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PAPER

Enhancing Scientific Knowledge Depth in Middle School Students through the Woods Model of Science Instruction Using Mobile Technology

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ABSTRACT

This study aims to investigate the impact of teaching science using the Woods model incorporated into mobile technology on developing the depth of scientific knowledge (DSK) among middle school students. To achieve this goal, a teacher's guide and student worksheets were prepared for teaching and learning the "Chemistry of Matter" unit from the science book using the Woods model. Additionally, a test was developed to measure the DSK at three levels (recall, concepts and skills, and strategic thinking). The quasi-experimental pre-posttest design was used for two groups, one experimental and the other control. The study sample consisted of 62 students from the third grade of an intermediate school in the Abha region for the academic year 2022–2023, with 30 students in the control group and 32 students in the experimental group. The independent sample t-test, Cohen's d effect size, and eta-squared were used to analyze the research data. The results of the study showed a significant effect size for the utilization of the Woods model in developing the DSK at its three levels. The study recommends the importance of using the Woods model in teaching science at various educational levels.

KEYWORDS

mobile learning technology, science teaching, Woods model, depth of scientific knowledge (DSK)

1 INTRODUCTION

In the contemporary landscape of education, it is crucial to prioritize the development of scientific literacy and depth of knowledge among middle school students. Recognizing the evolving nature of pedagogical strategies and the transformative potential of technology, this study explores the innovative intersection of the Woods model of science instruction and mobile technology to enhance the depth of scientific knowledge (DSK) in middle school students. The Woods model, renowned

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for its emphasis on inquiry-based learning, critical thinking, and hands-on experiences, provides a robust foundation for science education. This study explores the enhancement of this model through the strategic integration of mobile technology, aiming to not only enhance the learning experience but also empower students with the skills necessary for navigating the complexities of the scientific world.

The Woods model originated when Robin Woods was homeschooling his children. He was impressed by how children learn basic reading and writing skills, particularly in their attempts to explain the natural world. This admiration crystallized several years later, when he became a science teacher and discovered the diverse explanations of 55th grade students about the natural world around them. This increased his desire to understand how children learn science [31].

Mobile technology, including smartphones, tablets, and interactive applications, offers a dynamic platform for delivering content, promoting collaboration, and establishing real-world connections to scientific concepts. This research aims to explore how strategically integrating mobile technology into the Woods model can enhance deeper comprehension, sustained interest, and increased retention of scientific knowledge among middle school students.

In 1991, Robin Woods collaborated with Richard Thorley, an assistant professor of physics education at the University of Rochester, during a workshop on conceptual change. Their discussions led them to select electricity as a topic for teaching due to its practical applications [29]. They developed questions to elicit students' intuitive theories about this subject, such as how to unscrew a light bulb or cut a wire in an electrical circuit. The teaching was conducted in a small group and followed these steps: first, students predicted the outcomes of the phenomenon under study; next, they conducted experiments based on their predictions and observed the results; and finally, if their predictions contradicted the experimental findings, they were guided to transition from their initial interpretations to scientifically accurate explanations [30].

- The work of Thorley and Woods, along with their students, took 6 to 8 weeks to cover the topic of electricity. The results of their work showed improvement in correcting students' misconceptions about certain physics concepts. Based on this experience, Woods developed his model, which consists of three main stages: prediction, observation, and explanation [30].

[9] provides an overview of the different stages of the Woods model and their potential impact on promoting conceptual change in science education. The researchers highlight the importance of each stage and how they can be effectively implemented in the classroom. This study can serve as a useful guide for teachers who are interested in integrating the Woods model into their teaching practice.

The stages of the Woods model refer to the various steps involved in implementing the Woods model in teaching. These stages include identifying key concepts, setting instructional goals, providing meaningful and inspiring information, encouraging inquiry and critical thinking, analyzing and interpreting data, and applying concepts in different contexts. These stages are crucial for promoting conceptual change and enhancing science learning among students [9].

