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## Students' Metacognitive Strategies in Facing Learning Difficulties in Serenity & Kurtosis Materials

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### **Abstract**

*This study aims to examine the metacognitive strategies used by students in overcoming learning difficulties in statistical materials, especially the concepts of skewness and kurtosis. This material is often considered complex because it requires an understanding of abstract mathematical concepts and the ability to interpret statistical data. The research uses a qualitative approach with a case study method on students of the mathematics education study program. Data collection techniques were carried out through in-depth interviews, participatory observations, and document analysis. The results of the study showed that students used various metacognitive strategies such as learning planning, comprehension monitoring, and self-evaluation and reflection after the learning process. This strategy has been proven to help students identify misconceptions, strengthen their understanding of concepts, and improve their problem-solving skills in solving statistical problems. These findings provide important implications for the development of learning models that support students' metacognitive awareness in understanding complex statistical material.*

*Keywords: Metacognitive Strategies, Learning Difficulties, Squinting, Kurtosis, Statistics*

### **1. Introduction**

Mastery of statistical concepts is an important element in higher education, especially for students involved in the fields of social sciences, education, economics, and science (Asnur et al., 2024; Zulkifli et al., 2022). An in-depth understanding of statistical concepts allows students to read, analyze, and interpret data critically, which is the basis for evidence-based decision-making (Wang & Zhan, 2020). Among various statistical concepts, skewness and kurtosis play an important role in describing the distribution of data more comprehensively, especially in descriptive analysis and statistical assumption tests (Field, 2018). Unfortunately, these two concepts are often poorly understood due to their abstract nature and rely on visual and numerical interpretations of the data, leading to errors in statistical conclusions (Barakat et al., 2024).

The material skewness and kurtosis are not only conceptually important, but also fundamental in assessing the normality of data distribution, which is a requirement in various parametric statistical tests (Niemi & Niu, 2021). When students do not have a strong understanding of these two concepts, they tend to interpret the data incorrectly, which can have an impact on the validity of the research results (Oktarina et al., 2018); (Hariyadi et al., 2023; Ali et al., 2024; Dewanto et al., 2023; Wantu et al., 2024). Therefore, these statistical skills need to be taught contextually and oriented towards understanding, not just memorizing formulas. In this context, learning approaches that encourage awareness and self-control in thinking, such as metacognitive strategies, are very relevant to help students overcome learning difficulties in this material (Pintrich, 2002; Schraw & Dennison, 1994)

Skewness and kurtosis material in statistics is often a source of learning difficulties for students because it demands a high conceptual understanding and in-depth data analysis skills. Both concepts are abstract because they involve not only numerical calculations, but also interpretations of the form of data distribution (Matos et al., 2022). For example, understanding the skewness of the distribution is not only enough to know the value of skewness, but it must also be accompanied by the ability to interpret the shape of the curve and its direction of the skewness (Luciana, 2022; Suryono et al., 2023; Zulyusri et al., 2023). Similarly, kurtosis requires an understanding of the degree of collapse of a distribution compared to a normal distribution. This complexity causes students to often experience confusion and misinterpretation of the statistical meaning of these values (Garfield & Ben-Zvi, 2008).

This difficulty is compounded by the fact that many students study statistics procedurally—focusing on mechanical formulas and calculations—without understanding the conceptual meaning behind the numbers. This causes them to fail to relate statistical theory to the context of real data. In addition, this material is often delivered technically and has minimal visual or contextual approaches, making it difficult to understand by students who do not have a strong mathematical background. Research shows that abstract statistical concepts based on data interpretation require a learning approach that emphasizes not only content, but also cognitive and metacognitive strategies that allow students to monitor, reflect, and organize their own learning process (Lovett, 2001; Chance, 2002).

