CEAR
Centre for Education Action Research

التعليمية الفطيم Al-Futtaim Education Foundation

METACOGNITIVE SELF-AWARENESS AND TASK QUANTITY: EFFECTS ON STUDENT LEARNING QUALITY IN PHYSICS EDUCATION

ADRIAN WADDICOR

Deira International School
awaddicor@disdubai.ae

مدرسة ديرة الدولية
DEIRA INTERNATIONAL SCHOOL
FESTIVAL CITY
Al-Futtaim Education Foundation

Introduction

This action research investigates the relationship between students' metacognitive self-awareness and learning quality when presented with varying quantities of physics tasks. Despite Deira International School's recognition for outstanding science progress, Year 10 students demonstrated limited ability to study independently and apply physics concepts in unfamiliar contexts. This deficit in metacognitive awareness threatens both immediate academic performance and long-term success in STEM fields.

Drawing upon Self-Determination Theory (Ryan, 2000) and Universal Design for Learning principles (Rose, 2002), this study examines how varying task choices influences learning outcomes for students with different levels of metacognitive awareness.

Literature Review

Self-Determination Theory posits that optimal learning occurs when three psychological needs are met: competence, autonomy, and relatedness. Reeve (Reeve, 2012) demonstrated that when students perceive greater autonomy, they exhibit higher engagement and achievement—particularly relevant for physics education, where conceptual understanding requires sustained engagement with complex material.

Universal Design for Learning provides a framework for designing flexible learning environments that accommodate individual differences (Rose, 2002). While Schwartz et al. (Schwartz, 2002) found that excessive choices can create cognitive overload, Patall et al. (Patall, 2010) demonstrated that appropriate choice levels can enhance motivation and task persistence.

The intersection of metacognitive awareness and task design remains underexplored in physics education research. González and Paoloni (González, 2015) found that students' perceptions of autonomy predicted both metacognitive strategy use and academic performance but didn't directly examine how varying task numbers might influence these relationships.

Methods

This mixed-methods study examined two research questions:

1. How does students' metacognitive self-awareness correlate with learning quality when presented with different quantities of physics tasks?
2. To what extent does varying available task quantities affect students' engagement with metacognitive strategies?

Prior to implementation, students completed the Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (Schunk, 2011). Students then completed three tasks during a Year 10 Radioactivity unit:

- Binary Choice Task: Students selected either creating an infographic or developing an interactive quiz about ionizing radiation properties.
- No Choice Task: All students created a timeline of atomic model development.
- Multiple Choice Task: Students selected from seven different options for demonstrating understanding of radiation applications.

Data collection included MAI scores, content analysis using an 18-point standardized rubric, and structured observations of metacognitive behaviours. Due to attrition challenges, the final sample included five students representing varying levels of metacognitive awareness and academic performance.

Results

The findings revealed complex relationships between metacognitive awareness, task performance, and learning behaviors:

Student Profiles:

- Student A (MAI: 21/52): Binary choice task (8/18), Multiple choice (6/18). Demonstrated limited metacognitive behaviors but frequently sought external validation.
- Student B (MAI: 52/52): No choice task (6/18), Multiple choice (8/18). Despite highest metacognitive score, performance was moderate. Displayed numerous metacognitive behaviors.
- Student C (MAI: 5/52): Consistent performance (6/18) across all conditions. Showed no metacognitive behaviors.
- Student D (MAI: 34/52): Binary choice (9/18), No choice (6/18), Multiple choice (12/18). Demonstrated moderate-high metacognitive behaviors with widest performance variation.
- Student E (MAI: 31/52): No choice (15/18), Multiple choice (10/18). Approach appeared performance-oriented rather than learning-focused.

Key Patterns:

1. Students with moderate-high metacognitive awareness showed greater performance variation across task conditions.
2. Three of five students performed better on multiple-choice tasks compared to no-choice tasks.
3. The highest MAI score didn't correlate with highest performance.
4. Students with higher MAI scores generally demonstrated more observable metacognitive behaviors.
5. Task selection strategies, use of success criteria, feedback orientation, and task perception varied significantly among students.

Discussion and Reflections

The results challenge simplistic assumptions about differentiation through choice. While Self-Determination Theory suggests increased autonomy enhances motivation, the relationship depends heavily on students' existing metacognitive capabilities and task perception.