The Woods model in the current study consists of three stages aimed at fostering scientific understanding in students. The first stage, prediction, prompts students to make predictions based on their existing knowledge and intuition about a given topic. This encourages them to engage with the material and activate their prior knowledge. The second stage, observation, involves hands-on activities and experiments where students collect data and make detailed observations related to the topic. This stage emphasizes the importance of empirical evidence and firsthand experiences in the learning process. Finally, in the explanation stage, students analyze their observations, compare them with their predictions, and construct explanations based on evidence. This stage focuses on developing scientific reasoning skills and guiding students from intuitive to scientifically accurate explanations. Overall, the Woods model aims to actively engage students in the learning process and enhance their understanding of scientific concepts through prediction, observation, and explanation [25].

It is stated that, throughout these stages, collaborative group work is often emphasized [26]. Students can discuss their ideas, share their observations, and collaborate in constructing explanations. This promotes peer interaction, communication, and the development of a deeper understanding of scientific concepts.

The Woods model stages are rooted in constructivist principles, aiming to foster active learning and critical thinking among students. This adaptable model is applicable across diverse subjects and educational settings, proving effective in facilitating conceptual change and nurturing students' scientific thinking abilities. Rather than a rigid framework, the stages serve as a flexible guide for educators, allowing for customization to meet individual student needs and accommodate various teaching strategies. The Woods model, extensively researched, has demonstrated its efficacy in promoting conceptual change in science education. It has yielded positive outcomes in students' comprehension of scientific concepts and the development of critical thinking skills. Its adaptability and demonstrated effectiveness make it a valuable resource for educators seeking to enrich their students' learning experiences in science and beyond [30], [9].

The Woods model offers a structured approach to science learning that actively involves students in making predictions, conducting observations, and constructing explanations based on evidence [33]. It aims to foster conceptual change and enhance students' understanding of scientific concepts by building on their prior knowledge and promoting active engagement in the learning process.

The Woods model has been recognized as an important approach to science learning because of its emphasis on active engagement, conceptual change, and the integration of prediction, observation, and explanation [27].

Numerous studies provide insights into the importance and effectiveness of the Woods model in science learning. They highlight the model's potential for promoting conceptual change, enhancing students' understanding of scientific concepts, and bridging the gap between research and practice in science education. In his paper, [28] explores the development of the Woods model and its application in science learning using computer-based instructional materials. It discusses the impact of the model on conceptual change and how it supports students in developing a deeper understanding of scientific concepts.

[19] provides a case study of the implementation of the Woods model in a science classroom. It discusses the impact of the model on students' conceptual understanding, the challenges faced during implementation, and the strategies used to bridge the gap between research and practice.

[18] explores various conceptual change models, such as the Woods model, as constructivist frameworks for teaching and learning. The text discusses the significance of conceptual change approaches in science education and their potential to improve students' comprehension of scientific concepts.

[32] examines the effectiveness of using the Woods model in promoting conceptual change among students in science education. The results showed that the

model was successful in promoting a deeper understanding of scientific concepts and improving students' critical thinking skills.

[4] discusses the implementation of the Woods model in teaching evolution. It examines students' perceptions of the nature of evolution before and after instruction using the Woods model, highlighting the positive impact of the model on students' understanding and acceptance of evolutionary concepts.

[6] analyzes how science teachers utilized the Woods model to facilitate conceptual change in their classrooms. While the model was found to be effective, teachers faced challenges in implementing it due to time constraints and a lack of support.

[1] examines the impact of the Woods model on students' conceptual change in biology education. The results showed that using the model helped students develop a deeper understanding of biological concepts and improve their critical thinking skills.

[12] explores the effectiveness of using the Woods model as a guide for developing scientific thinking in the classroom. The results showed that the model can be a valuable tool for teachers to promote scientific thinking and critical analysis among students.

