

Integrating Decision Tree, Artificial Neural Network, and ANOVA to Identify Key Factors of Mathematics Self-Regulated Learning among Malaysian Chinese Independent Secondary School Students

Research Overview

This study explored key factors and gender differences in mathematics self-regulated learning among Malaysian Chinese independent secondary school students using decision trees, neural networks, and ANOVA. The results identify self-efficacy as the core factor, while revealing distinct strategic pathways between male and female students.

Purpose

This study aims to investigate the key influencing factors of self-regulated learning in mathematics among students in Malaysian Chinese independent high schools, and to analyze gender differences. Furthermore, the study integrates data mining techniques with traditional statistical analysis to construct a robust analytical framework characterized by both predictive power and explanatory capability.

Methods

This study adopts a quantitative research design and employs methodological triangulation by integrating decision tree analysis, artificial neural networks, and one-way analysis of variance (ANOVA) to examine the key factors of self-regulated learning (SRL) in mathematics among junior high school students in Malaysian Chinese Independent High Schools.

The participants consisted of approximately 4,300 students from 10 Chinese Independent High Schools. The research instrument was a Mathematics Self-Regulated Learning Scale, encompassing motivation, cognition, and metacognition.

Data were analyzed using methodological triangulation: decision tree analysis was used to identify key factors, artificial neural networks were applied to construct predictive models, and one-way ANOVA, along with effect size (η^2), was conducted to examine the magnitude of influence, enhancing the explanatory power and reliability of the results.

Results and Discussion

This study employs methodological triangulation through decision tree analysis, artificial neural networks, and one-way analysis of variance (ANOVA) to investigate the key factors influencing self-regulated learning (SRL) in mathematics among students in Malaysian Chinese Independent High Schools. The results indicate that although the three methods differ in analytical logic, their findings are highly consistent, all identifying overall learning motivation (Aa), cognitive strategies (Bb), and metacognitive strategies (Cc) as the core dimensions influencing students' mathematics self-regulated learning performance, demonstrating strong stability and explanatory power.

Based on SRL theory, the variables were categorized into three dimensions: motivation, cognition, and metacognition. Specifically, A5 represents self-efficacy; B1 and B3 represent rehearsal and critical thinking strategies; and C2 represents regulation in mathematics learning. Decision tree analysis shows that self-efficacy (A5) is the most critical splitting node, revealing a hierarchical pathway of “motivational beliefs → strategy use → learning performance.” Artificial neural network analysis further indicates that motivation (A2, A5), cognitive strategies (B1, B3), and self-regulation (C2) have significant effects on learning performance, corroborating the decision tree results. In statistical testing, one-way ANOVA shows significant differences among high-, medium-, and low-performance groups across all dimensions ($p < .001$), with an effect size of $\eta^2 = .124$, indicating a medium to large effect and demonstrating substantial differences in students' self-regulated learning performance.

In terms of gender analysis, the effect size for males ($\eta^2 = .105$) is moderate, while for females ($\eta^2 = .151$) it is large, indicating that SRL dimensions have stable effects on learning performance across genders. The SRL framework demonstrates stronger predictive power and greater explanatory strength for female students' mathematics performance. Further comparison reveals that both male and female students share consistency in the core predictive factor (self-efficacy), but differ in their strategic pathways. Male students tend to rely more on behavior-oriented strategies such as rehearsal and resource management, whereas female students are more inclined to employ higher-order cognitive and metacognitive strategies. These findings suggest that SRL is not a single process, and that gender differences exist in the use and regulation of learning strategies.

Overall, the findings align with the SRL theoretical framework of motivation, cognition, and metacognition, and the use of triangulation enhances the credibility of the conclusions. The results indicate that self-efficacy and metacognition are key factors in distinguishing students'

self-regulated learning performance, with gender differences observed in strategy use. These findings provide a reference for constructing empirical educational models using data mining approaches and suggest that differentiated instructional strategies should be adopted to enhance students' mathematics self-regulated learning. However, this study is based on cross-sectional data and self-report measures; future research may incorporate longitudinal data or classroom observations to further examine the stability of different strategic pathways.

Keywords : Self-Regulated Learning, Educational Data Mining, Mathematics Learning, Gender Differences