Impact of Analogical Learning on Metacognition and Scholastic Achievement of College Students in Physical Science

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ABSTRACT

This quantitative research study employed a quasi-experimental design to examine the effects of the analogical learning approach on metacognitive development and academic performance in physical science education. A total of 385 students enrolled in physical science courses at Iligan Medical Center College participated in the study. Stratified random sampling was used to select participants from different courses, ensuring representation across various domains. The experimental group received instruction using the analogical learning approach, while the control group received traditional instruction, allowing for a comparison of outcomes. The findings demonstrated significant support for the effectiveness of the analogical learning approach in enhancing multiple aspects of learning, including knowledge transfer, conceptual understanding, problem-solving ability, metacognition, and motivation. The results were consistent with prior research, further affirming the benefits associated with this instructional method. Additionally, the participants displayed a commendable level of metacognitive awareness, particularly in areas such as progress monitoring, identifying strategies for challenging problems, adapting learning strategies, understanding learning styles, and recognizing metacognitive strengths and weaknesses. These findings contribute to the existing literature by emphasizing the advantages of incorporating analogical learning strategies in educational settings. By harnessing analogical reasoning and fostering metacognitive development, educators can facilitate knowledge transfer, deepen conceptual understanding, enhance problem-solving skills, cultivate metacognitive awareness, and promote motivation among students. The results of this study underscore the potential benefits of implementing analogical learning strategies to improve learning outcomes in physical science education. The significant differences observed between pretest and post-test scores provide compelling evidence of the positive impact of the implemented intervention on participants' learning outcomes. In conclusion, this study provides valuable insights into the effectiveness of the analogical learning approach and its influence on metacognitive awareness in the context of physical science education. The results support the adoption of analogical learning strategies to enhance learning outcomes, while highlighting the importance of fostering metacognitive awareness to optimize students' learning experiences. These findings offer robust evidence of the positive effects of the implemented intervention on participants' learning outcomes, indicating the potential of the analogical learning approach to improve performance and understanding within the studied domain.

Keywords: Analogical learning, Metacognitive development, Academic performance, Physical science education, Quasi-experimental design, Knowledge transfer.

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INTRODUCTION

The field of education continually seeks effective strategies to enhance students' metacognitive development and scholastic achievement. In the context of physical science education, there is a recognized need to investigate the impact of innovative teaching approaches on students' cognitive processes and academic performance. This study aims to fill the existing research gap by examining the influence of the analogical learning approach on the metacognitive development and academic performance of physical science students.

Metacognitive development, which involves students' awareness and control of their learning processes, is a crucial aspect of academic success (Flavell, 1976). However, traditional instructional methods often overlook the explicit teaching of metacognitive strategies, leading to limited improvement in students' metacognitive abilities (Paris & Paris, 2001). Furthermore, academic performance in physical science subjects has shown room for improvement, as students struggle to grasp complex scientific concepts and apply them effectively (Bryan & Abell, 1999). Therefore, there is a pressing need to explore alternative instructional approaches that can enhance both metacognitive development and academic performance in physical science education. This research aims to examine the impact of the analogical learning approach on students' metacognitive development in the context of physical science education.

Previous studies have emphasized the significance of metacognitive development in students' learning processes (Flavell, 1976). Metacognition allows students to monitor their understanding, plan their learning strategies, and evaluate their progress, resulting in improved scholastic achievement (Zimmerman, 2000). However, traditional didactic teaching approaches often neglect the explicit instruction of metacognitive strategies, hindering students' ability to regulate their learning effectively (Paris & Paris, 2001).

Analogical learning, on the other hand, has emerged as a promising instructional approach that leverages students' prior knowledge and cognitive processes (Gentner, 1983). By drawing connections between familiar and unfamiliar concepts, analogical learning facilitates deeper understanding and transfer of knowledge (Richland et al., 2012). Although analogical learning has shown promise in various educational domains, its specific impact on metacognitive development and academic performance in physical science education requires further investigation.

While studies have explored the impact of different instructional approaches on metacognition and academic performance, the specific influence of the analogical learning approach in the context of physical science education remains largely unexplored. This research aims to address this research gap by systematically examining the effects of analogical learning on both metacognitive development and academic performance in physical science students. By doing so, it aims to contribute to the existing literature on effective instructional strategies in science education.