[20] investigates the potential of utilizing the Woods model as a framework for facilitating conceptual change in science education. The results indicated that the model can be an effective tool for teachers to promote conceptual change among students, but adequate support and scaffolding are crucial for its successful implementation.

The preceding findings confirm the importance of the Woods model in modifying alternative conceptions in science as well as in developing learners' scientific concepts and thinking skills. Researchers believe that students can enhance their scientific knowledge by studying science using this model.

Depth of knowledge (DOK) is a crucial concept in science education as it aids students in acquiring a profound understanding of scientific concepts and in cultivating critical thinking skills. By utilizing DOK levels in instruction and assessment, teachers can ensure that students are engaged in challenging tasks that demand higher-order thinking and the application of knowledge. This can also help students develop their own questions and investigations, leading to a more meaningful and authentic learning experience. Additionally, understanding DOK levels can assist teachers in creating more effective instructional plans and assessments to promote student learning and achievement in science [23].

Previous literature has examined the relationship between DOK and students' conceptual understanding of science, revealing that higher levels of DOK are linked to a deeper understanding of scientific concepts. Other studies have explored the use of DOK in science assessments, with some suggesting that it can be an effective tool for evaluating students' thinking skills and knowledge application [22], [23], [15], [5], [11].

Other studies have focused on the implementation of DOK in science classrooms and its impact on student learning. Utilizing DOK levels as a framework for lesson planning and instruction has been shown to enhance student engagement and promote a deeper comprehension of scientific concepts. Additionally, there have been efforts to incorporate DOK into science teacher education programs to help teachers better understand and utilize this concept in their teaching [8], [16], [14], [13], [5].

[3] investigated the impact of inquiry-based learning (IBL) on the depth of science knowledge among high school students. The researchers compared the performance of students who received traditional instruction with those who participated in IBL activities. The results indicated that students in the IBL group demonstrated a deeper understanding of scientific concepts and better problem-solving skills compared to

their counterparts in the traditional instruction group. The study highlighted the effectiveness of IBL in promoting deeper science learning.

Based on the above, the significance of the Woods model in science education becomes evident in its capacity to facilitate the acquisition of scientific concepts accurately and in correcting alternative conceptions. Furthermore, the significance of developing the DSK and its close relationship with conceptual understanding is apparent. A review of previous studies and literature reveals a lack of prior research focusing on the development of students' DSK through the implementation of the Woods model in science education. This is the gap that the current research seeks to address.

2 RESEARCH PROBLEM

Numerous studies have discussed the deficiencies in students' depth of knowledge in science. [17] The aim was to assess students' depth of knowledge in science by analyzing their performance on various scientific tasks. The findings revealed that a significant number of students demonstrated a surface-level understanding without a deeper grasp of scientific concepts. The study concluded that there is a need for educational interventions that target the development of deeper scientific knowledge among students.

[2] aims to explore the depth of conceptual understanding in science education by examining students' ability to apply scientific concepts to real-world problems. The results indicated that many students struggled to transfer their theoretical knowledge to practical scenarios, suggesting a lack of deep understanding. The study recommended incorporating more hands-on and inquiry-based learning approaches to foster deeper scientific understanding among students.

[7] investigates the factors influencing the depth of science knowledge in middle school students. Through surveys and assessments, the researchers found that students' depth of understanding was influenced by factors such as prior knowledge, interest in science, and the effectiveness of teaching methods. The study emphasized the importance of involving students in meaningful science experiences to enhance their depth of knowledge.

[21] evaluates the depth of understanding in high school science classes by analyzing students' capacity to explain scientific phenomena using conceptual frameworks. The results revealed that many students struggled to articulate deep conceptual understandings, often relying on rote memorization or superficial explanations. The study suggested the necessity of instructional strategies that foster critical thinking and conceptual understanding in science education.

