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RESEARCH PAPER

Impact of Dual Coding Strategy to Enhance Students' Retention of Scientific Concepts in Middle Schools

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ABSTRACT

Recognizing the significance of cultivating enduring conceptual understanding, this study seeks to explore the impact of the dual coding strategy on mitigating the observed challenges in scientific retention. Dual coding, rooted in Allan Paivio's theory posits that combining verbal and visual elements enhances learning and memory recall. This theoretical framework suggests that integrating dual coding into middle school science instruction may bridge the gap between immediate comprehension and long-term retention (Clark & Paivio, 1991; Mayer & Sims, 1994). The literature review within this study delves into existing research on the effectiveness of dual coding in enhancing students' memory retention and conceptual understanding in science education. It examines studies exploring the practical implementation of dual coding, its cognitive benefits, and potential challenges, specifically focusing on middle school settings. By investigating the impact of dual coding on scientific retention, this study aimed to provide actionable insights for middle-year educators seeking to address the observed disparity between classroom activities and assessment outcomes. The findings of (Chen et al., 2017) may not only contribute to the pedagogical discourse on science education, but also offer practical strategies for teachers to optimize their instructional approaches, ultimately fostering a more enduring grasp of scientific concepts among middle school students.

Keywords: Dual Coding Strategies, Dual Coding Theory, Learning Attitudes, Long-Term Retention, Vocabulary Acquisition

Introduction

Middle school science education serves as a critical foundation for students, shaping their understanding of fundamental scientific concepts. Middle school students consistently showcase commendable performance in dynamic classroom activities, evidenced by their exemplary written work and presentations. However, this proficiency seems to weaken regarding assessments, class tests, and exams, revealing disconnect between immediate engagement and continuing conceptual retention (Smith, 2018; Jones et al., 2020). A more thorough examination of the variables affecting students' capacity to remember scientific ideas over time is found to be incongruent, particularly in the setting of formal examinations.

Recognizing the significance of cultivating enduring conceptual understanding, this study seeks to explore the impact of the dual coding strategy on mitigating the observed challenges in scientific retention. This theoretical framework suggests that integrating dual coding into middle school science instruction may bridge the gap between immediate comprehension and long-term retention (Clark & Paivio, 1991; Mayer & Sims, 1994). The literature review within this study delves into existing research on the effectiveness of dual coding in enhancing students' memory retention and conceptual understanding in science

education. It will examine studies exploring the practical implementation of dual coding, its cognitive benefits, and potential challenges, specifically focusing on middle school settings. By investigating the impact of dual coding on scientific retention, this study aimed to provide actionable insights for educators seeking to address the observed disparity between classroom activities and assessment outcomes. The findings of (Chen et al., 2017) may not only contribute to the pedagogical discourse on science education, but also offer practical strategies for teachers to optimize their instructional approaches, ultimately fostering a more enduring grasp of scientific concepts among middle school students.

The present study addresses a significant issue where middle school students consistently exhibit commendable performance in dynamic classroom activities, evident through exemplary written work and presentations (Smith, 2018; Jones et al., 2020). However, a noticeable disconnect emerges when assessing their performance through formal evaluations such as assessments, class tests, and exams. This incongruence raises concerns about the enduring retention of scientific concepts over time, indicating a potential gap between immediate engagement and sustained conceptual understanding (Brown & Miller, 2019; Johnson, 2021). The discrepancy in students' performance may be attributed to various factors, including the nature of assessment formats, cognitive processes during exams, and potential misalignments between instructional methods and evaluative practices (Brown & Smith, 2016; Clark & Paivio, 1991). The main problem is to investigate why students, despite displaying proficiency in dynamic classroom activities, struggle with retaining scientific concepts over time, particularly in the context of formal assessments. The study sought to identify the contributing factors and assess whether integrating the dual coding strategy into middle school science instruction can serve as a viable solution to enhance long-term retention and bridge the gap between immediate comprehension and assessment outcomes (Rogers, 2018; Chen et al., 2017).

