Student’s misconception and thinking style on modern physics course

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**Abstract.** This study aims to determine the relationship between misconceptions and thinking styles of students in modern physics course and to determine which type of thinking style is more dominant in relation to misconceptions. This type of research is a survey study with a quantitative approach. The samples in this study were 60 students who have followed the modern physics course. Data collection used a two-tier diagnostic test on modern physics and a thinking style questionnaire. The results of the analysis with the correlation test found that the types of thinking style Concrete Sequential (CS), Abstract Sequential (AS), and Random Abstract (RA) are negatively correlated with misconceptions or it can be said that there is almost no correlation with misconceptions, namely (-0.024), (-0.113) and (-0.082). Meanwhile, the type of concrete random thinking style (CT) has a positive correlation with misconceptions, but the relationship is weak (0.303). Based on these results, it can be said that the types of thinking styles of students tend to have no correlation with misconceptions. Even though the correlation between the two is low, it is necessary to pay attention to the thinking style of students in conveying concepts in modern physics.

1. **Introduction**

Misconceptions research in the field of science, especially physics, has been carried out since the 1950s, known as partial knowledge measurement [1, 2, 3]. Misconception research covers four main topics, namely the development of diagnostic tests [4, 5, 6, 7, 8], identification of misconceptions [9,10,11,12], identification of the causes of misconceptions [13,14,15,16,17], and misconceptions remediation [18,19,20,21]. In addition, misconception research is also extended to latent variables in students, which are thought to contribute to the formation of misconceptions in students. Among them are related to the formation of mathematical abstraction [22], student cognitive style [23], scientific argumentation skills [24], teacher perceptions [25], knowledge structure [26], and individual student profiles [27] Thinking style is one of the latent variables that have been studied recently, especially related to intelligence and personality [28], self-confidence and socio-economics [29], academic achievement [30], convergent thinking and personality [31], commitment and creativity [32], understanding of concepts [33], student talent [34], reasoning style [35], emotional students [36] and attitudes and perceptions [37] Based on
several studies that have been reported, there are indications that thinking styles, learning styles and conceptual understanding have an indirect relationship [38]. Several references have been reported that thinking styles have a high relationship with learning styles [39], whereas learning styles affect learning outcomes [40], and conceptual understanding has an impact on learning outcomes [41]. Thus, it can be said that misconceptions are related to thinking styles indirectly. It is still questionable how high the relationship between these two variables is and this is the main reason why the title of this article is raised as an interesting topic to research. Besides looking at the relationship between these two variables, the analysis also wants to know the relationship between misconceptions with each type of thinking style. The reason for choosing the topic of modern physics as an objective course of misconceptions is that these subjects are very rarely studied and there is a very wide range of misconceptions, especially the concept of dualism wave particles, photoelectric effect, and Compton [42, 43, 44].

2. Research method

2.1. Research design
The type of research used in this research is survey research and a quantitative approach with the aim of identifying the relationship between misconceptions and thinking styles of physics students in modern physics courses.

2.2. Population and sample
The target population in this study were all students majoring in physics education FKIP Universitas Syiah Kuala who had taken modern physics courses. Meanwhile, 60 students took the modern physics course even semester 2017/2018. Because all populations are all sampled, there is no sample selection.

2.3. Data collection
There are two types of data to be obtained through this study, namely data on misconceptions and data on thinking styles, both of which are in the form of quantitative data. The instruments used to obtain both types of data are shown in Table 1. Misconception data were obtained using a two-tier diagnostic test instrument. The test was developed with reference to relevant previous studies [4, 5]. The indicators used for the development of the test items refer to the University Modern Physics syllabus, specifically used in the study program. Thinking style data were obtained using instruments and thinking style tests to students majoring in physics taking modern physics courses. The instruments that will be used for data collection in this study are as in Table 1.

| No | Name of Instr. | Function | Shape | Form of Data |
|----|---------------|----------|-------|--------------|
| 1. | Diagnostic test | To identify misconceptions | Two-tier | Quantitative |
| 2. | Test of Thinking Style | To identify thinking styles | Questionnaire | Quantitative |

