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Research Paper

Theoretical frameworks and empirical evidences of tactile learning style as a veritable tool for improving biology performance among secondary school students

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ABSTRACT

This position paper explored the theoretical frameworks and empirical evidence supporting the use of tactile learning style as an effective tool for improving biology performance among secondary school students. It highlighted the significance of biology education and the advantages of considering tactile learning style, such as hands-on activities and manipulatives, during instructions to improve student engagement, motivation, and understanding of complex concepts. The methodology involved review of existing theoretical frameworks and empirical studies from peer-reviewed journals, books, and educational reports, focusing on the impact of tactile learning style. The paper reviewed key theories, including Kolb's Experiential Learning Theory and Gardner's Multiple Intelligence Theory, and presented findings from various studies proving the impacts of tactile learning on academic performance. The study concluded that the tactile learning style plays an important role in improving biology instruction in secondary schools. Some of the suggestions made include given due consideration to tactile learners during instruction, further research and professional development for biology teachers.

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1. INTRODUCTION

Biology is a science subject that provides an understanding of the living world and its processes. It is an essential subject for secondary school students in many countries, including Nigeria, as it prepares them for higher education and careers in science and health-related fields. Achieving a good level of biology performance is important for students to succeed academically and professionally. Yet, according to [1], there has been widespread criticism of students' low performance in biology in secondary schools. Research has shown a positive correlation between tactile learning style and biology performance among secondary school students. For instance, studies by [2], [3] found that incorporating tactile learning activities in biology instruction improved student performance and engagement.

Tactile learning style, also known as kinesthetic learning, involves active physical activities and hands-on learning experiences [4], [5]. Studying tactile learning style in biology instruction is significant as it helps educators design effective learning activities that meet the needs of tactile learners [6]. Incorporating tactile learning activities in the biology classroom can enhance student engagement, motivation, and understanding of complex concepts [4]. According to the Visual-Auditory-Kinesthetic (VAK) model, which categorizes learning styles into visual, auditory, reading/writing, and kinesthetic, tactile learners make up a significant portion of the population [7].

According to [8], Dunn and Dunn indicated that approximately 20-30% of school-aged children have an auditory learning style, about 40% are visual learners, and around 30-40% have a tactile/kinesthetic or visual/tactile learning style. This implies that students have individual learning preferences that impact how they recognize, remember, and retrieve information [9], [4], [6]. Matching learners' learning styles with the learning environment and available resources can lead to improved learning outcomes. Research has shown that students with a tactile learning style often struggle in traditional classroom settings that rely heavily on lectures and reading assignments [4]. They benefit from interactive and physical activities, such as laboratory experiments, field trips, and group projects, which allow them to engage with the material in a hands-on manner. By incorporating tactile learning strategies into biology instruction, teachers can provide a more inclusive and effective learning environment for all students, especially those with tactile learning preferences.

2. RELATED WORK

2.1 The Concept of Tactile Learning Style

Learning style refers to how a learner focuses, comprehends, and remembers new and challenging information. Akhmedjanova defined learning style as the capability of learners to receive and comprehend information within the context of learning situations. Akinbobola [8] argued that learning style is shaped by both innate traits and external factors. According to, the three most prevalent learning styles are visual, auditory, and tactile (kinesthetic). The tactile learning style involves the use of hands-on experiences and physical activities to enhance the retention of information. It is a type of learning style in which individuals learn best through physical interaction and manipulation of objects [4]. Understanding the tactile learning style is important for biology teachers as it allows them to design instruction that is more inclusive and effective for all students.

