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TACTILE TEACHING STRATGIES: CONCEPTUAL UNDERSTANDING IN GRADE 10 SCIENCE

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Abstract: This study investigated the effectiveness of tactile teaching strategies in enhancing the conceptual understanding of Grade 10 Science learners. As it was anchored in Kolb's Experiential Learning Theory, Bruner's Discovery Learning and Theory of Instruction, and Constructivist principles, this study used a quantitative quasi-experimental one-group pretest and posttest design involving five intact classes consisting of 210 learners of Bitoon National Vocational High School, Dumanjug, Cebu. All data were collected using a validated assessment instrument and analyzed through descriptive and inferential statistics. The results confirmed that learners showed various perceptual learning styles, with auditory and visual preferences being the most preferred. The pretest findings showed that all participants were at the Beginning Proficiency Level, indicating limited background information and prior knowledge about the concept. After the implementation of the intervention, posttest scores significantly improved, with a statistically significant difference ($p < 0.001$) and a large effect size observed (Cohen's $d = 2.90$). However, no significant differences were found in posttest performance when grouped according to their perceptual learning styles, suggesting that learning preferences did not significantly influence learners' academic learning outcomes. These findings indicated that tactile teaching strategies effectively enhance conceptual understanding regardless of learners' preferred learning modalities. The study also emphasized the value of multimodal, scaffolded, and experiential instructional approaches incorporating tactile teaching strategies in Science education and designing an enhanced lesson exemplar to guide teachers in creating meaningful learning experiences that support conceptual development.

Key words: tactile teaching strategies, conceptual understanding, lesson exemplar, experiential learning, constructivism

Introduction:

Science education plays a pivotal role in developing the learners' 21st century skills such as their analytical, critical, and problem-solving abilities. It is supposed to foster scientific literacy and conceptual understanding rather than just mere knowledge acquisition. However, learners' inability to understand abstract scientific concepts is one of the major challenges faced by science educators nowadays. Based on the result of the Program for International Student Assessment (PISA, 2022), the Philippines ranked 79th in Science among 81 participating countries that means learners have difficulties with their conceptual understanding and higher-order thinking skills. This is due to the continued practice of using traditional and teacher-centered approaches that make emphasis on rote memorization rather than active learning and inquiry (Eddy, 2020; Domingo & Barrot, 2021).

Tactile teaching strategies are instructional approaches or techniques that engage learners through hands-on activities including the use of manipulatives, interactive objects, and other kinesthetic-based experiences that allow learners to have in-touch exploration for scientific concepts. These strategies are believed to enhance the performance and conceptual understanding of learners as these encourage active engagement and meaningful learning (Tene et al., 2024; Irigoyen, Larrea, & Graña, 2024). Moreover, these approaches improve memory retention, increase motivation, address diverse learning styles, and develop scientific skills by activating the learners' senses as pathways for learning (Acut, 2024).

Even Grade 10 learners, as the final stage of Junior High School, still tend to commit definitions and facts to memory without fully comprehending their significance or application in real-life scenarios. Traditional teaching approaches that mainly rely on lectures, textbooks, and rote memorization rather than involving learners in active,

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experiential, and hands-on learning activities are frequently considered contributing factors to this issue (Eddy, 2020).

Conceptual understanding is well-demonstrated when learners apply scientific ideas in practical contexts and make connections between new and existing knowledge. Learners learn best when they actively participate in creating their own understanding through meaningful experiences. Unfortunately, several science classes still make use of teacher-centered teaching methods, which limit learners' ability to independently investigate, explore, manipulate, and uncover scientific concepts. This results in misconceptions which later will impede the growth and development of learners' conceptual understanding and higher-order thinking abilities (Acut, 2024).

To address this issue, the researcher started exploring innovative teaching strategies that prioritized experiential, inquiry-based, and hands-on learning. One method was the use of tactile teaching strategies that reinforced abstract scientific concepts through learners' senses (hearing, sight, touch, and movement), which enabled them to use tangible materials, experimentation, audio-visual learning simulations, and physical model manipulations, bridging the gap between concrete experiences and abstract concepts and improving conceptual understanding.