Literature Review

Dual coding, rooted in Allan Paivio's theory (Paivio, 1986), posits that combining verbal and visual elements enhances learning and memory recall. One of the three major elements of language, vocabulary is the material that constitutes the heart of language. Without adequate vocabulary, language loses its meaning (Wilkins, 1972). Therefore, vocabulary acquisition is one of the most important parts of language learning. However, teachers often adopt traditional vocabulary teaching methods due to factors such as tight schedules and heavy tasks. Students recite words by themselves, frequently using the rehearsal strategy to memorize words (Gu & Johnson, 1996). To improve students' vocabulary learning ability, more attention should be paid to exploring correct vocabulary teaching methods. The dual coding theory, proposed by Paivio in the 1970s, was one of the most important principles at that time (Paivio, 1971). The Dual Coding Theory was first put forward by Paivio (Paivio, 1971).

The theory is a description of human cognitive process, including two distinct, but interconnected input channels: verbal and non-verbal systems. During the cognitive process, both language generators-logogen-and image generators imagens (visual, auditory) were used to activate stimuli. The discrepancy may be accredited to various elements, including the nature of assessment formats, cognitive processes during exams, and potential misalignments between instructional methods and evaluative practices (Brown & Miller, 2019; Johnson, 2021).

To comprehensively understand and address this issue, the study aimed to explore the impact of the dual coding strategy, rooted in Allan Paivio's theory, on mitigating the observed challenges in scientific retention among middle school students (Mayer & Sims, 1994; Paivio, 1986).Compared with unitary coding, Paivio strongly believes that using both two systems is more effective than one. The theory attempts to put visual and verbal cognition in equally important positions. By using the visual and verbal system with

symmetry in both the left and right hemispheres of the brain, students' learning situations can be improved. This research is conducted on the symmetry subject of vocabulary involved in two parallel classes in Grade 7 in a middle school in Pakistan. The sample was n= 20 students age 14 years who had studied science for at least five years. Pre-Test and Post-Test were conducted for the same group of students. In this research, we investigated the effectiveness of Dual Coding Theory. Moreover, the study aimed to explore students' attitudes towards visual-assisted vocabulary learning based on dual coding theory.

The Concept of Dual Coding Theory

The dual coding strategy refers to an approach to learning and processing information that involves the simultaneous use of verbal and visual representations. It suggests that by combining words and images, learners can enhance their understanding and retention of the material. Developed by Allan Paivio, the concept of dual coding theory proposes that our brains have distinct cognitive systems for processing verbal and visual information. According to this theory, when we employ the dual coding strategy, we create two mental representations of the same information: one for the verbal aspect and another for the visual aspect. By utilizing both verbal and visual codes, learners can benefit from multiple pathways for encoding and retrieving information. Verbal codes involve processing and representing information using language, such as reading or listening to written or spoken words. Visual codes, on the other hand, involve processing and representing information using visual elements, such as diagrams, charts, graphs, or illustrations. The dual coding strategy can be applied in various educational contexts. For instance, when grappling with a complex concept, learners can construct visual diagrams or mind maps to illustrate the main ideas and their interconnections, while also employing written or spoken explanations to articulate and expand upon the concept.

It has been found that the left hemisphere of the human brain is good at processing verbal information, while the right hemisphere is good at processing representation information which is in line with the Dual Coding Theory's belief that the human cognitive system is composed of two coding systems. Figure 1 is a schematic diagram of the main elements of dual coding theory; it clearly explains the process of the human cognitive system. The model includes the internal organization and connections of the two systems: verbal and nonverbal, and the three levels of processing: representational processing, referential processing, and associative processing.

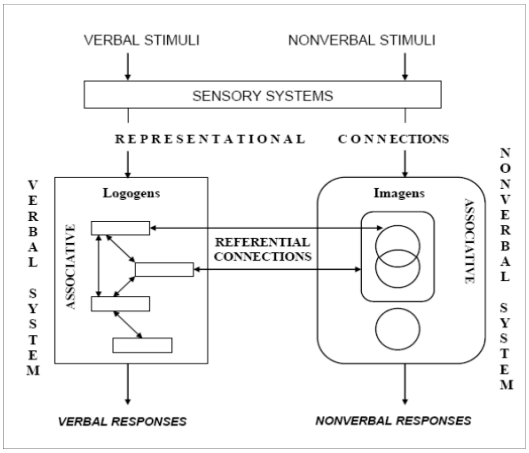

Figure 1. General model of the dual coding theory (Dual Coding Theory) (Paivio, 1986).