Metacognitive strategies play an important role in helping students cope with learning difficulties, especially in abstract and complex material such as skewness and kurtosis in statistics (Palma-Luengo et al., 2025). Metacognition includes awareness of one's own thought processes as well as the ability to organize, monitor, and evaluate learning independently (Schraw & Moshman, 1995). When students apply metacognitive strategies such as planning before studying, monitoring during the learning process, and reflection after studying, they can identify difficult parts of the material, choose the right completion strategy, and evaluate the success of the approach used. This allows students to be more active and responsible for their learning, as well as being able to form connections between theoretical concepts and their application in statistical data analysis (Gujarati & Porter, 2010).

In addition to helping overcome learning difficulties, metacognitive strategies have also been shown to significantly improve students' conceptual understanding. By using strategies such as self-questioning, summarizing, and concept mapping, students can reconstruct their knowledge in a more meaningful and in-depth way (Njeri, 2024). Research shows that students who have high metacognitive awareness tend to have higher thinking skills, are able to understand the relationships between concepts, and are more flexible in solving problems (Zohar & Dori, 2012). In the context of statistical learning, the use of metacognitive strategies allows students not only to memorize formulas, but also to understand the meaning of data distribution and the significance of skewness and kurtosis values, thereby improving the accuracy of data interpretation and the quality of their statistical analysis (He et al., 2024).

Although many studies have proven the effectiveness of metacognitive strategies in improving general learning outcomes, studies that specifically explore the relationship between learning difficulties in statistical materials and the use of metacognitive strategies are still limited (Nurtamam et al., 2023; Elfira & Santosa, 2023; Rahman et al., 2023; Santosa et al., 2024). Statistics, as a branch of science that requires quantitative skills and high-level logical reasoning, often poses conceptual and procedural learning barriers. Students generally have difficulty in understanding the distribution of data, the interpretation of statistical parameters such as skewness and kurtosis, and the relationship between concepts and their application (Suyatmo et al., 2023; Utomo et al., 2023; Yusuf Santosa et al., 2023). However, most studies still focus on quantitative learning outcomes without exploring how cognitive and metacognitive processes work in helping students overcome these difficulties (Gal & Ginsburg, 1994; Garfield, 2002).

In fact, understanding students' thinking processes when facing statistical challenges is very important to design the right learning strategy. Studies that link specific difficulties in statistics and metacognitive strategies can provide new insights for the development of more effective and personalized pedagogical approaches in statistical learning. Without an in-depth exploration of this metacognitive dimension, lecturers and curriculum developers may miss out on opportunities to facilitate reflective and independent learning. Therefore, there is an urgent need to conduct research that systematically explores how students use metacognitive strategies in dealing with complex statistical concepts, in order to support the achievement of higher conceptual understanding and strong analytical skills (Artzt & Armour-Thomas, 1992; Phan, 2010).

## 2. Research Methods

This study uses a descriptive qualitative approach with the aim of exploring in depth the metacognitive strategies used by students in dealing with learning difficulties in skewness and kurtosis materials. The subject of the study is a student of the mathematics education study program who has taken a basic statistics course. The sampling technique was carried out by purposive sampling, with the criteria: students who have difficulties with the material and are willing to be actively involved in the interview and observation process. Key data were collected through semi-structured in-depth interviews, observation of the learning process, and document analysis (student learning notes or reflections), which allowed the researcher to get a complete picture of the students' thinking processes and learning strategies in a naturalistic manner.

Data analysis was carried out using the Miles and Huberman interactive model which included three stages: data reduction, data presentation, and conclusion/verification. The validity of the data is strengthened through triangulation of sources and techniques, as well as member checking to ensure the validity of the researcher's interpretation of the participants' statements and actions. The entire analysis process is directed to identify patterns of metacognitive strategies such as planning, monitoring, and self-evaluation used by students in overcoming conceptual and procedural obstacles in statistical materials. The results of the analysis are expected to contribute to the development of statistical learning methods that are more responsive to students' learning difficulties and support the improvement of their metacognitive awareness.

### 3. Results and Discussions

#### Factors Influencing the Use of Metacognitive Strategies

The use of metacognitive strategies in learning is influenced by various factors, both internal and external. Internal factors include learning motivation, self-efficacy, and individual learning style. High intrinsic motivation encourages students to be active in managing their learning process, such as setting goals, monitoring progress, and evaluating learning outcomes. According to Zimmerman (2002), individuals with high learning motivation are more likely to use metacognitive strategies consistently because they have a clear goal orientation in achieving academic success (Al-Refae et al., 2021).