Students with moderate-high metacognitive awareness demonstrated greater responsiveness to task choice variation, while the student with lowest awareness performed identically across conditions. This aligns with cognitive load theory (Paas, 2010), suggesting that decision-making processes consume cognitive resources that might otherwise be dedicated to content learning for students lacking established metacognitive strategies.

The disconnect between observable metacognitive behaviors and performance outcomes was striking. Student B demonstrated high metacognitive awareness but achieved only moderate performance, while Student E attained the highest score despite limited metacognitive engagement. This suggests metacognitive awareness alone is insufficient; students must apply these skills effectively within specific contexts.

Changes to Practice

These findings prompted significant changes to teaching practice:

1. Providing a wider range of learning activities addressing different preferences and strengths.
2. Explicitly sharing reasoning for selecting instructional methods, modeling metacognitive decision-making.

3. Incorporating structured engagement with success criteria throughout the learning process.
4. Developing strategies to help students view tasks as meaningful learning opportunities rather than items to complete.

Conclusion

This research reveals that students with different metacognitive awareness levels respond uniquely to varying task choices. High metacognitive awareness scores don't automatically translate to superior learning outcomes, and students' perception of tasks significantly impacts engagement.

Effective differentiation involves more than providing choices; it requires developing students' capacity to make meaningful learning decisions while supporting growing metacognitive awareness. Developing metacognitive capabilities alongside content knowledge is essential for helping students become independent learners capable of applying physics concepts across varied contexts—crucial for both academic success and future engagement with STEM disciplines.

References

CAST. (2018). *The UDL Guidelines* (Version 2.2). Retrieved May 3, 2025, from https://udlguidelines.cast.org/

Dignath, C., & Büttner, G. (2018). Teachers' direct and indirect promotion of self-regulated learning in primary and secondary school mathematics classes: Insights from video-based classroom observations and teacher interviews. *Metacognition and Learning, 13*(2), 127–157. https://doi.org/10.1007/s11409-018-9181-x

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

González, A., & Paoloni, P. V. (2015). Perceived autonomy-support, expectancy, value, metacognitive strategies and performance in chemistry: A structural equation model in undergraduates. *Chemistry Education Research and Practice, 16*(3), 640–653. https://doi.org/10.1039/C5RP00055A

Paas, F., & Van Merriënboer, J. J. G. (2010). Cognitive load theory: New conceptualizations, specifications, and integrated research perspectives. *Educational Psychology Review, 22*(2), 115–121. https://doi.org/10.1007/s10648-010-9130-6

Patall, E. A., Cooper, H., & Robinson, J. C. (2010). The effectiveness and relative importance of choice in the classroom. *Journal of Educational Psychology, 102*(4), 896–915. https://doi.org/10.1037/a0019545

Reeve, J. (2012). A self-determination theory perspective on student engagement. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 149–172). Springer. https://doi.org/10.1007/978-1-4614-2018-7_7

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Association for Supervision and Curriculum Development.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Schunk, D. H., & Zimmerman, B. J. (Eds.). (2011). *Handbook of self-regulation of learning and performance*. Routledge.

Schwartz, B., Ward, A., Monterosso, J., Lyubomirsky, S., White, K., & Lehman, D. R. (2002). Maximizing versus satisficing: Happiness is a matter of choice. *Journal of Personality and Social Psychology, 83*(5), 1178–1197. https://doi.org/10.1037/0022-3514.83.5.1178

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary Educational Psychology, 27*(1), 51–79. https://doi.org/10.1006/ceps.2001.1091

Taasoobshirazi, G., & Farley, J. (2013). Construct validation of the physics metacognition inventory. *International Journal of Science Education, 35*(3), 447–459. https://doi.org/10.1080/09500693.2012.750433

Thomas, G. P. (2013). Eliciting metacognitive experiences and reflection in a Year 11 chemistry classroom: An activity theory perspective. *Journal of Science Education and Technology, 22*(3), 300–313. https://doi.org/10.1007/s10956-012-9392-x

Zohar, A., & Barzilai, S. (2013). A review of research on metacognition in science education: Current and future directions. *Studies in Science Education, 49*(2), 121–169. https://doi.org/10.1080/03057267.2013.847261