In the Philippines, the Department of Education highlighted the importance of learner-centered, inquiry-based pedagogies that fostered scientific comprehension and process skills (DepEd, 2016). This was consistent with the current trends in education that encouraged active and learner-centered learning environments. However, many teachers still lacked systematic approaches that incorporated tactile teaching strategies into lesson designs and classroom implementation.

In Bitoon National Vocational High School, a technical-vocational school, Grade 10 Science learners consistently showed a declining pattern in understanding science concepts as reflected in their academic performances and test results. This was because of the massive use of teacher-centered approaches, as teachers could cover more topics within a shorter instructional time. This occurred due to overlapping activities, which led to frequent interruption of classes and resulted in less active and meaningful learning experiences as well as weak conceptual understanding.

Even though recent studies had insisted on the effectiveness of hands-on, technology-integrated, interactive, and learner-centered approaches in enhancing science learning outcomes (Tene et al., 2024; Irigoyen et al., 2024; Acut, 2024), several gaps remained evident. Most of these studies focused on general science instruction, with limited emphasis on the use of tactile teaching strategies in enhancing conceptual understanding in actual classroom settings among Grade 10 learners in technical-vocational schools in the Philippines. Furthermore, there was a lack of research that incorporated tactile teaching strategies that teachers could systematically apply in lesson design and classroom implementation. In addition, only a few studies assessed conceptual understanding as the primary outcome of tactile-based instruction within a school context. These research gaps strengthened the need for a contextualized investigation on the effectiveness of tactile teaching strategies in enhancing the conceptual understanding of Grade 10 Science learners in Bitoon National Vocational High School.

With the concerns stated above, this study was conducted with the goal of determining the effectiveness of tactile teaching strategies in enhancing the conceptual understanding of Grade 10 Science learners in Bitoon National Vocational High School. The findings of this study were used in designing lesson exemplars that science teachers could utilize as their reference in making their lesson plans with the integration of tactile teaching methods during their science classes.

Literature Review:

The K to 12 Science Curriculum of the Department of Education (2016) clearly encourages learner-centered, inquiry-based instruction and the use of hands-on, mind-on activities to improve scientific process skills and long-lasting conceptual understanding. To develop scientific literacy, the curriculum emphasizes the importance of concrete activities and inquiry, which makes tactile teaching strategies pedagogically aligned with curriculum goals and national policy. Accordingly, hands-on, feel-based activities and other tactile teaching techniques are becoming more acknowledged as crucial elements of science education. This is supported by the study of Ferreira and Vasconcelos (2020), who found that a multisensory approach to science education improved learners' understanding and interests. This implies that learners can develop complex mental models of scientific phenomena when they use their sense of touch along with other senses. Furthermore, as emphasized by Nwosu et al. (2023), using structured

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activity-based, or tactile tasks has a consistent positive impact on learners' motivation, engagement, and cognitive abilities.

The next set of research studies showcased the positive results of tactile teaching strategies as being implemented physically in science classes.

Xiang and Srinivasan (2023) implemented a hands-on activity called "What's in the Box" in large science classes and achieved significant improvement in students understanding of the nature of science and scientific inquiry. Moreover, Kibga (2021) revealed that hands-on activities utilizing local, easily accessed materials in science lessons can significantly increase curiosity and improve conceptual understanding compared with lecture-only instructions. In addition, Masood (2023) conducted a pretest-posttest control-group experimental study using activity-based in Physics and found out that hands-on groups showed statistically significant gains in achievement versus the control group.

During the pandemic time when face to face classes were impossible, tactile teaching strategies aided with technology still resulted to learners' positive impact towards their conceptual understanding in science topics.