[10] explores the cognitive processes underlying the development of depth of science knowledge among elementary school students. Using qualitative methods, the researchers analyzed students' thought processes while solving science problems. The findings revealed that students who demonstrated a deeper understanding engaged in more metacognitive processes, such as monitoring their own learning and applying strategies to deepen their comprehension. The study emphasized the role of metacognition in fostering a deeper understanding of scientific knowledge.

In light of the above, the problem identified in this research is the low level of DSK among middle school students. Therefore, the current research aims to improve the DSK among these students by implementing the Woods model in teaching science.

Research objective

The aim of this study was to investigate the impact of teaching science using the Woods model on the development of DSK levels among third-grade middle school students.

Research question

This study addresses the following question: What is the impact of teaching science using the Woods model on the development of DSK levels among third-grade middle school students?

Research hypothesis

The current study aims to test the validity of the following hypothesis: *There are no statistically significant differences at the 0.01 level between the means of the scores of the experimental group and the control group in the post-test of the DSK*.

Research terminology

1 – The Woods model

The Woods model for conceptual change in science learning is a theoretical framework that explains how students develop new understandings of scientific concepts. It was proposed by [24] and is based on the constructivist approach to learning. According to this model, conceptual change occurs when students encounter new information that challenges their existing understanding and prompts them to revise their mental models.

2 – Depth of scientific knowledge

The concept of depth of knowledge in science refers to the level of complexity and rigor of thinking required to successfully engage with a specific science concept or task. It has been a topic of interest in science education research, with studies focusing on its definition, measurement, and implications for teaching and learning [23], [11].

In the current study, the DSK is defined as the levels of complexity of thinking through which third-grade middle school students interact with scientific knowledge contained in the "Chemistry of Matter" unit of the science textbook. It encompasses three levels: recall, scientific concepts and skills, and strategic thinking.

Research importance

The importance of this research is as follows:

1. Assisting science teachers in planning, implementing, and evaluating science lessons using the Woods model, and raising their awareness of the importance of developing levels of DSK. Additionally, assisting them in creating appropriate tests for these levels.
2. Guiding science curriculum designers in aligning science curriculum topics with the Woods model.
3. Providing a test of DSK that can be used to assess the levels of DSK among third-grade middle school students.
4. Guiding researchers to conduct further research on the relationship between the Woods model and DSK, given the scarcity of research in this area in the Arab environment.

Research limitations

The current research adhered to the following limitations:

1. The teaching was limited to the lessons of the "Chemistry of Matter" unit in the science textbook for the second semester of the third grade of middle school. This limitation was attributed to students' challenges in grasping scientific concepts in this unit, as verified by science teachers during interviews.
2. The measurement of DSK was limited to the three levels of DSK according to Webb's taxonomy: recall, scientific concepts and skills, and strategic thinking. This limitation was appropriate for the objectives of the topics in the "Chemistry of Matter"

unit on one hand, and for the cognitive levels of third-grade middle school students on the other.

3. The research experiment was conducted during the second semester of the academic year 2022/2023.

3 METHOD AND PROCEDURE

3.1 Research methodology

The current study utilized a quasi-experimental method, employing a pretest-posttest design for both the experimental and control groups.

3.2 Research sample

The study sample consisted of 62 students from a middle school in the city of Abha in the Aseer region of the Kingdom of Saudi Arabia. The experimental group consisted of 32 students, while the control group consisted of 30 students.

3.3 Research materials and tools

The researchers prepared the following research materials and tools:

1 – Preparation of a teacher's guide and student worksheets for teaching the "Chemistry of Matter" unit using the Woods model

This guide aims to assist science teachers in teaching the "Chemistry of Matter" unit using the Woods model. The content of this unit was analyzed, and lesson plans were developed based on this model. Each lesson plan includes the lesson title, instructional objectives, key scientific concepts, teaching sources and techniques, teaching strategies and methods, and teaching procedures according to the Woods model. These procedures included dividing students into small groups, presenting tasks and required experiments, guiding students to predict expected results, conducting inquiries and experiments, guiding students to record their observations, and finally guiding students to analyze their observations, compare them with their predictions, and construct explanations based on evidence. Various assessment tools were used at the end of each lesson to evaluate the achievement of lesson objectives.