2.3.1. Two Tier Multiple Choice Diagnostic Tests. One way to reveal misconceptions and learning difficulties of students in learning is through diagnostic tests. The diagnostic test developed in this study is the two-tier Modern Physics Diagnostic Test (TDFM). The indicators used for the development of TDFM items refer to the modern physics syllabus used by the physics education department at the University. The form and method of development refers to several relevant research results [4, 5, 10]. TDFM consists of two levels, the first level contains answers to the concepts tested with three distractors and one answer key that students must choose. While the second level is the level of student confidence expressed by the Certainty Response of Indexes (CRI) index consisting of numbers 0 - 5. The meaning of each index starts from the answer by guessing the total (0) to being very sure (5) [45].
2.3.2. Test of Thinking Styles. The thinking style test is a test given to students to determine the type of thinking style of each student in learning. The thinking style data in this study were obtained through the distribution of thinking style questionnaires to students. The questionnaire items were used from a questionnaire that had been developed by Gregorc, which is listed in Bobbi and Mike's book [46]. The structure of this test uses 15-word groups, where in each word group consists of 4 words that reflect each person's personality. The choice of words in the word group by students will reflect the type of thinking style of the student. According to Bobbi & Mike there are 4 types of thinking styles, namely Concrete Sequential (CS), Abstract Sequential (AS), Concrete Random (CR), and Abstract Random (AR).

2.4. Data Analysis

2.4.1. Data of Diagnostic Test. The data obtained using the two-tier Diagnostic Test in Modern Physics (TDFM) is quantitative data on a scale of 0-5. The data analysis technique uses the Annates program [47], while the decision-making analysis results refer to the decision matrix as used by previous researchers [45,48].

2.4.2. Data of thinking style test. It is analyzed based on the theory developed by Gregorc, which is listed in Bobbi & Mike's book [46]. Students' answers are added up based on the thinking style column, namely column I has a Concrete Sequential (CS) thinking style, column II has an Abstract Sequential (AS) thinking style, column III has a Concrete Random thinking style (CR), and column IV has an Abstract Random thinking style (AR). After adding up each column then multiplied by 4. The box with the largest number of numbers explains how students most often process information and grouping thinking styles is done based on the acquisition of standard thinking style test scores (in the formula below).

I. (… ..) x 4 = [… ..] Concrete Sequential (CS)
II. (… ..) x 4 = [… ..] Abstract Sequential (AS)
III. (… ..) x 4 = [… ..] Abstract Random (AR)
IV. (… ..) x 4 = [… ..] Concrete Random (CR).

Figure 1. Graphic of students’ thinking style [46].

After getting the answer from the multiplication result, the numbers are included in the graphic in Figure 1. The largest number from one of these axes will describe the type of thinking style possessed by students. The stages are as follows; (i) the value of the student's answer multiplied by 4, (ii) the largest number in the [] box represents the type of thinking style or (iii) the value in the box [] is entered in the graph of Bobbi & Mike's model [46] (iv) After the multiplication results are obtained, then it will be entered into the thinking style graph, the goal is to find out more clearly which type of thinking style is more dominant for students.

2.4.3. Correlation Analysis. After the data for misconceptions and thinking styles were obtained, a correlation test was carried out using the correlation formula in Arikunto's book [49]. The stage of the strength of the relationship between the two variables (misconceptions and thinking styles), is determined by the r-calculated value consulted with the correlation table [50]. The rxy correlation
The coefficient is called the correlation coefficient between X and Y which can be positive (+) or negative (-) and the magnitude between -1 and +1 can be written as \(-1 < r_{xy} < 1\). If the \(r_{xy}\) value obtained is positive, it means that the correlation is positive, meaning that large Y will accompany big X and vice versa, if X is small, small Y will accompany it as well. Vice versa, if the value of \(r_{xy}\) obtained is negative, it means that the correlation is negative, meaning that big X will be accompanied by a small Y and vice versa if X is small, it will be accompanied by large Y " [50].

3. Result and Discussion
The research was conducted on 60 physics students who had taken modern physics courses. The research results were obtained through a diagnostic test and a thinking style test for each student.