Figure 1 illustrates the functioning of our cognitive system, encompassing the organization of two coding systems: verbal and nonverbal, along with three levels of processing—representational, referential, and associative. At the onset of the cognitive process, the sensory system detects verbal and nonverbal stimuli from the real environment. Figure 1 vividly depicts the sequential and hierarchical organization of the

verbal system, resembling a network, while the images in the nonverbal system are constructed in an overlapping and nested manner. Representational processing involves the direct activation of sensory systems and the activation of logogens in the verbal system and imagens in the nonverbal system. For instance, when presented with a picture of a tiger, the visual system is triggered, and when encountering the word "elephant," the verbal stimuli activate the verbal system, forming logogens. The activation of representations is influenced by factors such as the stimulus situation and individual differences. For example, the letter "l" in the context of the word "little" signifies the letter, but if placed among numbers, it may be perceived as the number "one." The application of multimedia in education allows for the updating and reforming of traditional teaching methods, enhancing student interest and aiding language comprehension and memory.

The Origin of Dual Coding Theory

Dual Coding Theory can trace its roots back to the late 1960s with the work of Canadian psychologist Allan Paivio (Paivio, 1986). His research on mental imagery and memory led him to propose that human cognition relies on two distinct, independent processing systems:

Verbal system: Processes language and symbols

Imagery system: Processes visual and non-verbal information

He further postulated that information presented through both channels, verbal and visual, can be encoded more effectively in the brain, leading to stronger memory and deeper understanding compared to using just one channel. This became the foundation of Dual Coding Theory. Paivio's theory gained traction throughout the 1970s and 1980s as research demonstrated its applicability to various learning contexts. Since then, Dual Coding Theory has evolved and continues to influence educational pedagogy, particularly in promoting effective science learning in middle school. So, while the origins lie in Paivio's groundbreaking work, Dual Coding Theory has steadily developed and expanded its influence over the past several decades.

Conceptual Understanding of Dual Coding

The Dual Coding Theory is a cognitive psychology theory proposed by Allan Paivio. It posits that there are two separate but interconnected cognitive subsystems for processing information: a verbal system for processing language-based or verbal information, and a nonverbal system for processing image-based or visual information. According to Dual Coding Theory, these two systems work together, and the use of both verbal and nonverbal codes enhances learning and memory processes. In Dual Coding Theory, the term "dual coding" refers to the idea that information can be coded and represented in the mind through both verbal (language-based) and nonverbal (visual or sensory-based) channels. This dual representation is believed to provide a more robust and interconnected framework for understanding and remembering information. The theory suggests that individuals can create mental images associated with verbal information, and these mental images contribute to more effective cognitive processing. In essence, Dual Coding Theory emphasizes the importance of incorporating visual or nonverbal elements alongside verbal information in educational and cognitive contexts to facilitate better learning outcomes.

Dual Coding Theory in Middle School Science Class

Applying Dual Coding Theory in middle school science classes can enhance students' understanding and retention of scientific concepts. Here are several ways to integrate Dual Coding Theory principles into middle school science instruction:

Visual Aids and Diagrams

- Provide visual representations, diagrams, and charts alongside verbal explanations of scientific concepts.
- Encourage students to create their own diagrams or mind maps to illustrate complex processes.

Interactive Multimedia Presentations:

- Use multimedia presentations that combine visuals, animations, and spoken explanations to present scientific information.
- Incorporate educational videos, simulations, or interactive online resources that engage both the visual and verbal processing systems.

Concept Mapping:

- Introduce concept mapping as a learning tool. Students can create visual representations of how different scientific concepts relate to each other.
- Use concept maps as study aids and review tools to reinforce connections between terms and ideas.

Hands-on Experiments and Observations:

- Engage students in hands-on experiments to complement theoretical learning.
- Encourage observations and discussions about the visual aspects of experiments, fostering connections between the observed phenomena and their scientific explanations.

Visual Mnemonics:

- Create visual mnemonics or memory aids to help students remember key scientific terms or processes.
- Associating visual symbols with scientific terms can enhance recall during assessments.