LITERATURE REVIEW

This study delves into the two key concepts of analogical learning and metacognitive development, providing the foundation for understanding their relationship with instructional approaches and students' cognitive processes and academic performance in physical science education. Analogical learning involves drawing connections between familiar and new concepts, enabling knowledge transfer and deeper comprehension (Duit, 1991; Jameson et al., 2013). Gentner's structure-mapping theory (1983) is incorporated into the theoretical framework to explain how individuals establish connections between different domains for improved learning and problem-solving. On the other hand, metacognition involves students' awareness and control of their cognitive processes, regulating their learning, setting goals, and adapting strategies (Papleontiou-Louca, 2003; Zimmerman & Schunk, 2011). Flavell's metacognitive theory (1976) highlights the importance of metacognitive knowledge and regulation in enhancing learning

outcomes.

In the study by Richland et al. (2012), the theoretical and practical aspects of analogy use in science education are explored, highlighting the significance of analogical reasoning in various aspects of learning, including knowledge transfer, conceptual understanding, problem-solving, metacognition, and motivation. This study lays the groundwork for understanding how integrating analogical reasoning positively influences metacognitive development and academic achievement among college students in physical science.

Additionally, Fernandes & Albuquerque (2016) investigate the effects of metacognitive instruction on problem-solving skills in a computer-based physics environment, emphasizing the importance of metacognitive awareness in academic performance in science education. Understanding metacognition's role in problem-solving sheds light on how integrating analogical learning approaches may enhance problem-solving abilities and contribute to improved scholastic achievement in physical science.

Although not directly focused on analogical learning, Smith &Kosslyn's (2014) study provides insights into cognitive psychology's implications for learning and memory processes, offering valuable background knowledge for studying the impact of analogical learning on college students in physical science.

Similarly, Karpicke & Blunt's (2011) research explores the effectiveness of retrieval practice compared to concept mapping, highlighting the role of metacognitive processes in enhancing learning outcomes. This understanding informs research on how analogical learning may interact with other strategies to impact scholastic achievement among college students in physical science.

Finally, the classic study by Gick&Holyoak (1983) investigates schema induction and analogical transfer, providing foundational research on the role of analogical reasoning in knowledge transfer and problem-solving. This study contributes to our understanding of how analogical learning strategies may facilitate metacognitive development and academic achievement in the context of physical science education.

METHODOLOGY

This study employed a quantitative research design with a quasi-experimental approach to investigate the impact of the analogical learning approach on metacognitive development and academic performance in physical science education. The comparison of outcomes between the experimental group, which received instruction using the analogical learning approach, and the control group, which received traditional instruction, was made possible through the quasi-experimental design. The sample consisted of 385 students enrolled in physical science courses at Iligan Medical Center College, selected using stratified random sampling to ensure representation across different courses.

Data for the study were collected from the selected sample of 385 students, with a focus on examining the impact of the analogical learning approach on metacognitive development and scholastic achievements in physical science education. Pre- and post-tests were specifically designed to measure students' understanding of physical science concepts and their application of metacognitive strategies. Additionally, surveys and questionnaires were administered to assess students' self-perceived metacognitive abilities, their attitudes towards the analogical learning approach, and overall satisfaction with the learning experience.

Quantitative data from the assessments and surveys were analyzed using appropriate statistical techniques. Descriptive statistics, such as means, were calculated to summarize the data, while inferential statistical analyses, including t-tests, were conducted to compare the outcomes between the pretest and the posttest. These analyses will provide valuable insights into the effectiveness of the analogical learning approach in

promoting metacognitive development and academic performance in the context of physical science education.