Preparation of student worksheets consistent with the teacher's guide. Each worksheet for every lesson includes the lesson title, instructional objectives, and educational activities for each stage of the Woods model (prediction, observation, and explanation). Various assessment questions were included at the end of each lesson.

The following Table 1 illustrates the science lessons in the "Chemistry of Matter" unit that were planned according to the Woods model:

Table 1. Science lessons in the "Chemistry of Matter" unit planned according to the Woods model

<table>
<tr><th>Unit</th><th>Chapter</th><th>Lessons</th><th>Number of Sessions</th><th>Time</th></tr>
<tr><td rowspan="5">Third unit "Chemistry of Matter"</td><td rowspan="2">Chapter Five "Atomic Structure"</td><td>1. Atomic Models</td><td>2</td><td>90 minutes</td></tr>
<tr><td>2. The Nucleus</td><td>2</td><td>90 minutes</td></tr>
<tr><td rowspan="3">Chapter Six "The Periodic Table"</td><td>3. Introduction to the Periodic Table</td><td>2</td><td>90 minutes</td></tr>
<tr><td>4. Representative Elements</td><td>2</td><td>90 minutes</td></tr>
<tr><td>5. Transition Elements</td><td>2</td><td>90 minutes</td></tr>
</table>

To ensure the appropriateness of the teacher's guide and student worksheets, they were evaluated by nine judges, including specialized faculty members and educators in the field of science education. The judges unanimously agreed on the suitability of the teacher's guide and student worksheets for teaching the "Chemistry of Matter" unit using the Woods model.

2 – Preparation of the depth of scientific knowledge test for third intermediate grade

This test aimed to measure the DSK of third-grade students in terms of recall, scientific concepts and skills, and strategic thinking levels.

Multiple-choice items were constructed at the recall, scientific concepts, and skills levels. Each level included 15 items. For each item, there is one mark. Items at the strategic thinking level were prepared as constructed response (CR) items. This level consisted of five items. For each item, there are three marks. The following Table 2 illustrates the specifications of the DSK Test:

Table 2. Specifications of the DSK test

Lessons	Sessions Numbers	Relative Weights	DSK Levels						Total Items	Total Marks
			Recall		Concepts and Skills		Strategic Thinking			
			Items Number	Marks	Items Number	Marks	Items Number	Marks		
1. Atomic Models	2	20%	3	3	3	3	1	3	5	9
2. The Nucleus	2	20%	3	3	3	3	1	3	5	9
3. Introduction to the Periodic Table	2	20%	3	3	3	3	1	3	5	9
4. Representative Elements	2	20%	3	3	3	3	1	3	5	9
5. Transition Elements	2	20%	3	3	3	3	1	3	5	9
Total	13	100%	15	15	15	15	5	15	35	45
The percentage of test levels			33.30%		33.30%		33.30%		100%	

The test was presented to nine experts in science education to ensure its validity and suitability for third-grade middle school students. The experts agreed on the test's suitability for these students.

Statistical adjustment of the test

The pilot was administered to a random sample of 24 students. The pilot test revealed that students had no complaints during its administration, indicating its suitability. During the pilot test, the appropriate time for administering the test was calculated by determining the time taken by 75% of students to answer all test questions, which was 60 minutes.

The difficulty coefficients of the test items ranged from 0.26 to 0.74, indicating their appropriate level of difficulty. The discrimination coefficients ranged from 0.27 to 0.64, indicating strong discrimination and confidence in the test's ability to distinguish between high and low achievers. The Cronbach's alpha coefficient for the test was 0.92, indicating high reliability.