2.2 Characteristics of Tactile Learners

Tactile learners, also known as kinesthetic learners, have unique characteristics that distinguish them from other learners [10]. Tactile learners prefer to learn through movement and touch, which can help them process and retain information more effectively. They thrive in environments that allow them to manipulate objects, conduct experiments, and engage in physical activity [9]. Tactile learners often struggle in traditional classroom settings that rely heavily on lectures and reading assignments [4]. They benefit from the use of manipulatives, such as models and diagrams, as well as laboratory experiments and field trips. Tactile learners may struggle with abstract or theoretical concepts without concrete and tangible experiences [10]. They tend to be very hands-on and prefer to learn through active exploration of real-

world objects and materials (experimentation) [11], [12]. Tactile learners may become easily bored or disengaged during passive or lecture-based instruction and may benefit from opportunities to interact with the material in a more physical or tactile way [10]. Understanding the characteristics of tactile learners is crucial in the teaching of biology to create effective learning environments that cater to the diverse learning needs of students, thereby supporting their academic success [13].

2.3 Theoretical Framework for Tactile Learning Style and Biology Performance

Theoretical frameworks provide a structured and systematic approach to understanding the complex relationship between tactile learning style and biology performance in secondary school students. Six theoretical frameworks are presented to guide research and practice in this area:

2.4 Kolb's Experiential Learning Theory (ELT)

Kolb's Experiential Learning Theory (ELT) explains how individuals learn through experience [13]. According to theory proposed by [14], learning is most effective when it involves a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. The tactile learning style aligns well with Kolb's ELT, as it emphasizes hands-on learning experiences and the use of the senses in the learning process to better retain and apply information. Aligning with Kolb's ELT in tactile learning strategies can be a valuable tool for improving biology performance among secondary school students.

2.5 Dunn and Dunn Model of Learning Styles

The Dunn and Dunn model emphasizes individualized learning strategies that match students' unique learning preferences [15]. The model, developed by Rita Dunn and Kenneth Dunn, suggests that individuals have unique learning styles influenced by biological, environmental, and experiential factors. It identifies five sensory modalities: visual, auditory, kinesthetic, tactile, and olfactory [15]. Incorporating tactile learning activities into the biology classroom can address the kinesthetic-tactile modality identified by [16] model to cater to the needs of learners who prefer this modality.

2.6 Cognitive Load Theory (CLT)

John Sweller's Cognitive Load Theory (CLT) posits that individuals' working memory has limited capacity, and teaching techniques should be designed to prevent overloading it and enhance learning outcomes [17]. Tactile learners may have higher cognitive load when learning through traditional lectures or reading, as their preferred learning style involves physical interaction and hands-on experience [18]. Incorporating tactile learning strategies into instruction can help reduce cognitive load and increase learning efficiency for tactile learners.

2.7 Gardner's Multiple Intelligence Theory

Howard Gardner's Multiple Intelligence Theory proposes that intelligence is not a single entity but a collection of different types of intelligences, each relatively independent of the others [19]. Gardner initially proposed seven intelligences, later adding an eighth, naturalistic, and discussing the possibility of a ninth, existential. Tactile learning style emphasizes touch and physical interaction, engaging bodily-kinesthetic intelligence. Rooting tactile learning style in the biology classroom from this theory can provide a useful framework and practical implications in understanding the diversity of students' intelligence, thereby forming the basis for improved performance in biology among secondary school students.

2.8 Visual-Auditory-Kinesthetic (VAK) Learning Styles Model

The VAK model, developed by Neil Fleming and Colleen Mills [9], categorizes learners into three types based on their preferred mode of receiving and processing information: visual, auditory, and kinesthetic [5]. The model suggests that understanding these styles can help teachers create effective lesson plans that cater to individual students' strengths [9]. Incorporating VAK strategies in biology instruction may benefit tactile learners who share a focus on experiential, hands-on learning experiences.

2.9 Constructivism Approach

Constructivist theory, pioneered by Piaget, posits that learners construct their understanding of the world based on their experiences, and learning is a process of actively constructing knowledge rather than passively receiving it [20]. The role of the teacher is to facilitate this process by providing a supportive learning environment and opportunities for learners to explore, experiment, and reflect on their experiences [21]. In the context of tactile learning style and biology performance, constructivism suggests that students are more likely to retain information and develop a deeper understanding of biological concepts when they are actively engaged in hands-on experiences. By providing opportunities for students to explore and manipulate biological concepts through tactile activities, instructors can facilitate the construction of meaning and enhance students' conceptual understanding.

