference and explanation (Facinoe, 1995; Indrawatiningsih et al., 2019). This section describes the respondents, research design, procedure and instruments used in this study.

2.1 Respondents

Sixty-two (62) 17-year-old students of a cluster school in Pahang served as respondents in this study. Sekolah Menengah Kebangsaan Jengka Pusat (SMKJP) is one of the cluster schools in Pahang that was awarded the status of a cluster school for consistent excellent school based on academic, co-curricular, students' appearance, school management, culture, relationship with the outsiders, human capital development, and other resources. This group of students was chosen because they are mature enough to answer the questionnaire and the level of critical thinking questions is up to their age. Data were gathered during one of the collaboration programs between the Faculty of Computer and Mathematical Sciences, UiTM Pahang, Jengka Campus, and SMKJP. This school was chosen because this is the only one cluster school in this district.

2.2 Research Design

There were 14 questions adapted from Beatrice (1995) to be answered by each student. For example, students were asked, "If I have to learn how to do something, I learn best when; I watch someone show me how" (V); "Hear someone tell me how" (A); "Try to do it myself" (K). Another example of a question is "If I had to remember a list of items, I would remember it best if; I wrote it down (V)"; Said them over and over to myself" (A); Move around and used my fingers to name each item" (K). The summary of the learning style inventory is shown in Table 1.

Table 1: Summary of the Learning Style Inventory.

Learning Style	Operational Definition
V	Read, write, and visualize. Students like to draw diagrams, illustrations, charts, and use mind mapping
A	Read, write, and explain. Like to read aloud, describe diagrams, illustrations, and charts aloud or discuss them with someone else.
K	Learn best by doing, through movement, physical activities, and a 'hands-on' approach

*Beatrice (1995)

Each student was asked to total up the number of answers in each category. The score is calculated for each category. The highest category chosen was considered as the most preferred learning style for them. For example, if a student answered V for most of the questions, it means the student was assumed to have a visual learning style. Next, the students were also required to answer a few critical thinking questions on mathematics. They were asked to sit in a group of 8 students, and questions were delivered to them one by one using a slide show. Each student had to show their answer to everybody present by showing what they had written, and students with correct answers would stay in the group, and the students with wrong answers were eliminated. The score was measured based on the number of correct answers obtained by the students. The sample questions that are given to the students are shown in Figure 1.

1) Choose the correct statement. a) 100 kg of iron is heavier than 100 kg of cotton. b) 100 kg of iron is lighter than 100 kg of cotton. c) 10 kg cotton is heavier than 1 kg iron.	2) How many bottles with capacity 250 millilitres can be filled with 400 litres of water a) 16 b) 160 c) 1600 d) 16000

Figure 1: Sample questions of critical thinking in mathematics

To answer question 1, students should know they have to choose the right answer based on the weight and types of things given (Interpretation). Then, they need to analyze the weight (Analysis). Next, they must evaluate each statement (Evaluation) and give reason (Inference). Lastly, they can explain why they choose the answer (Explanation). Similar process must be done by students to answer all the questions.

2.3 Procedure and instrument

The present study applies a descriptive analysis approach in analysing the questionnaire's responses on learning style and critical thinking score to identify the preferred learning style and the respondents' critical thinking level. A t-test was carried out to examine the influence of gender on the students' learning style and critical thinking score. Analysis of variance (ANOVA) was also conducted to test whether there is any significant difference between learning style (visual, auditory, and kinesthetic learner) and their critical thinking score. Then, multiple comparison analysis testing for detailed information of ANOVA result. Finally, the relationship between learning style and critical thinking quizzes score was tested by Spearman rank.

3. Results and Discussion

This study involved 62 students as the respondents. A set of questionnaires consists of 14 questions and critical thinking problems focused on three domains of learning styles chosen V, A and K. In this section, the results for the preferred learning style and the respondents' critical thinking level in mathematics problems were presented and discussed.