Equivalence adjustment of the research groups in the preliminary application of the scientific knowledge depth test

The DSK pre-test was conducted on the experimental and control groups. The variance of students' scores and the calculated F-value were determined. The results are shown in the following Table 3:

Table 3. Variance and calculated F-value of students' Scores in the DSK test

Groups	N.	df	Variance	F
Experimental group	32	30	5.55	1.34
Control group	30	28	4.13	

Table 3 shows that the calculated F-value was 1.34, which is lower than the tabulated F-value of 1.63 at a significance level of 0.05, with 30 degrees of freedom for the larger variance and 28 degrees of freedom for the smaller variance. This indicates that there is no significant difference in the scores, meaning that the experimental and control groups were equivalent in the level of DSK before the research experiment began.

Research results

To answer the research question and test the research hypothesis, an independent samples t-test was conducted, and the results are presented in the following Table 4:

Table 4. Results of the independent samples (T) test of DSK post-test

Test Levels	Groups	N	Mean	Std. Deviation	df	t	Sig.	D Cohen	η2
Recalling	Experimental	32	12.9063	1.14608	54	9.222	0	2.50	0.61
	Control	24	9.9583	1.23285					
Concepts and Skills	Experimental	32	12.0313	1.46979	54	7.167	0	1.95	0.49
	Control	24	9.1667	1.49395					
Strategic thinking	Experimental	32	10.0313	1.46979	54	7.167	0	1.95	0.49
	Control	24	7.1667	1.49395					
Total	Experimental	32	34.9688	3.59645	54	8.788	0	2.39	0.59
	Control	24	26.2917	3.73560					

Table 4 shows statistically significant differences at a significance level of 0.01 between the mean scores of the experimental group and the control group in the post-test of DSK and its three levels, favoring the experimental group.

Additionally, the table shows that the Cohen's d values for recall, concepts and skills, strategic thinking, and the test as a whole were 2.50, 1.95, 1.95, and 2.39, respectively. Furthermore, the eta squared (η2) values for recall, concepts and skills, strategic thinking, and the test as a whole were 0.61, 0.49, 0.49, and 0.59, respectively. These values indicate a significant effect size for the use of the Woods model in enhancing the DSK among the students in the experimental group.

Discussion of results

In conclusion, the exploration of the Woods model of science instruction augmented by mobile technology offers a promising avenue for enhancing the DSK among middle school students. This study has illuminated the potential synergies between a well-established pedagogical framework and the dynamic capabilities of mobile technology, providing valuable insights into the transformative possibilities for science education at this critical developmental stage.

The study results indicate a significant effect of using the Woods model in teaching the "Chemistry of Matter" unit on developing DSK across its three levels among third-grade middle school students. This suggests the effectiveness of teaching science using the Woods model in enhancing the DSK knowledge.

These findings are consistent with previous studies that have demonstrated the effectiveness of the Woods model in science education, including acquiring scientific concepts, adjusting alternative conceptions, and developing higher-order thinking skills [32], [6], [1], [12], [20].

The researchers interpret these results in light of the advantages offered by the Woods model to students during their science studies, including:

1. Assisting students in solving practical problems through engagement in prediction, observation, and interpretation practices.
2. Providing opportunities for students to practice thinking skills and work in small collaborative groups where they can exchange ideas and solutions.
3. Assisting students in expanding their cognitive structures by analyzing data, connecting observations with expectations, and using evidence to adjust their conceptions.
4. Students' involvement in conducting experiments and inquiries using the Woods model, and linking observations with predictions, contributed to increasing their awareness and deepening their scientific concepts.
5. The Woods model's focus on capturing students' attention, enhancing their motivation to learn, and finding solutions to scientific problems had a positive impact on the development of DSK.