Webb and colleagues (2022) emphasized that tactile (haptic) feedback to 3-D simulations helped middle-school learners interact with nanoscale biological models and improved collaborative, problem-solving, and conceptual engagement. Their study just shows that tactile feedback – whether delivered physically or via technology – can make microscopic and spatially complex scientific ideas more accessible to learners who otherwise struggle to visualize such phenomenon. Likewise, Ji (2024) evaluated hands-on learning video assignments (HLVAs) during and after COVID era and reported that structured hands-on video tasks sustained learning gains in biology topics. He indicated that, if well-scaffolded, tactile teaching techniques can be adapted to hybrid and remote learning. Similarly, Shao et al. (2024) found that a mix of video instruction and guided hands-on experiments can be equally or more effective than traditional in-person experiments for certain topics, providing concrete experiences necessary for learners to build and test conceptual models, and emphasizing the value of carefully designed tactile experiences combined with reflection.

Abella et al. (2024) found that dimensions of science teaching such as hands-on practices and assessment or feedback are strongly interrelated, emphasizing that tactile teaching strategies must be integrated with reflective assessment for full effect in classroom settings. As a matter of fact, Laid and Adlaon (2025) examined innovative science teaching strategies including hands-on learning, technology integration, and learner-centered approaches and found out with emphasis that hands-on learning often enhanced engagement and problem-solving skills, although effective implementation requires teacher training and proper resources.

There are also research studies that relate the use of tactile teaching strategies with the learning styles of the learners.

Gilakjani (2020) found that perceptual learning styles such as auditory, visual, kinesthetic, and tactile strongly influenced learners' engagement when instructional activities match the mode they prefer. In support, Shao et al. (2024) believed that kinesthetic and tactile learning styles become increasingly relevant as learners react more positively to manipulative-based tasks rather than passive learning. In addition, Yilmaz (2024) showed that collaborative, group tasks increase motivation and comprehension in science when learning activities involve tactile teaching strategies.

Tactile teaching strategies are believed to influence learners' engagement especially on on-task, behavior, and focus participation. Twizeyimana (2024) stated that hands-on instructional strategies have repeatedly shown improvement on task behavior, lessen destructions, and increase meaningfully as learners interact with the lesson materials. Also, Yunzal Jr. (2024) found that tactile activities improve behavioral engagement by providing real-life experiences that can sustain interest towards learning.

The findings of other related studies have been instrumental in guiding the proponent to conduct his own study on how effective tactile teaching strategies among Grade 10 Science learners in enhancing their conceptual understanding. These related studies emphasize the importance of engaging learners through active learning and meaningful experiences that help them better understand abstract scientific concepts. In addition, the proponent is further encouraged to explore how tactile teaching strategies can be effectively applied in the classroom. Moreover, the results of this study will also be used on developing a lesson exemplar that integrates tactile teaching strategies, which may serve as a guide for science teachers in enhancing the conceptual understanding of the learners.

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Materials and Methods:

Design

This study utilized a quantitative quasi-experimental design using one-group pretest-posttest approach, complemented by descriptive analysis of learners' learning preferences involving five intact Grade 10 classes to be treated as one to determine the effectiveness of tactile teaching strategies in enhancing the scientific conceptual understanding of Grade 10 learners of Bitoon National Vocational High School. The researcher used quasi-experimental design because it determined whether an intervention or strategy influences a group of participants. In this study, tactile teaching strategies served as the independent variable, while learners' improvement in their conceptual understanding through their pretest and posttest performances served as the dependent variable. In this design, the same group of learners from five Grade 10 sections were given a pretest before the implementation of the tactile teaching strategies, and a posttest was given afterward. Any difference between the pretest and posttest scores was analyzed whether there is a significant improvement in conceptual understanding after giving the intervention.

Environment

This study was conducted at Bitoon National Vocational High School, one of the public secondary schools of Cebu Province Division, in Dumanjug District II and the only technical-vocational school in the whole municipality and just one of the few in the whole division. The school had around 1,422 enrollees divided into 9 sections per grade level including senior high school. This school was chosen as it implements the K to 12 Science Curriculum and has multiple Grade 10 sections (9 sections with around 42-45 students each) represented with a typical range of learner abilities.