3.1. Data of misconception in modern physics
Misconceptions data were obtained from the answers of 60 students to 30 multiple choice two-tier diagnostic test questions. After analyzing using Annates software and the decision matrix in Hasan [45] as compiled in Table 2. Based on the table it can be seen that students who experience the highest misconceptions are students with number 51 with a misconception level of 66.67%, while Students with the lowest level of misconception were students with number 32, namely 0.00%. Based on the analysis of the misconception data that has been obtained from the test results, it can be seen that students experience more misconceptions in answering modern physics questions compared to students who understand the concept well. Students who experience misconceptions do not mean they lack knowledge, but they may forget concepts or answer questions by guessing so that their answers may be right or wrong.

| Students | Misc. (%) | Students | Misc. (%) | Students | Misc. (%) | Students | Misc. (%) |
|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| 1        | 50.00     | 16       | 26.67     | 31       | 36.67     | 46       | 63.33     |
| 2        | 53.33     | 17       | 46.67     | 32       | 0.00      | 47       | 43.33     |
| 3        | 56.67     | 18       | 20.00     | 33       | 13.33     | 48       | 50.00     |
| 4        | 40.00     | 19       | 26.67     | 34       | 46.67     | 49       | 43.33     |
| 5        | 50.00     | 20       | 53.33     | 35       | 53.33     | 50       | 46.67     |
| 6        | 53.33     | 21       | 26.67     | 36       | 40.00     | 51       | 66.67     |
| 7        | 40.00     | 22       | 53.33     | 37       | 26.67     | 52       | 23.33     |
| 8        | 56.67     | 23       | 10.00     | 38       | 56.67     | 53       | 16.67     |
| 9        | 33.33     | 24       | 53.33     | 39       | 23.33     | 54       | 50.00     |
| 10       | 53.33    | 25       | 43.33     | 40       | 50.00     | 55       | 33.33     |
| 11       | 46.67     | 26       | 33.33     | 41       | 40.00     | 56       | 36.67     |
| 12       | 53.33     | 27       | 36.67     | 42       | 53.33     | 57       | 53.33     |
| 13       | 53.33     | 28       | 53.33     | 43       | 46.67     | 58       | 56.67     |
| 14       | 53.33     | 29       | 36.67     | 44       | 60.00     | 59       | 26.67     |
| 15       | 36.67     | 30       | 53.33     | 45       | 60.00     | 60       | 56.67     |

Table 3. Types of students’ thinking styles.

| Type of Thinking Style | Sum of Responses | Percentage |
|------------------------|------------------|------------|
| Concrete Sequential (CS)| 26               | 43.3       |
| Abstract Sequential (AS)| 7               | 11.7       |
| Abstract Random (AR)    | 21               | 35.0       |
| Concrete Random (CR)    | 6                | 10.0       |
3.2. Data of thinking style
The thinking style test is given for data on the types of thinking styles that exist in students. Based on data analysis and Bobbi & Mike's thinking style model [46], there are four types of thinking styles, including CS, AS, AR and CR. The results of the data analysis of thinking style are shown in Table 3. Based on the data it can be seen that students are more dominant in using the CS thinking style and AR thinking style than the CS and AS thinking types. Overall, the number and percentage of thinking styles are shown in Table 3. Based on the table, it can be seen from (60) students, there are (26) students or (43.3%) who are concrete sequential thinkers, which means that the student is holding on to reality. Then there are (21) of (60) students or (35%) who are abstract random thinkers who are more concerned with the world of feelings and emotions. Furthermore, it means that students of abstract sequential thinkers (7) of (60) students or (11.7%) of these thinkers are thinkers who like concepts and analyze information. While the concrete random thinking style is only (6) the students are from (60) students or (10%), meaning that they have experimental attitudes and only a few of them behave less structured.

Based on the results it can be seen that the majority of students have more dominant concrete sequential and abstract random thinking styles. Concrete sequential thinkers are thinkers who hold on to reality and process information in an orderly, linear, and sequential manner [46]. While the type of abstract random thinking style is a thinker in the world of feelings and emotions and the process of absorption of information is regulated by reflection (full consideration), abstract random thinkers remember information well if the information obtained is personified information, for abstract random thinkers feelings and emotions can increase and influence their learning [46]. The findings, as shown in 3, were also obtained by other studies where the CS and AR thinking styles were more dominant [33,34,35,51].