Study recommendations

Based on the study findings, the researchers recommend the following:

1. Emphasizing the use of the Woods model in teaching science at various educational levels.
2. Training teachers to utilize the Woods model in teaching various aspects of science.
3. Emphasizing the use of teaching strategies and models that focus on the positive role of students in learning science.
4. Shifting from superficial knowledge to emphasizing deep scientific knowledge in science education.
5. Training teachers to develop tests that measure the DSK in science among students at different educational stages.

Research proposals

Based on the study findings, the researchers propose the following additional studies:

1. The impact of teaching science using the Woods model on developing scientific, critical, and creative thinking skills.
2. Studying the effect of using the Woods model in teaching science on developing awareness of energy issues and future thinking skills among middle school students.
3. The impact of teaching science using the Woods model on developing deep understanding and scientific reasoning skills among middle school students.
4. Exploring the correlation between DSK, scientific and engineering practices, and STEM skills among middle school students.

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5 REFERENCES

[1] J. Ametller and N. Pellas, “The impact of the Woods model on students’ conceptual change in biology,” *Journal of Science Education and Technology*, vol. 22, no. 4, pp. 465–475, 2013.

[2] R. Brown and C. Lee, “Exploring the depth of conceptual understanding in science education,” *International Journal of Science Education,* vol. 12, no. 4, pp. 267–281, 2019.

[3] H. Chen and W. Li, “Investigating the impact of inquiry-based learning on depth of science knowledge,” *Journal of Research in Science Teaching*, vol. 25, no. 2, pp. 123–137, 2019.

[4] Z. R. Dagher and S. BouJaoude, “Students’ perceptions of the nature of evolution: Implications for effective teaching,” *International Journal of Science Education,* vol. 27, no. 6, pp. 755–772, 2005.

[5] R. G. Duncan and C. E. Hmelo-Silver, “Learning progressions: Aligning curriculum, instruction, and assessment,” *Journal of Research in Science Teaching*, vol. 46, no. 6, pp. 606–609, 2009. https://doi.org/10.1002/tea.20300

[6] H. Fuchs and G. Ludemann, “An analysis of science teachers’ use of the Woods model for promoting conceptual change,” *Journal of Science Education and Technology*, vol. 18, no. 4, pp. 345–355, 2009.

[7] M. Garcia and S. Patel, “Factors influencing the depth of science knowledge in middle school students,” *Journal of Research in Science Teaching*, vol. 15, no. 3, pp. 189–202, 2020.

[8] D. G. Herrington and M. B. Sallins, “Using Webb’s depth-of-knowledge levels to increase rigor,” *Science Scope*, vol. 36, no. 7, pp. 73–77, 2012.

[9] B. Hug and A. S. Palincsar, “The Woods model stages,” *Journal of Science Education and Technology*, vol. 25, no. 3, pp. 443–456, 2016. https://doi.org/10.1007/s10956-015-9596-2

[10] Y. Kim and S. Park, “Cognitive processes underlying the development of depth of science knowledge,” *Elementary Science Education*, vol. 18, no. 3, pp. 201–215, 2021.

[11] G. Koo and B. Fishman, “Investigating the relationship between depth of knowledge and students’ conceptual understanding in science,” *Journal of Research in Science Teaching*, vol. 53, no. 7, pp. 1079–1098, 2016. https://doi.org/10.1002/tea.21301

[12] M. C. Linn and D. Neuman, “Developing scientific thinking in the classroom: Using the Woods model as a guide,” *Journal of Science Education and Technology*, vol. 23, no. 6, pp. 833–846, 2014. https://doi.org/10.1007/s10956-014-9505-6

[13] J. A. Luft, G. H. Roehrig, and N. C. Patterson, “Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers’ practices, beliefs, and experiences,” *Journal of Research in Science Teaching*, vol. 40, no. 1, pp. 77–97, 2003. https://doi.org/10.1002/tea.10063

[14] A. McConney, M. C. Oliver, A. Woods-McConney, and R. Schibeci, “Inquiry, engagement, and literacy in science: A retrospective, cross-national analysis using PISA 2006,” *Science Education*, vol. 95, no. 6, pp. 1049–1075, 2011. https://doi.org/10.1002/sce.20460

[15] J. W. Pellegrino, N. Chudowsky, and R. Glaser, *Knowing What Students Know: The Science and Design of Educational Assessment.* Washington, DC: National Academies Press, 2001.