Participants

The participants of this study were all five intact classes of Grade 10 Science learners who were officially enrolled in Bitoon National Vocational High School during the school year 2025-2026. Each section had approximately 42-45 students as shown in Table 1.

Table 1

List of Grade 10 Sections with their corresponding number of students

Name of Sections	Number of Students	Actual Participants (%)
Grade 10 – Dove	45	97.78
Grade 10 – Flowerpecker	44	95.45
Grade 10 – Kingfisher	44	97.73
Grade 10 – Oriole	42	92.86
Grade 10 – Swift	42	100.00
Total	**217**	**96.77**

Note: Actual participants (%) = $\frac{\text{total number of actual participants}}{\text{total number of students}}$ x 100

These five intact classes with a total of 217 learners were chosen based on their regular schedule and availability during the study period. As all students were part of the study, each of them was allowed to answer the perceptual learning style preference questionnaire, pre- and post- test, and all were subjected to tactile teaching strategies. Moreover, learners from each section shared similar learning needs and represented the specific group that the tactile teaching strategies aimed to support.

However, during the administration of the pre-test and post-test, a total of only 210 (96.77%) learners were able to complete the instrument while seven (3.33%) of them were unable to complete and take the test due to absenteeism. One (1) from Grade 10 – Dove, two (2) from Grade 10 – Flowerpecker, one (1) from Grade 10 –

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Kingfisher, and three (3) from Grade 10 – Oriole. Consequently, according to the exclusion criteria, only those who completed both the pretest and posttest were included in the final statistical analysis to ensure matched comparison of scores.

Instruments

This study used two sets of questionnaires: the Standardized Perceptual Learning Style Preference Questionnaire and a Teacher-Made Science Conceptual Understanding Questionnaire.

The Perceptual Learning Style Preference Questionnaire is a 30-item questionnaire in which the learners must decide whether they agree or disagree with each statement. This was utilized to identify the most preferred learning style(s) of Grade 10 Science learners. This instrument determines how learners best process and understands information– whether through visual, auditory, tactual, or kinesthetic styles. In this study, identifying learners' preferences is essential in understanding how tactile teaching strategies can support and enhance their conceptual understanding in Science. The results of this instrument provided valuable baseline information that guided the interpretation of learners' performance and their responses to the tactile activities being implemented.

The Teacher-Made Science Conceptual Understanding Questionnaire was used as both the pretest and posttest to assess the conceptual understanding of Grade 10 Science learners before and after the implementation of tactile teaching strategies. It is also a 30-item questionnaire focused on the first three lessons of the fourth quarter which was carefully constructed based on the identified Most Essential Learning Competencies (MELCs) prescribed by the Department of Education to ensure alignment with the intended learning outcomes. Each correct item was given one (1) point and zero (0) for incorrect answers.

The Table of Specifications (TOS) was carefully developed to ensure that the teacher-made questionnaire adequately measured the conceptual understanding of Grade 10 Science learners. It guided the construction of the pretest and posttest, ensuring that the test items were aligned with the learning competencies. In this study, the TOS distributed the test items across different cognitive levels – remembering, understanding, applying, and analyzing–to assess not only basic knowledge but higher-order thinking skills as well which are essential in science learning. Each learning competency was given equal weight, with 10 items corresponding to 33.33% of the total test, indicating balanced representation of the content. The distribution of items across the different cognitive levels reflects a strong emphasis on conceptual understanding, where learners are not only expected to recall information but also to explain, apply, and analyze scientific concepts. This is relevant to the use of tactile teaching strategies, as these approaches encourage active engagement and deeper learning through hands-on and experiential learning activities, allowing learners to better connect abstract concepts with real-life experiences.