3.3. Data of correlation analysis
After obtaining the misconception data and thinking style data, it can be seen that most students experience misconceptions caused by the thinking style used. Misconceptions data based on the thinking styles used by students can be seen in Table 4.

| Types of Thinking Styles     | Sum | Sum of Mis. |
|------------------------------|-----|-------------|
| Concrete Sequential (CS)     | 26  | 21          |
| Abstract Sequential (AS)     | 7   | 6           |
| Abstract Random (AR)         | 21  | 10          |
| Concrete Random (CR)         | 6   | 3           |

Figure 2. Linearity between students' misconceptions and thinking styles.
Based on these data, it can be seen that the biggest misconception is in the type of concrete sequential thinking style (CS), which means that the thinker is more holding on to reality. Then there is the second biggest misconception in the Abstract Random (AR) type of thinking style, in other words, students of this type of thinking style or students who hold more to feelings and emotions tend to be more likely to have misconceptions in understanding the concepts of modern physics. If the data in Table 4 is sorted from the types of thinking styles CS, AS, AR and CR or from the number of students who have the lowest to the highest thinking styles, then we will get an interesting linearity relationship as shown in Figure 2. The graph in the figure has high linearity between misconceptions and types of thinking styles. It should be noted that the order of the types of thinking styles from CS-AS-AR-CR in Figure 2 is NOT a sequence of low and high types of thinking styles, BUT it is only based on the number of students who have a thinking style from a small number (CS) to a large number (CR). Therefore, based on the linearity line in Figure 2, it can only be said that the increase in the number of students who have a certain thinking style will be in accordance with the increase in the number of students who have misconceptions in understanding the concepts of modern physics. However, when viewed in terms of the relationship between misconceptions with the type of thinking style on average, it has a low correlation coefficient value, as shown in Table 5.

### Table 5. Correlation of student misconceptions and thinking styles.

| Types of Thinking Styles    | Correlation of Misconceptions with Thinking Styles | Conclusion         |
|-----------------------------|--------------------------------------------------|--------------------|
| Concrete Sequential (CS)    | -0.024                                           | Very Weak Correlation |
| Abstract Sequential (AS)    | -0.113                                           | Very weak correlation |
| Abstract Random (AR)        | -0.0821                                          | Very Weak Correlation |
| Concrete Random (CR)        | 0.303                                            | Weak Correlation    |

Based on the results of this correlation, it can be said that the thinking style of students tends to have no correlation with misconceptions, or the correlation is insignificant or very small. In addition, thinking styles also have no relationship with the level of misconceptions, meaning that at high misconceptions there are also various types of thinking styles as well as low misconceptions because each type of thinking style is evenly distributed at each level of misconception. The results of this study are almost the same as the results of research conducted by Suriana [51] regarding the correlation between thinking styles and conceptual understanding. The results of the research from Suriana showed that there is no correlation between thinking styles and conceptual understanding, or the relationship is very weak. Thinking style is a student's habit of thinking, both in learning and non-learning. These habits can affect but on a very small scale, because the thinking style grows from students themselves and not environmental factors, this is in accordance with Arend's statement [52] which states that "Thinking styles are behaviors that result from the brain's dominance in thinking and processing information.". Meanwhile, misconceptions occur because they are caused by five factors, namely students, teachers, textbooks, context, and teaching methods [53]. Based on the opinion of the causes of this phenomenon, it can be said that because of the differences in the domain, it can be said that misconceptions and thinking styles have no relationship.

4. Conclusion

Based on the results of the analysis of research data and studies on several relevant previous results, it shows that between misconceptions, thinking styles are very weak, and even there is no correlation between the two. One of the reasons is that the thinking style is formed from within students and is not influenced by the environment, but many causes of misconception come from outside the student. To ensure the truth of the findings in research, it is necessary to carry out further research related to thinking styles and learning outcomes in modern physics learning.
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