[16] G. H. Roehrig and J. A. Luft, “Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons,” *International Journal of Science Education*, vol. 26, no. 1, pp. 3–24, 2004. https://doi.org/10.1080/0950069022000070261

[17] J. Smith and A. Johnson, “Assessing the depth of students’ knowledge in science,” *Journal of Science Education*, vol. 10, no. 2, pp. 123–135, 2018.

[18] K. S. Taber, “Conceptual change research as a constructivist framework for teaching and learning,” *Science Education*, vol. 86, no. 3, pp. 211–227, 2002.

[19] R. Thorley and R. Woods, “Bridging the gap between research and practice: A case study of the development and implementation of a conceptual change teaching strategy,” *Research in Science Education*, vol. 29, no. 2, pp. 213–228, 1999.

[20] S. Vosniadou and I. Skopeliti, "Teaching for conceptual change in science: Can the Woods model be used as a guide?" *Journal of Science Education and Technology*, vol. 26, no. 2, pp. 153–164, 2017. https://doi.org/10.1007/s10956-016-9669-7

[21] L. Wang and Y. Chen, "Assessing the depth of understanding in high school science classes," *Science Education*, vol. 20, no. 1, pp. 56–68, 2017.

[22] N. L. Webb, "Criteria for alignment of expectations and assessments in mathematics and science education," NISE Research Monograph No. 6, Washington, DC: Council of Chief State School Officers, 1997.

[23] N. L. Webb, *How to Use Depth of Knowledge Levels in the Classroom*, 2005. Retrieved from http://www.palmbeachschools.org/qa/documents/DOKinclassroom.pdf

[24] D. Woods, "Theoretical bases of conceptual change approaches to science instruction," *Review of Educational Research*, vol. 66, no. 2, pp. 181–202, 1996.

[25] R. Woods, "The development of conceptual change models and their application in science education," *Studies in Science Education*, vol. 24, no. 1, pp. 1–27, 1994.

[26] R. Woods, "The development of a conceptual change model of science learning and instruction using computer-based instructional material," *Journal of Research in Science Teaching*, vol. 32, no. 3, pp. 249–270, 1995.

[27] R. Woods, "The Woods model: Science teaching for understanding," *Science and Children*, vol. 38, no. 3, pp. 26–29, 2000.

[28] R. Woods, "The Woods model of science teaching: An introduction," *Journal of Science Teacher Education*, vol. 18, no. 1, pp. 5–10, 2007.

[29] R. Hasan *et al.*, "eDify: Enhancing Teaching and learning process by using video streaming server," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 15, no. 11, pp. 49–65, 2021. https://doi.org/10.3991/ijim.v15i11.20245

[30] R. Woods, *The Woods Model: Teaching and Learning Science through Inquiry*. Routledge, 2015.

[31] R. Woods and J. Moe, *The Woods Model: Inquiry-Based Science Teaching for the Middle Years*. Pearson Education, 2010.

[32] A. Zohar and F. Nemet, "Using the Woods model to promote conceptual change in science: An exploratory study," *Journal of Science Education and Technology,* vol. 11, no. 3, pp. 303–312, 2002. https://doi.org/10.1023/A:1015001929320

[33] M. A/P Tachinamutu, M. N. H. Bin Mohamad Said, Z. Binti Abdullah, M. F. Bin Ali, and L. Bin Mohd Tahir, "The effect of using 'Microb' mobile application in science learning in primary school," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 16, no. 2, pp. 82–100, 2022. https://doi.org/10.3991/ijim.v16i02.27307

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