Furthermore, to ensure the reliability of the instrument, it was pilot tested in another section that was not included in the actual study. The reliability coefficient was computed using Cronbach's alpha, if it gives a value of ≥0.70, then it indicates an acceptable reliability value and a good internal consistency. The results of the reliability testing were computed using JAMOVI version 2.7.12 and it showed high internal consistency, with Cronbach's alpha values of 0.80, 0.82, and 0.81 for each learning competency, respectively, as presented in Table 2. These values indicate that the instrument is highly reliable and appropriate for measuring learners' conceptual understanding. Since, the questionnaire was structured into three parts, for each distinct learning competency, hence, the subscales were analyzed independently rather than as a single composite measure.

Table 2

Reliability Coefficient per Learning Competency

Constructs	Number of Items	Cronbach's alpha (α)	Interpretation
Learning Competency #1	10	0.80	Good
Learning Competency #2	10	0.82	Good
Learning Competency #3	10	0.81	Good
Total	**30**		

Legend: Cronbach's alpha (α): 0.90 – 1.00 is Excellent, 0.80 – 0.89 is Good, 0.70 – 0.79 is Acceptable, below 0.70 is Poor and need for revision

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As shown in Table 2, the reliability analysis using Cronbach's alpha for each subscale revealed a good internal consistency, therefore, it is both valid and reliable, making it appropriate for evaluating the effectiveness of tactile teaching strategies in enhancing the conceptual understanding of Grade 10 Science learners.

Data Gathering Procedure

Pre-Data Gathering Procedure. The researcher obtained official consent from the Schools Division Superintendent of DepEd Cebu Province, the University of the Visayas Ethics Review Board, and the Dean of the University's Graduate School before starting data collection. A transmittal letter was sent to the school principal of Bitoon National Vocational High School, Dumanjug, Cebu to ask permission in conducting the study. Participants were informed through a consent letter outlining the study's objectives and guaranteeing their voluntary participation and strict confidentiality. In addition, the prepared teacher-made questionnaire was pilot-tested before gathering data.

Actual Data Gathering Procedure. The pretest was administered to the selected five intact Grade 10 Science classes with a time allotment of 45 minutes to determine their baseline conceptual understanding before giving the intervention. The researcher implemented tactile teaching strategies on the first unit lesson during the 4th quarter over a period of 2 weeks or approximately 6 class sessions in a 5E's inquiry model (Engage, Explore, Explain, Elaborate, Evaluate). As tactile teaching strategies were implemented, it was supported by auditory, visual, kinesthetic, and tactile approaches. Visual learners were provided with visual materials such as diagrams, charts, and models to help them visualize and interpret scientific concepts. Auditory strategies, including teacher explanations, guided discussions, video viewing and peer sharing, were integrated to reinforce understanding through listening and verbal interaction. Kinesthetic activities, like the use of gestures and actions, role-playing, and simulations were provided to allow learners engage in learning tasks. For tactile activities, learners were focused on hands-on exploration, experimentation and other concrete materials and physical models. When the intervention was over, posttest with the same concepts and questions was provided to the same group of learners. It was made sure that the posttest was conducted under the same conditions as the pretest to ensure consistency.

Post-Data Gathering Procedure. The researcher tabulated, analyzed, and interpreted the results from the given pretest and posttest questions. Careful steps were taken to maintain confidentiality of every response before the data was gathered and encoded for analysis. After the completion of the data analysis, all collected data were securely stored and will be used only for the purpose of this study on tactile teaching strategies in enhancing the conceptual understanding of Grade 10 Science learners. Afterward, all data will be properly disposed of. The soft copies will be permanently deleted, and printed materials will be shredded to strictly maintain confidentiality.

Data Analysis

Descriptive statistics were utilized to determine the learners' perceptual learning style preferences. The PLSPQ was scored following the prescribed procedure wherein item scores were summed and multiplied by two to obtain the final perceptual learning style score for each learner. The final scores were analyzed using descriptive statistics such as frequency counts and percentages to determine the most and least preferred learning strategies among the participants.

On the other hand, the computation of average scores, frequency, and percentages was done to analyze the learners' pretest and posttest scores and was interpreted using the proficiency level descriptors adopted from the Department of Education (DepEd, 2015), based on the Mean Percentage Score (MPS) as shown in Table 3 below. These measures described the learners' level of science performance before and after the intervention and provided a clear overview of their initial and final achievement levels. It classifies learners' performance into beginning, developing, approaching proficiency, proficient, and advanced levels.