Table 2: Percentage of Students' base on their Preferred Learning Style

Learning style	Frequency	% Respondent	Frequency	% Male	Frequency	% Female
V	44	71.0	13	29.5	31	70.5
A	14	22.6	4	28.6	10	71.4
K	4	6.5	2	50	2	50
Total	62		100%			

Table 2 shows the percentage of students' choices based on their preferred learning styles. The most preferred learning style for students in this study is visual, which is 44 (71%). As for auditory and kinesthetic, only 14 (22.6%) and 4 (6.5%) of the respondents fall into these categories, respectively. Although findings showed that visual was the most preferred learning style, it does not necessarily mean that only this group of students should be the central focus. Students with strong learning style preferences find various teaching approaches to help them avoid boredom (Hill et al., 2016). This finding can be used to develop teaching styles and to convey teaching materials that fit our students. The results show that the visual learning style is more dominant than the other two, but some students obtain the same score for the two categories. For example, they get the same score in visual and auditory or auditory and kinesthetic. It is suggested that some individuals possess more than one preferred style of learning (Myers and Dyer, 2006).

Table 3: Descriptive Statistics of Variables.

Variables	N	Minimum	Maximum	Sum	Mean	Standard Deviation	Skewness
V	62	1	13	448	7.23	2.391	-.395
A	62	0	8	242	3.90	1.879	.236
K	62	0	7	174	2.81	1.687	.273
Critical Thinking	62	4	18	572	9.23	4.325	.313

Table 3 indicated a descriptive analysis for each variable answered by 62 students. The most preferred students' learning styles in this study is V with the range score is 1 to 13, followed by A with the range score is 0 to 8 and K with the range score is 0 to 7. Based on the result of the minimum score for each learning style, there at least 1 question that answered by all respondents as V while for A and K, there are student that did not answer for both learning styles at all. The highest of the maximum score for V is 13 with the highest total score is 448. This result is clearly showed that the average highest mean score value for visual learning style 7.23, with an approximately small standard deviation of 2.391 for data consistency. The critical thinking score in mathematics problems obtained by the students are in the ranges from 4 to 18, with mean score of 9.23. All the variables are approximately normal, with the skewness value less than ± 1.

Table 4: Influence of Gender in the Learning Style and Critical Thinking.

Variable	Gender	N	Mean	Std. Deviation	Mean difference	T-test statistics	p-value
V	f	31	8.61	1.498	0.613	1.286	0.205
	m	13	8.00	1.291			
A	f	10	6.70	0.949	0.950	1.870	0.086
	m	4	5.75	0.500			
K	f	2	6.5	0.707	0.500	1.000	0.423
	m	2	6.00	0.000			
Critical Thinking	f	43	8.84	4.64	1.268	1.195	0.238
	m	19	10.11	3.45			

*f: female, m: male, significant at the 0.05 level.

Table 4 shows no significant difference between male and female learning styles since $\text{p-value} > 0.05$, consistent with Yenice (2012). However, this result is contradicted to Ghazivakili et al. (2014) that found a significant relationship between learning style and gender. The difference in sample size and the different ratio between males and females may contribute to the diverse result. Furthermore, the result also shows no significant difference between gender in the level of critical thinking in mathematics ($\text{p-value} > 0.05$). This finding is consistent with previous research, which found that males and females possess a similar level of critical thinking (Andreou et al., 2014; Yenice, 2012; Myers and Dyer, 2006). Therefore, these results answered and supported both H_1 and H_2 in this study.

Table 5: Result of ANOVA Test on Critical Thinking between Three Learning Styles.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	120.397	2	60.199	3.481	.037*
Within Groups	1020.442	59	17.296		
Total	1140.839	61			

* Significant at the 0.05 level.