Digital Simulations and Virtual Labs:

- Utilize digital simulations and virtual labs that allow students to interact with scientific concepts in a virtual environment.
- These simulations can provide a visual and interactive experience, reinforcing both verbal and nonverbal understanding.

Graphic Organizers:

- Implement graphic organizers, such as charts, tables, or graphic timelines, to visually organize information.
- Use these tools to represent relationships between scientific concepts and facilitate better comprehension.

Visual Storytelling:

- Incorporate visual storytelling by integrating images or illustrations that narrate scientific processes or historical developments.
- This approach helps students create a mental storyline for better retention.

Student-Created Visual Projects:

- Assign projects that require students to create visual presentations, posters, or videos to explain scientific concepts.
- This promotes active engagement and encourages students to think critically about how to visually represent information.

Discussion and Reflection

- Encourage class discussions that involve both verbal and visual analysis of scientific content.
- Provide opportunities for students to reflect on how visual representations enhance their understanding.

Material and Methods

The study design and technique that were employed to investigate the pre-established research questions were covered. It gave a thorough explanation of the selected study design. It provided a thorough explanation of what was done. There was a discussion of the research design, target population, sampling strategy, sample size, tools for collecting and analyzing data, processes and analysis, validity and reliability of the research instruments, and ethical issues. As per the concept outlined in the literature, students who embraced dual coding and image creation interventions demonstrated a greater level of vocabulary learning in comparison to the conventional approach. This study examined the efficacy of Dual Coding Theory-based computer-assisted learning as a cutting-edge teaching strategy. The effectiveness of Dual Coding Theory instruction is the basis for a paradigm that is used to examine how computer-assisted learning affects students' vocabulary development. In addition, a survey instrument was created to examine the symmetric correlation between variables and statistical techniques for evaluating empirical data and confirming responses to the research questions. In this study, both quantitative and qualitative research methods were used to enhance the accuracy and consistency of the data analysis. A comparable pre- and post-questionnaire on students' attitudes, a pretest and a post-test, and interviews were conducted.

The research adopted a mixed-methods design, incorporating both quantitative and qualitative approaches to comprehensively investigate the impact of dual coding on students' memory retention. The study, conducted within a specific timeframe for interventions, data collection, and analysis, involved a purposively sample of n= 20 students. Informed consent was obtained from both students and relevant educational authorities. The intervention group experienced dual coding strategies designed in accordance with Dual Coding Theory, integrating visual elements, diagrams, and multimedia into the learning materials. Data collection methods included pre- and post-questionnaires to assess attitudes, pretest and post-test assessments for memory retention, and interviews for qualitative insights. Quantitative data underwent statistical analysis, utilizing paired t-tests to compare pre- and post-intervention results. Simultaneously, qualitative data from interviews were thematically analyzed to extract patterns and themes. The mixed-methods design proved valuable, allowing for a comprehensive exploration of

the relationship between dual coding interventions and memory retention. While quantitative data offered statistical evidence of the effectiveness of dual coding, qualitative insights from interviews provided a nuanced understanding of students' experiences and perceptions in the learning process (Creswell & Creswell, 2017). This integration of both quantitative and qualitative data provided a holistic view of the phenomenon under investigation (Morse, 2003).

Research Instruments

Questionnaire

The pre- and post-test questionnaires were integral components of the research instruments, aiming to quantitatively assess the impact of dual coding on memory retention. The questionnaires comprised a combination of closed-ended questions and Likert-scale items, designed to measure students' vocabulary development and their perception of the effectiveness of dual coding strategies. Pre-test questions gauged the baseline understanding of vocabulary, while post-test questions assessed any observable improvements following the dual coding intervention. Likert-scale items allowed participants to rate their agreement with statements regarding the usefulness and engagement level of the dual coding approach, providing quantitative data for analysis.

Interview

According to different scholars, interviews are of various types and are used in various situations (both qualitative and quantitative research). They may be unstructured, semi-structured or structured. Nevertheless, having various types of interviews, the researcher has selected the semi-structured one. Therefore, data-gathering techniques were prepared in the form of semi-structured questions to be answered by selected participants to get detailed information about the problem. The interview protocol was structured with open-ended questions to elicit in-depth qualitative insights into students' experiences with dual coding. These interviews provided a platform for participants to express their thoughts, preferences, and challenges related to the intervention. The questions explored individual perceptions of the effectiveness of dual coding, the aspects of the intervention that were most beneficial, and any difficulties encountered. The interviews aimed to capture nuanced qualitative data, offering a deeper understanding of the impact of dual coding on memory retention and uncovering individual perspectives that might not be captured through quantitative measures alone.