Top of Form

ANALYSIS AND DISCUSSIONS

4.1 Analogical Approach

Table 4.1: Impact of Analogical Learning Approach

Table 1 Impact of Analogical Learning Approach

	Mean	Description
Transfer of knowledge:	2.8	Agree
Conceptual understanding:	2.7	Agree
Problem-Solving Ability	2.7	Agree
Metacognition	2.7	Agree
Motivation	2.7	Agree
Mean	2.7	Agree

The table presents the mean values and descriptions for various variables, including transfer of knowledge, conceptual understanding, problem-solving ability, metacognition, and motivation. The mean value for each variable is 2.7 or 2.8, indicating agreement among the respondents regarding these constructs. The means and agreement expressed in the table provide initial evidence supporting the positive impact of the analogical learning approach on transfer of knowledge, conceptual understanding, problem-solving ability, metacognition, and motivation. These findings contribute to the existing literature and underscore the potential benefits of implementing analogical learning strategies in educational contexts.In reference toTransfer of Knowledge, the mean value of 2.8 suggests that the respondents generally agree that the analogical learning approach facilitates the transfer of knowledge. This finding aligns with previous research highlighting the effectiveness of analogical learning in promoting the transfer of knowledge across different domains (Smith &Kosslyn, 2014).In terms of Conceptual Understanding, with a mean value of 2.7, the respondent's express agreement that the analogical learning approach enhances conceptual understanding. This finding supports previous studies that have emphasized the positive impact of analogical learning on developing a deeper understanding of complex concepts (Richland et al., 2012).With regards to Problem-Solving Ability, the mean value of 2.7 indicates agreement among the respondents regarding the positive influence of the analogical learning approach on problem-solving ability. This finding is consistent with research that has highlighted the role of analogical reasoning in fostering problem-solving skills and promoting creative thinking (Gick&Holyoak, 1983).In the aspect of Metacognition, respondents also express agreement (mean value of 2.7) regarding the impact of the analogical learning approach on metacognition. This aligns with the theoretical framework of the study, which posits that analogical learning can enhance students' metacognitive development by encouraging reflection, self-monitoring, and strategic thinking (Flavell, 1976).In terms of Motivation, with a mean value of 2.7, respondents agree that the analogical learning approach positively influences motivation. This finding is consistent with research suggesting that engaging instructional approaches, such as analogical learning, can enhance students' motivation and active participation in the learning process (Deci & Ryan, 2000).

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4.2. Metacognitive Awareness Inventory

Table 2. Metacognitive Awareness Inventory

	Mean	Description
I am aware of the strategies I use to monitor my own learning progress and understanding.	3.3	Just aware
I can identify when I am confused or need further clarification in my learning.	3.1	Just aware
I consciously plan and organize my study materials and resources to enhance my learning.	3.1	Just aware
I reflect on my learning progress and adjust my study strategies accordingly.	3.1	Just aware
I recognize the effectiveness of different learning strategies and adapt them to suit my needs.	3.2	Just aware
I am conscious of my preferred learning style and how it influences my approach to studying physical science.	3.1	Just aware
I set clear goals for my physical science learning and track my progress towards achieving them.	3.0	Just aware
I use self-questioning and self-explanation techniques to deepen my understanding of physical science concepts.	3.2	Just aware
I actively monitor my comprehension and identify areas where I need further clarification or practice.	2.9	Just aware
How aware are you of the specific steps you take when faced with a challenging problem or concept in physical science?	3.3	Just aware
How aware are you of your preferred learning style and how it influences your approach to studying physical science?	3.2	Just aware
How aware are you of the cognitive strategies you use to enhance memory retention and recall of physical science concepts?	3.1	Just aware
How aware are you of your own metacognitive strengths and weaknesses when it comes to learning physical science?	3.2	Just aware
How often do you seek feedback from teachers or peers to gain insights into your own thinking processes and learning strategies in physical science?	2.9	Occasionally
How often do you set clear goals for your physical science learning and track your progress towards achieving them?	3.1	Occasionally
How often do you reflect on your learning progress and adjust your study strategies accordingly?	3.1	Occasionally
How often do you actively monitor your own comprehension and identify areas where you need further clarification or practice?	3.1	Occasionally
How often do you engage in self-questioning and self-explanation while learning new physical science topics?	2.9	Occasionally
Mean	3.1	Just aware

The data presented in Table 2 provides insights into the participants' metacognitive awareness based on their responses to the Metacognitive Awareness Inventory. The table highlights the top 5 highest mean values. These variables indicate the areas where participants demonstrate the highest level of metacognitive awareness. These variables reflect the participants' relatively higher levels of awareness in terms of monitoring their own learning progress and understanding, identifying strategies for challenging

problems, recognizing the effectiveness of learning strategies, understanding the influence of learning style, and being aware of metacognitive strengths and weaknesses. These findings indicate that participants possess a commendable level of metacognitive awareness in these areas. It suggests that they have developed an understanding of their own learning processes and the strategies needed to enhance their learning experience. These results align with previous research emphasizing the importance of metacognitive awareness in promoting effective learning outcomes (Efklides, 2011). The participants' higher mean scores in these areas indicate their potential to apply metacognitive strategies to support their learning in the context of physical science.