3. METHODOLOGY

This position paper employed a review methodology, analyzing existing theoretical frameworks and empirical studies on tactile learning styles and biology performance among secondary school students. The syntheses of the literature in this paper involved several steps, ensuring a thorough review of existing literature.

3.1 Data Sources and Search Strategy

Academic databases such as Google Scholar, JSTOR, ScienceDirect, and ERIC were searched to identify relevant peer-reviewed articles, conference papers, theses, and academic books published. Keywords used in the search included "tactile learning," "kinesthetic learning," "biology education," "secondary school students," "hands-on activities," and "learning styles." The search aimed to gather a wide range of studies that explored the relationship between tactile learning styles and student performance in biology.

3.2 Inclusion and Exclusion Criteria

To ensure the relevance and quality of the selected studies, specific inclusion and exclusion criteria were established. Studies were included if they:

- Investigated the relationship between tactile learning styles and biology performance.
- Focused on secondary school students.
- Were published in peer-reviewed journals or as conference papers, theses, or academic books.
- Provided empirical data or theoretical analysis related to the topic.

3.3 Studies Were Excluded If They:

- Did not focus on secondary education.
- Lacked empirical data or methodological rigor.
- Were reviews or meta-analyses without primary data.

3.4 Data Extraction and Analysis

Data from the selected studies were extracted systematically from existing literature., focusing on key variables "tactile learning," "kinesthetic learning," "biology education," "secondary school students," "hands-on activities," and "learning styles. Theoretical frameworks supporting tactile learning, such as Kolb's Experiential Learning Theory and Gardner's Multiple Intelligence Theory, were also identified and examined. The extracted literature was then synthesized thematically. Special attention was given to how tactile learning styles influence student engagement, motivation, and understand complex biological concepts.

3.5 Evaluation of Tactile Learning Strategies

The effectiveness of various tactile learning strategies was evaluated based on the empirical evidence provided in the selected studies. Strategies such as hands-on laboratory activities, use of models

and diagrams, incorporation of digital technologies like virtual and augmented reality, group work, and real-life applications were synthesized for their impact on student performance and retention of knowledge.

3.6 Synthesis of Findings

The findings from the literature were synthesized to provide an understanding of the impact of tactile learning styles on biology performance. This synthesis included:

1. A discussion of the theoretical frameworks that support the use of tactile learning in biology education.
2. An evaluation of empirical evidences demonstrating the positive effects of tactile learning on student performance.
3. Practical suggestions for incorporating tactile learning into biology instruction, based on successful strategies identified in the literature.

Although this study did not involve primary data collection, ethical considerations were adhered to by accurately representing the findings of the reviewed studies and acknowledging all sources of information. The integrity of the review process was maintained by following rigorous academic standards in the selection, analysis, and reporting of the literature.

4. RESULTS AND DISCUSSION

Literature findings were synthesized under three headings: empirical studies on the impact of tactile learning style on biology performance, strategies for incorporating tactile learning in biology instruction and, implications and future directions for research and practice.

4.1 Empirical Studies on the Impact of Tactile Learning Style on Biology Performance

Numerous empirical studies have investigated the impact of tactile learning style on biology performance among secondary school students. A review of these studies reveals that tactile learning style can have a significant positive impact on biology performance, particularly when instruction is tailored to meet the unique needs and preferences of learners. For example, a study by [21] found that tactile learners demonstrated higher levels of knowledge retention and deeper understanding of complex biological concepts when instruction included hands-on activities and manipulatives. Similarly, a study by [22] found that students who received tactile-based instruction outperformed their peers in terms of knowledge acquisition and retention, as well as critical thinking and problem-solving skills. Another study by [23] found that tactile learners benefited from instruction that incorporated visual aids, such as diagrams and charts, in addition to hands-on activities. The researchers suggested that these types of visual aids can help tactile learners better understand abstract biological concepts and make connections between different pieces of information.