In addition, self-efficacy or belief in one's own abilities also plays an important role in the use of metacognitive strategies. Students who believe that they are able to understand difficult material are more motivated to use strategies such as self-monitoring and self-evaluation. Schraw and Dennison (1994) explain that strong self-efficacy is positively correlated with the frequency and effectiveness of using metacognitive strategies in completing academic tasks. Individual learning styles also influence how and how often metacognitive strategies are used. For example, learners with reflective learning styles are more likely to use evaluative strategies in examining their own understanding of a concept. Fleming and Mills (1992) developed the VARK (Visual, Aural, Read/Write, Kinesthetic) model which shows that different learning styles require different metacognitive approaches to be effective in understanding complex information, such as statistical material.

External factors such as teaching quality, availability of learning resources, and academic environment also contribute to shaping students' metacognitive behavior. Teachers who encourage self-reflection and provide regular feedback will improve students' metacognitive awareness. According to Pintrich (2002), explicit learning interventions in teaching metacognitive strategies directly can significantly improve students' learning skills (Orencia, 2018; Aprilia, 2021)

The use of educational technology is also a relevant external factor. Digital learning platforms that provide self-evaluation and progress tracking features allow students to be more active in managing their learning process. As stated by Azevedo and Cromley (2004), a computer-based learning environment that supports tracking the learning process can improve students' metacognitive awareness, especially in understanding abstract concepts such as skewness and kurtosis in statistics. Finally, social and cultural backgrounds can also influence the tendency to use metacognitive strategies (Ichsan et al., 2023). Students from academic environments that emphasize independent learning and critical thinking are usually more accustomed to applying these strategies. In a cross-cultural study, Veenman et al. (2006) showed that there were significant differences in the use of metacognitive strategies between students from collectivist and individualistic cultures, which were closely related to parenting styles and educational values in their social environment.

#### Overview of Learning Difficulties in Skewness and Kurtosis Material

Skewness and kurtosis material are part of advanced descriptive statistics that often cause learning difficulties for students, especially those who do not have a strong foundation of statistical understanding. Skewness describes the narrowness of the data distribution, while the kurtosis describes the peak of the distribution. This concept is abstract because it is not enough to be understood mathematically, but also requires visual and contextual interpretation of the form of data distribution (Garfield & Ben-Zvi, 2007).

One of the main causes of difficulty in understanding this material is the lack of connection between mathematical formulas and real-world applications. Students often understand skewness only as a number without really understanding the meaning of the form of distribution in question (Wang & Zhan, 2020). This is in line with the findings of Batanero et al. (2010) who stated that the difficulty in learning statistics is caused by the weak ability

of students to interpret graphical and numerical representations simultaneously, especially on the topic of distribution. Another common mistake that occurs is in identifying the type of skewness (positive, negative, or symmetrical) and interpreting the value of the kurtosis. Many students assume that a high kurtosis value always means "more dispersed distribution", when in fact kurtosis refers to the tailedness or "tapering" of the distribution tail. This misunderstanding of the concept shows that there is a fundamental misconception rooted in statistical learning that is too focused on calculations and lacks visualization (Lovett, 2001). In addition, technical language in statistics materials is also an obstacle in the learning process. Terms such as leptokurtic, platykurtic, and mesokurtic tend to be unfamiliar to students, especially if they are not accompanied by concrete visual examples. Gal et al. (2005) emphasized that the low statistical literacy of students is also caused by a lack of understanding of statistical terms and a weak ability to read data in a real context (Matos et al., 2022).