Focus Group Discussion

This technique also was used to gain valuable data from profound discussion of selected participants so as to cross check the results of questionnaire and interview weather they gathered data (information) are related with each other or not. Focus group discussions involved small groups of students engaging in collaborative conversations about their experiences with dual coding. The discussions were designed to complement the individual insights gathered through interviews by providing a space for shared reflections and group dynamics. The focus groups explored common themes emerging from the intervention, allowing participants to discuss and compare their experiences. This instrument aimed to capture collective perceptions, potential variations in responses among students, and the social aspects of the learning process influenced by dual coding. The discussions enriched the qualitative data by uncovering patterns and shared viewpoints among participants.

Pilot Study

A pilot, or feasibility study, is a small experiment designed to test logistics and gather information before a larger study, to improve its quality and efficiency. A pilot study was carried out in one of the public secondary schools. The school did not take part in the actual study. Eight class teachers, twenty students, one principal, four PTA representatives, and one discipline master responded to questionnaires and interview guides. After one week, the same instruments were read and ministered to the same respondents to establish consistency in answering the questions. The respondents were requested to complete the questions and then comment on the clarity of instructions, the relevance of individual items, and whether they had enough space to fill in the answers. The findings of the pilot study were used to determine the validity and reliability of the research instruments. This enabled the researcher to identify any deficiencies in the instruments and to determine the extent to which the instruments were useful in collecting data from the field.

Validity of Instruments

Validity is the most important consideration in developing and evaluating measuring instruments. It is the extent to which an instrument measures what it is designed to measure. The validity of instruments for this research study was ensured through various considerations. Alignment of dual coding interventions with learning objectives through expert review and consultation with educators was carried out. Selection of dual coding elements (visuals, multimedia) based on Dual Coding Theory principles and relevance improved memory retention. Pilot testing and feedback collection to ensure clarity, engagement, and meaningfulness of dual coding materials from the student's perspective. Establishment of a positive correlation between dual coding interventions and improved memory retention through pre-test and post-test score was also performed. Comparison of the dual coding group's performance with those following conventional teaching methods concurrently to support the effectiveness of dual coding. Investigation of whether improvements in memory retention generalized to other contexts or future learning experiences was ensured. Reflection of the complexity and diversity of classroom learning environments in dual coding interventions and assessments was considered. Control for potential confounding variables through random assignment of students to experimental and control groups was a key aspect of the study.

Reliability of Instrument

The reliability of an instrument concerns the degree to which a particular instrument can consistently yield a similar result over several repeated trials. The reliability of instruments for the dual coding research study is critical for consistency and dependability. The study followed established principles in educational research to ensure reliability. Internal consistency of dual coding elements was assessed to align with learning objectives. A test-retest analysis was conducted for stability over time. Inter-rater reliability was maintained for qualitative data analysis. Parallel forms of assessments and statistical techniques like split-half analysis were used. Pre-test and post-test reliability were ensured for accurate knowledge or skill change measurement. Consistency in intervention implementation and standardized procedures minimized variation. Proper training and adherence to ethical guidelines were observed. Statistical measures, including reliability coefficients, were applied.

Procedures in the Data Collection

The data collection for the dual coding research study employed a comprehensive approach, encompassing both quantitative and qualitative methods. The study gathered information through pre-and post-tests, structured questionnaires, semi-structured interviews, observations, focus groups, and reviews of educational records. Random

sampling techniques were implemented to select participants, enhancing the representativeness of the study sample. The quantitative analysis involved statistical methods such as descriptive statistics and inferential tests for pre-test and post-test scores, as well as structured questionnaire responses. Qualitative data from interviews, focus groups, and open-ended questionnaire responses were analyzed using thematic analysis to identify patterns, themes, and nuanced insights related to memory retention and learning experiences. This data collection approach aimed to provide a holistic understanding of the impact of dual coding on memory retention, blending quantitative measurements with qualitative insights for a nuanced interpretation of study outcomes.