A study by [3] found that tactile learners had higher levels of engagement and motivation when instruction incorporated hands-on activities and tactile materials. The researchers suggested that this increased engagement and motivation may contribute to higher levels of knowledge retention and better performance in biology. Similarly, a study by [24] found that tactile learners who were taught with the aid of interactive whiteboards and other tactile materials achieved higher levels of understanding and retention of biological concepts compared to their peers who were taught with traditional lecture-style instruction. Another study by [25] found that tactile learners who were taught with the aid of virtual reality tools had higher levels of knowledge retention and understanding of complex biological concepts than their peers who were taught with traditional instruction methods. A study by investigated the effect of tactile-based instruction on the learning outcomes of college students in an introductory biology course. The study found that students who received instruction that incorporated tactile elements, such as hands-on laboratory activities and the use of models and diagrams, achieved significantly higher scores on assessments of their understanding of biological concepts compared to students who received traditional lecture-style instruction.

A study by [2] also found that incorporating tactile-based instruction into biology classrooms can lead to increased levels of student engagement and motivation. The study compared the learning outcomes of two groups of students in an introductory biology course, one group that received traditional instruction and one group that received instruction that incorporated tactile elements. The study found that the group that received tactile-based instruction had higher levels of engagement and motivation, as well as higher levels of performance on assessments of their understanding of biological concepts. A study by [26] found that incorporating tactile-based instruction into a high school biology classroom had a positive effect on students' attitudes towards science. The study compared the attitudes of two groups of students towards science, one group that received traditional instruction and one group that received instruction that incorporated tactile elements. The study found that the group that received tactile-based instruction had more positive attitudes towards science, as well as higher levels of performance on assessments of their understanding of biological concepts.

However, there few numbers research that reported negative effect of tactile learning style. For instance; a study by [5] analyses the correlation of the different learning styles on the achievement in biological science among 375 secondary school students using learning styles questionnaire and biological science achievement test. The findings of the study revealed that, Visual learning styles were found to have positive high correlation in the achievement than the other learning styles (tactile learning style inclusive). Again, a study conducted by [13] investigated the relationship between learning styles and academic performance in biology among Nigerian secondary school students. The study revealed a negative correlation between visual and kinesthetic (tactile) learning styles and academic performance in biology, while a positive correlation was observed with auditory learning style. The study further revealed no significant differences between male and female biology students' performance in terms of their visual, auditory, or kinesthetic (tactile) learning styles.

4.2 Strategies for Incorporating Tactile Learning in Biology Instruction

Recent research studies like [1], [25], [27], [28], [29] have highlighted a variety of strategies for incorporating tactile learning in biology instruction, aimed at enhancing student engagement, performance and retention. Some of these strategies are briefly explained.

- **Hands-on Laboratory Activities:** Studies like [27] have shown that incorporating hands-on laboratory activities into secondary school biology instruction improved students' understanding of biological concepts and increased their motivation to learn. This allows students to manipulate materials [11] and engage in active learning.
- **Use of Models and Diagrams:** Using models and diagrams that students can physically manipulate to explore biological concepts [11] and [29]. For example, a study by [28] found that the use of 3D models in school biology instruction increased students' understanding of the structure and function of biological systems. Matazu [1] also found that, students taught biology using relevant instructional resources performed better and retained more knowledge than those taught using conventional method without instructional materials.
- **Incorporating Digital Technologies:** Incorporating digital technologies such as virtual reality or augmented reality, is another strategy that has shown promise in enhancing tactile learning in biology instruction. Studies like [25] have revealed that the use of augmented reality (or virtual reality) in biology instruction improved students' understanding of biological concepts, increased their engagement and interest to learn.
- **Group Work and Collaboration:** Encouraging group work and collaboration among students through activities that involve building models or conducting experiments. A study by [30] found that group work and collaboration in biology instruction improved students' critical thinking and problem-solving skills.
- **Real-Life Applications:** Incorporating real-life applications of biological concepts, such as case studies or field trips, to provide tactile learners with practical, hands-on experiences. Field trips in biology instruction improved students' attitudes towards science and their understanding of concepts in biology [31].