Difficulties in understanding skewness and kurtosis are also exacerbated by the math anxiety that is common in non-statistician students (Wang & Zhan, 2020). This anxiety can inhibit the critical and reflective thinking process that is actually indispensable in understanding data distribution. According to Onwuegbuzie and Wilson (2003), anxiety about statistics greatly affects the way students absorb concepts, especially if they are not familiar with data-based problem-solving approaches. Finally, limitations in active learning strategies used in teaching statistics also contribute to low student understanding. Conventional approaches such as lectures and formula-based practice questions are considered less effective for materials that require interpretation and visualization such as skewness and kurtosis. In accordance with Garfield's (1995) suggestion, learning statistics should involve hands-on experience with data, the use of statistical software, and context-based discussions so that students can internalize concepts more deeply.

### **Patterns of Relationship between Difficulty Level and Metacognitive Strategies**

The relationship between the level of material difficulty and the use of metacognitive strategies suggests a complex but consistent pattern in a variety of learning contexts. Research shows that the higher the level of difficulty of a material, the greater the tendency of students to actively use metacognitive strategies, especially in the form of planning and self-evaluation (Zimmerman, 2002). In the context of statistical learning such as skewness and kurtosis, students who face high difficulties tend to be more aware of the need for structured learning strategies to help understand abstract concepts. Nevertheless, metacognitive skills do not necessarily arise as an automatic response to difficulties. Some studies show that only students with high metacognitive awareness are able to identify difficulties as signals to change their approach to learning. As revealed by Veenman, Van Hout-Wolters, and Afflerbach (2006), the effectiveness of metacognitive strategies is greatly influenced by the individual's ability to recognize learning difficulties reflexively and respond to them with appropriate strategies (Primi et al., 2021).

Students with moderate to high learning difficulties generally show improvements in the use of monitoring strategies, such as rereading material, asking questions to themselves, or double-checking answers (Palma-Luengo et al., 2025). This activity serves as a control over the learning process and is an indicator that they are trying to understand the material in depth (Schraw & Moshman, 1995). In the context of complex statistical material, monitoring strategies can help students avoid misconceptions or logical errors in interpreting data. On the other hand, students who feel that the level of difficulty is too high and is not accompanied by adequate support or guidance may actually experience learning despair, which inhibits the use of metacognitive strategies. This is in accordance with the theory of cognitive load (Sweller, 1988) which states that excessive cognitive load can interfere with the process of self-regulation, including the use of metacognitive learning strategies. In situations like these, basic cognitive strategies such as memorizing formulas are more often used than higher metacognitive strategies (Bachtiar et al., 2023; Uluk et al., 2024).

Interestingly, students with low difficulty levels sometimes do not feel the need to use metacognitive strategies explicitly. They tend to rely on procedural knowledge that has been mastered, so that the learning process becomes more automated and does not involve in-depth evaluation or planning (Wang & Zhan, 2020). This means that the use of metacognitive strategies tends to increase when students feel challenged or are in the optimal difficulty zone (Flavell, 1979; Pintrich, 2002). Thus, it can be concluded that there is a positive relationship pattern between the level of difficulty and the use of metacognitive strategies, but the relationship is mediated by other factors such as self-awareness, self-efficacy, and learning environment support. This pattern emphasizes the importance of educational interventions that focus not only on the material, but also on the development of students' awareness and metacognitive skills in order to be able to respond to learning challenges more adaptively and reflexively (Niemi & Niu, 2021).

#### 4. Conclusion

From the results of this study, it can be concluded that students use various metacognitive strategies such as learning planning, monitoring understanding, and self-evaluation and reflection after the learning process. This strategy has been proven to help students identify misconceptions, strengthen their understanding of concepts, and improve their problem-solving skills in solving statistical problems. These findings provide important implications for the development of learning models that support students' metacognitive awareness in understanding complex statistical material. Furthermore, this study found a pattern of relationship between the level of difficulty felt by students and the intensity of using metacognitive strategies. Students who experience high difficulties tend to be more active in applying reflective strategies than those who find the material relatively easy. However, the success of using this strategy is greatly influenced by other factors such as learning motivation, self-efficacy, learning style, and academic environment support. Therefore, it is important for lecturers to design statistical learning that not only presents the material conceptually and contextually, but also encourages students' metacognitive awareness in facing learning challenges.

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