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Table 3
Standard Proficiency Level

Mean Percentage Score (MPS)	Proficiency Level
90 – 100%	Advanced
85 – 89%	Proficient
80 – 84%	Approaching Proficiency
75 – 79%	Developing
Below 75%	Beginning

Note: Proficiency levels are based on the Department of Education (DepEd Order No. 8, s. 2015)

A paired-samples t-test with the level of significance set at 0.05 was used to determine the significant difference between the learners' pretest and posttest scores. This is ideal for the one-group pretest-posttest design since it compares two sets of scores gathered from the same group of learners before and after the intervention. In addition, Cohen's d (effect size) was calculated to measure the magnitude of improvement in learners' scores from pretest to posttest. JASP version 0.19.3 or JAMOVI version 2.7.12 was used for statistical processing to ensure accuracy of computations. The findings were interpreted to determine the effectiveness of tactile teaching strategies in enhancing the conceptual understanding of the Grade 10 Science learners.

A one-way ANOVA was used to determine whether posttest performance differed based on learners' learning preferences. This test compares the mean posttest scores of learners grouped according to their dominant learning preference. If the ANOVA yielded a significant result, Tukey HSD post hoc analysis was performed to determine which specific learning preference groups differed. If the assumption of homogeneity of variance was violated, the Games-Howell post hoc test was used.

The proposed lesson exemplar would be developed through the synthesis of the study's findings, including learners' learning style preferences and performance results. Patterns and relationships that were identified from quantitative data served as the basis for designing a lesson exemplar that emphasizes tactile teaching strategies integrating auditory, visual, kinesthetic, and tactual activities to support and enhance conceptual understanding in Grade 10 Science.

Results and Discussion:

Learners' Perceptual Learning Style Preferences

This section presents the perceptual learning style preferences of Grade 10 Science learners. These preferences provide a basis for understanding how learners process information and engage with tactile teaching strategies. The results also serve as a guide in aligning instructional approaches to enhance conceptual understanding.

Table 4
Perceptual learning styles of students

Style	***F***	***%***
Auditory	54	25.70
Visual	50	23.80
Kinesthetic	38	18.10
Tactile	28	13.30
Dual	29	13.80
Multimodal	11	5.20

Note: *n=210.*

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Table 4 presents the perceptual learning styles of students in percentage which indicate the top three (3) ranks in their preference, described as auditory and visual. These learning modes show 50-54% of the students have this preference. That for most of the respondents their perceived learning style is auditory which is a quarter (25.70%) of the respondents.

In the study of Rhouma, W.B. (2016), the kinesthetic mode of learning style was the most preferred; however, this finding did not support the study under investigation. Instead, the table showed that auditory and visual were the preferred perceptual styles. Furthermore, with regards to visual, auditory, and tactual learning styles, high and low achievers exhibited similar preferences. One of the implications of this study was that both teachers and learners should be introduced to the concept of perceptual learning style for a better understanding of their own learning to maximize their chances of success in foreign language learning.

Overall, the finding implied that respondents had varied learning styles. While it was true that people had unique preferences for how they took in information, the idea that individuals had a fixed learning style that dictated their ability to learn was largely considered a neuromyth in modern cognitive science. Scientific research generally showed that tailoring instruction to a specific style (like visual or auditory) did not actually improve learning outcomes. Instead, most people learned best when information was presented through multiple modalities, for example, seeing a diagram while hearing an explanation.

Pretest and Posttest Performance of Grade 10 Science learners

This section presents the pretest and posttest scores of the Grade 10 Science learners before and after the implementation of tactile teaching strategies. The pretest results provide baseline information on the learners' initial level of conceptual understanding, while the posttest results show their level of understanding after the intervention. These results serve as basis for determining any improvement in learners' performance.