As exhibited in Table 5, there is a significant difference in critical thinking between students' preferred learning styles, which is 0.037 ($\text{p-value} < 0.05$). Different learning styles possess a different level of critical thinking which is in line with Puwarto et al. (2020). Since each student's ability to receive and process information differs, students receive information in various ways based

on their preferred learning style. The ability to think critically in mathematics is influenced by how each student receives different knowledge. Further study should be carried out to determine which group of learning styles are the most critical thinkers. Somehow, Birgili (2015) proposed problem-based learning to enhance critical thinking on top of the learning style.

Table 6: Multiple Comparison Analysis Testing of each Type of Student's Learning Style.

Learning Style (I)	Learning Style (J)	Mean Difference (I-J)	Std. Error	Sig.
V	A	.370	1.276	.773
V	K	5.727*	2.172	.011*
A	K	5.357*	2.358	.027*

*Significant at the 0.05 level.

Further analysis was done using multiple comparison analysis testing, and the detailed ANOVA results were shown in Table 6. This analysis is used to identify the significant difference between students' critical thinking test scores of any two learning styles. The results from Table 6 answered the null hypotheses H_3, H_4, and H_5. There is no significant difference between visual and auditory learners in the critical thinking test score with $\text{p-value} = 0.773$ ($\text{p-value} > 0.05$), which does not support the null hypothesis H_3. Meanwhile, there is a significant difference between visual and kinesthetic learners ($\text{p-value} = 0.011$) and auditory and kinesthetic learners ($\text{p-value} = 0.027$) in the critical thinking test score. Thus, these results supported H_4 and H_5 stated in this study.

Table 7: Relationship between Students' Learning Style and their Critical Thinking Test Score.

		A	K	V
Critical Thinking	Pearson Correlation	-.050	.197	-.111
	Sig. (2-tailed)	.701	.125	.389
	N	62	62	62

Based on Table 7, there is no relationship between learning style and critical thinking with the significant p-value > 0.05 and supported H_6 in this study. This result aligns with Myers and Dyer (2006), who found no significant difference in students' critical thinking skills in their general learning style. They also argued that there are no differences in critical thinking ability between students of other learning styles. Besides that, this result is also supported by Aljaberi and Gheith (2019). They demonstrated that the inference abilities in mathematics and sciences among pre-service teachers are not significantly related to their learning style. Nevertheless, this finding is contradicted by Yenice (2012), who found a positive relationship between learning style and critical thinking, as well as Ghazivakili et al. (2014), who showed that critical thinking, learning style, and academic achievement are significantly related. The summary of the hypothesis testing result in this study is shown in Table 8.

Table 8: Result of Hypothesis Testing

Hypothesis Statement	Result of Hypothesis
H_1: There is no significant difference between the male and female learning styles	Supported
H_2: There is no significant difference between the male and female levels of critical thinking	Supported
H_3: There is no significant difference between visual and auditory learners in the critical thinking test score	Supported
H_4: There is no significant difference between visual and kinesthetic learners in the critical thinking test score.	Not supported
H_5: There is no significant difference between auditory and kinesthetic learners in the critical thinking test score.	Not Supported
H_6: There is no relationship between learning style and critical thinking.	Supported

4. Limitation

Small sample size and instruments used in evaluating critical thinking were not gone through pilot study might not be up to the standard may contribute to the diverse result. Increasing the sample size and inclusion of students from other cluster schools might improve our result's validity. The age group and the maturity of students may also have affected the result obtained. This study also has limitations since the respondents were not demographically representative. This study only considers visual, auditory, and kinesthetic learning styles. Researchers could further improve this study by considering other characteristics, such as reading, active, intuitive, and other learning styles.

5. Conclusion

In conclusion, this study showed that the most popular learning style among the sample studied is visually followed by auditory and kinesthetic. Apart from that, the learning styles between male and female students have no difference. Hands-on activities are also very much encouraged to make all senses engaged in the learning process. It is crucial to rotate the teaching styles to give the students opportunities to participate in meaningful activities. On the other hand, students should learn to suit their styles and develop various kinds of learning styles. Further research on learning styles in different disciplines and different social and cultural backgrounds is fully recommended to understand learning and help educators implement the best method in a class.

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