4.3 Causal Relationship of the Pretest and Post test

Table 3. Causal Relationship of the Pretest and Post test

	t	df	p-value
Pretest	24.259	19	0.00
Post Test	31.352	19	0.00

The table presents the results of the causal relationship analysis between the pretest and post-test scores. The statistical values provided include the t-value, degrees of freedom (df), and the corresponding p- value. The pretest t-value of 24.259 indicates a significant difference between the pretest scores and the population mean. The high t-value suggests that the pretest scores are substantially different from the expected mean value. The p-value of 0.00 indicates that this difference is statistically significant, providing evidence that the pretest scores are not due to chance. Similarly, the post-test t-value of 31.352 suggests a significant difference between the post-test scores and the population mean. The large t-value indicates a substantial difference between the observed post-test scores and the expected mean value. The p-value of indicates statistical significance, indicating that the post-test scores are significantly different fromwhat would be expected by chance alone. The pretest and post-test scores reveal highly significant differences. These findings suggest that the intervention or treatment implemented between the pretest and post-test had a significant impact on the participants' performance or understanding of the measured variable. The results indicate that the intervention or treatment, implemented between the administration of the pretest and post-test, led to significant improvements in the measured variable. This finding supports the effectiveness of the intervention or treatment in enhancing the participants' performance or understanding.

CONCLUSION

The findings from both the mean values of the variables related to analogical learning and metacognitive awareness provide substantial support for the effectiveness of the analogical learning approach in enhancing various aspects of learning, including transfer of knowledge, conceptual understanding, problem-solving ability, metacognition, and motivation. The respondents' agreement on the positive impact of analogical learning aligns with previous research, further reinforcing the benefits associated with this instructional approach (Smith &Kosslyn, 2014; Richland et al., 2012; Gick&Holyoak, 1983). Furthermore, the participants demonstrate a commendable level of metacognitive awareness, particularly in domains such as monitoring progress, recognizing strategies for challenging problems, adapting learning strategies, understanding learning style, and being aware of metacognitive strengths and weaknesses. These findings contribute to the existing literature and emphasize the advantages of incorporating analogical learning strategies in educational settings. By harnessing analogical reasoning and fostering metacognitive development, educators can facilitate knowledge transfer, deepen conceptual understanding, enhance problem-solving skills, cultivate metacognitive awareness, and promote motivation among students (Flavell, 1976; Deci & Ryan, 2000; Efklides, 2011). Moreover, the results of this study offer valuable insights into the effectiveness of the analogical learning approach and its impact on metacognitive awareness within the

realm of physical science education. These findings underscore the potential benefits of implementing analogical learning strategies to improve students' learning outcomes, while also highlighting the significance of metacognitive awareness in facilitating effective learning experiences. The significant differences observed between the pretest and post-test scores indicate that the implemented intervention had a substantial positive impact on the participants' learning outcomes. The pretest scores deviated significantly from the expected mean value, indicating notable differences in the participants' initial performance or understanding before the intervention. Similarly, the post-test scores exhibited a significant difference from the expected mean value, suggesting substantial improvements in the measured variable as a result of the intervention. These statistically significant differences between the pretest and post-test scores provide compelling evidence supporting the positive effects of the implemented intervention on the participants' learning outcomes. The findings highlight the potential of the intervention to enhance students' performance and understanding within the studied domain. This study contributes valuable insights into the effectiveness of the analogical learning approach and its influence on metacognitive awareness in the context of physical science education. The results support the adoption of analogical learning strategies to promote improved learning outcomes among students. Additionally, the study underscores the importance of fostering metacognitive awareness as a means to enhance students' learning experiences. The significant differences observed between the pretest and post-test scores provide robust evidence of the positive impact of the implemented intervention on the participants' learning outcomes.

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