- **Multisensory Approach:** Incorporating a multisensory approach to biology instruction, which includes visual, auditory, and kinesthetic elements, has been reported by [6], [29] to improved students' understanding and recall of biological concepts.
- **Use Variety of Teaching Methods:** More so, another approach is to use a variety of teaching methods such as demonstrations, discussions, laboratory activities etc. These strategies can be combined depending on the specific content and objectives of the biology curriculum in order to meet the diverse learning needs of students in bid to improve their academic performance [13], [6].

4.3 Implications and Future Directions for Research and Practice

The review of related literature revealed several implications and prospects for future research and practice. Firstly, there is a need for further exploration into the effectiveness of tactile learning strategies across different student populations and educational settings. Integrating tactile approaches into teacher training programmes [32] and curriculum development could enhance biology instruction. Future studies should also investigate the long-term effects of tactile learning on student motivation, engagement, and academic achievement in biology. These efforts could lead to more inclusive and effective educational practices that benefit a diverse range of learners in secondary school biology education.

5. CONCLUSION

The study concluded that the tactile learning style plays a significant role in improving biology instruction in secondary schools. By incorporating tactile activities, teachers can improve student engagement, motivation, and comprehension of complex biological concepts. Theoretical frameworks such as Kolb's Experiential Learning Theory and Gardner's Multiple Intelligence Theory support the adoption of tactile learning style in instruction. Empirical evidence recognized the positive impact of tactile learning on student performance. Maximizing these advantages requires investment in teacher professional development, curriculum design, and further research.

5.1 Suggestions

The following suggestions are put forward for effective consideration of tactile learning style in biology instruction for improvement.

1. Biology teachers should provide opportunities for students to explore and manipulate biological concepts through tactile activities such as hands-on laboratory experiments, dissections, and model building. This will help students gain a deeper understanding of complex biological processes.
2. Teachers should incorporate diagrams, charts, and other tactile materials into their instruction. Visual aids combined with tactile experiences can enhance students' comprehension and retention of biological information.
3. Policy makers should invest in professional development programs for teachers, focusing on effective ways to incorporate tactile learning into biology instruction. Training should include practical workshops and resources to support teachers in creating a tactile-rich learning environment.
4. Educational authorities should integrate tactile learning strategies into the biology curriculum. This includes developing and providing curriculum guides that emphasize the importance of tactile learning and suggest specific activities and materials to be used in the classroom.
5. Researchers should investigate the effectiveness of different tactile learning strategies on various age groups and diverse populations of students. This will help identify the most effective approaches for different student demographics and inform future educational practices.
6. Schools should encourage collaboration among teachers to share best practices and successful strategies for implementing tactile learning in biology education. Creating a community of practice can foster innovation and improve teaching methods across educational institutions.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Suleiman Sa'adu Matazu	✓	✓	✓	✓		✓		✓	✓	✓	✓			
Akilu Isma'il		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

Not Applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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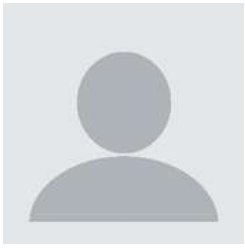
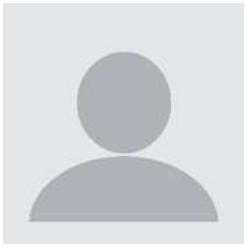
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