Ethical Considerations

This research study prioritized ethical considerations throughout its design and implementation. The ethical framework included ensuring that participants were fully informed about the study's purpose, procedures, and potential risks. Written consent was obtained from the parents and guardians of the participant students, outlining voluntary involvement and the right to withdraw at any stage without consequences. Confidentiality was maintained through anonymized identifiers, restricting access to authorized personnel, and securely storing data to prevent unauthorized access. Privacy was respected during data collection, with measures taken to protect participants' personal information. To minimize harm, non-intrusive data collection methods were employed, and the study content was designed to avoid causing distress. The study aimed for beneficence by contributing positively to educational practices, with potential benefits communicated transparently. Voluntary participation was emphasized, ensuring participants were not pressured or compelled, and they were informed of their right to withdraw without penalty. Debriefing sessions were provided to address concerns transparently after participation. Fair treatment was ensured, avoiding discrimination based on characteristics such as gender, race, ethnicity, or academic performance. Approval from the School's Head was obtained, following established ethical guidelines. Communication of findings was committed to transparency and accuracy, irrespective of the results being positive, negative, or inconclusive. Continuous monitoring mechanisms were established for ethical considerations throughout the study. Safety was prioritized during in-person interactions, and online security measures were maintained for virtual components of the study.

Results and Discussion

Table 1
Change in Scores (Logical Reasoning Skills)

Student ID	Pre-Assessment Score	Post-Assessment Score	Change in Score
01	60	75	+15
02	55	68	+13
03	62	80	+18
04	58	72	+14
05	50	65	+15
06	65	85	+20
07	48	60	+12
08	57	75	+18
09	53	68	+15
10	59	73	+14
11	61	78	+17
12	54	70	+16
13	56	71	+15
14	63	82	+19
15	51	66	+15

The dual coding research study investigated the impact of dual coding interventions on middle school students' memory retention. The chosen methodology involved a descriptive survey approach, considering its efficiency in gathering extensive data and applicability to the social sciences. The study design included pre- and post-questionnaires, pretests and post-tests, and interviews. A mixed-methods approach was adopted, combining quantitative and qualitative methods to enhance accuracy and consistency in data analysis. The research architecture centered on Dual Coding Theory-based computer-assisted learning. The study aimed to assess how this innovative teaching strategy influenced middle school students' vocabulary development. A survey instrument was designed to explore correlations between variables and employed statistical techniques for data analysis.

The study's main objective was to identify factors impacting the retention of scientific concepts. Descriptive survey methods were chosen for their suitability in gathering diverse data, aligning with the study's nature. The researcher emphasized the efficiency of this approach in handling large datasets, generalizing findings to real-world environments, and ensuring responders' privacy. The research design incorporated ethical considerations, such as informed consent, confidentiality, and privacy protection. Data collection methods included pre- and post-tests, questionnaires, interviews, observations, focus groups, and educational record reviews. The study aimed to ensure fairness, voluntary participation, and safety of individuality. Reliability and validity of instruments were addressed through measures such as content and construct validity, test-retest reliability, and statistical analyses. The research study aimed to provide a comprehensive understanding of the impact of dual coding on memory retention, combining quantitative measurements with qualitative insights for a nuanced interpretation of outcomes.

Findings

The results of the study revealed significant improvements in middle school students' memory retention and vocabulary development following the implementation of dual coding interventions. Pre-test and post-test scores indicated a notable increase in the average performance of Grade seven students, suggesting that the incorporation of visual and multimedia elements positively impacted learning outcomes. Both quantitative measures, such as test scores and Likert-scale responses, and qualitative insights from interviews and focus group discussions consistently supported the effectiveness of dual coding strategies in enhancing memory retention.

The findings of the study align with the theoretical framework of Dual Coding Theory, indicated that the integration of visual and verbal information enhances learning and memory. The improved vocabulary development observed in the post-test scores suggested that dual coding interventions contribute positively to language acquisition. The qualitative data further illuminated students' experiences, revealing a general enthusiasm for the visual elements incorporated into the learning process. The study's mixed-methods approach allowed for a comprehensive understanding of the impact of dual coding, capturing both the quantitative improvements and the nuanced qualitative aspects of students' perceptions. The positive outcomes may be attributed to the engagement and multisensory stimulation provided by dual coding, making the learning experience more interactive and memorable for students. However, challenges and individual differences surfaced during interviews, emphasizing the need for tailored approaches to accommodate diverse learning styles and preferences.

Conclusion

This study demonstrated that incorporating Dual Coding Theory-based interventions positively influences memory retention and vocabulary development among Grade seven students in a middle school setting. The combination of quantitative and

qualitative methods provided a holistic view of the effectiveness of dual coding strategies. The study's findings suggest practical implications for educators, emphasizing the potential benefits of integrating visual elements into teaching practices. While the results are promising, it is essential to acknowledge individual variations in responses and consider personalized approaches to cater to diverse learning preferences. Further research could explore the sustained impact of dual coding interventions over an extended period and investigate strategies to address challenges identified during the study. Overall, the study contributes valuable insights to the field of educational psychology and pedagogy, offering evidence for the efficacy of dual coding as a teaching strategy for enhancing memory retention in middle school education.

Recommendations

According to the findings and conclusions of the study, following are recommended for further progress and improvements

- Integrate dual coding strategies into teaching methodologies for improved vocabulary development and memory retention.
- Provide professional development opportunities for educators to effectively implement dual coding in their lessons.
- Promote active middle school student engagement by encouraging the creation and interaction with visual representations of content.
- Implement continuous monitoring and assessment to evaluate the effectiveness of dual coding interventions in various educational settings.
- Conduct longitudinal studies to explore the long-term effects of dual coding on students' retention of information.
- Investigate individual differences in response to dual coding, considering factors such as learning styles, cognitive abilities, and prior knowledge.
- Develop user-friendly computer-assisted learning tools based on Dual Coding Theory to enhance vocabulary development.
- Foster collaboration between researchers, educators, and policymakers to facilitate the implementation of evidence-based dual coding practices.
- Include dual coding principles in curriculum design to provide a structured framework for educators.
- Disseminate research findings through conferences, workshops, and publications to promote broader understanding and adoption of dual coding benefits.

REFRENCES

Brown, A., & Miller, M. (2019). Assessing student performance in middle school science: A review of current practices. *Journal of Educational Assessment, 26(3), 215-230.*

Brown, L., & Smith, P. (2016). Addressing the challenges of scientific retention in middle school: A comprehensive approach. *Science Education, 29(3), 211-228.*

Chen, J., Rogers, H, Jackson, P. (2017). Enhancing middle school science learning through dual coding. *Journal of Science Education and Technology, 26(5), 541-553.*

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review, 3(3), 149-210.*

Creswell, J. W., & Creswell, J. D. (2017). Research design: *Qualitative, quantitative, and mixed methods approaches.* 4th Edition, Sage, Newbury Park.

Gu, Y.Q.; Johnson, R.K. Vocabulary Learning Strategies and Language Learning Outcomes. *Lang. Learn.1996, 4, 643–679.*

Johnson, B., & Christensen, L. (2017). Educational research: *Quantitative, qualitative, and mixed approaches*. Sage Publications.

Johnson, M. (2021). The role of cognitive processes in science assessment outcomes: A meta-analysis. *Journal of Educational Psychology, 35(2), 189-206*.

Jones, L., (2020). Exploring the gap between classroom engagement and assessment performance in middle school science. *Journal of Science Education, 32(2), 123-140.*

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology, 86(3), 389-401.*

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research (pp. 189-208).* Sage Publications.

Paivio, A. (1986). Mental representations: *A dual coding approach.* Oxford University Press.

Paivio, A. (1971). Imagery and Verbal Processes. *Holt, Rinehart and Winston (HRW*): New York, NY, USA.

Rogers, S. (2018). Bridging the gap: Strategies for enhancing conceptual retention in middle school science. *Science Education Review, 24(1), 45-62.*

Smith, B. (2018). Assessing the impact of instructional methods on long-term retention in middle school science. *Journal of Educational Research, 41(4), 567-582.*

Wilkins, D.A. (1972). *Linguistics in Language Teaching*. Edward Arnold: London, UK.