Table 5

Pretest and Posttest Science Performance of the Learners

Proficiency Level	Pretest MPS (%)	*f*	%	Posttest MPS (%)	*f*	%
Advanced	0	0	0	0	0	0
Proficient	0	0	0	0	0	0
Approaching Proficiency	0	0	0	0	0	0
Developing	0	0	0	75.00	2	0.95
Beginning	33.33	210	100.00	53.55	208	99.05
Overall MPS	**33.33**	**Beginning**		**53.86**	**Beginning**	

Note: n=210

Legend: 90 – 100% is Advanced, 85 – 89% is Proficient, 80 – 84% is Approaching Proficiency, 75 – 79% is Developing, and Below 75% is Beginning

MPS – Mean Percentage Score

Table 5 presents the performance of Grade 10 Science learners before and after the implementation of tactile teaching strategies in relation to their perceptual learning styles. This was done to determine the effect of these strategies alongside the learners' perceptual preferences, which differed from one learner to another and may influence hoe effectively they learn. Perceptual learning styles are "the means by which learners extract information from their surroundings through the use of their five senses" (Davis, 2007). According to Oxford (2001), these refer to the channels with which the student is the most comfortable, while Reid (1987) describes them as variations in how learners use their senses to understand, organize, and retain experience. Thus, the way instruction is delivered plays a significant role in learning (Daud, 2014; Dunn & Burke, 2008).

The pretest results evidently showed that all learners were at the Beginning Proficiency level, indicating that they were still in the earliest stage of acquiring a skill or language. This highlighted the need for appropriate teaching strategies that aligned with their learning styles.

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After the implementation of tactile teaching strategies, the posttest results showed an improvement in the overall mean percentage score (MPS) to 53.86. However, most of the learners (99.05%) remained at the Beginning level, while very few (0.95%) progressed to the Developing level. Developing Proficiency level characterized a learner who had moved past the initial struggle of a beginner but still required support to complete complex tasks. This indicated that although there was measurable progress in scores, it was not yet enough to shift most learners to a higher proficiency level. According to Maal (2004, cited in Cook, 2009), visual learners represented 20% to 40% of the population while auditory learners represented only 20% to 30%. It went without saying that in teacher-centered classes, teaching benefited auditory learners in the first place and visual ones in the second place.

The results further implied that tactile teaching strategies could support learning by increasing engagement and helping learners better process concepts, especially when aligned with their perceptual preferences. However, these strategies should be continuously used, applied, and combined with visual and auditory approaches to achieve more substantial improvements. This supported the idea that multimodal instruction was more effective in addressing diverse learners' needs. "Teachers tend to judge students to be good learners based on their ability to concentrate more than on motivation level". Accordingly, learners feel at ease when instruction matches their preferred learning styles, making learning more meaningful. In this study, most learners preferred visual and auditory, confirming that learners–whether high or low achievers–exhibit similar perceptual learning preferences (Rhouma, W.B. 2016).

Difference between the pretest and post-test performance

This section presents the difference between the pretest and posttest performance of Grade 10 Science learners after the implementation of the tactile teaching strategies. It determines whether there is a significant improvement in their academic performance. The results provide evidence on the effectiveness of the intervention being implemented and utilized in the study.

Table 6

Difference between the pretest and posttest scores of the learners

Variables	Mean Score	t value	df	p value	Decision	Interpretation
Pre-test	13.31	35.729	209	<0.001	Reject Ho	Significant
Post-test	21.50					

Legend: Significant if p value is <.05.

The table shows that the p value is < 0.001 which is interpreted as significant, leading to the decision of rejecting the null hypothesis. Thus, there is a significant difference in the pre-test and post-test scores of the learners. This means that the change in scores is unlikely to have happened by chance. This finding suggests that whatever happened between the two tests, such as the implementation of tactile teaching strategies aligned with learners' perceptual learning style preferences, had a measurable effect on learners' performance.

This further means that the intervention introduced was effective in improving learners' science performance. Based on Cohen's d, the value was 2.90. A Cohen's value of 2.90 indicates an extremely large effect size, suggesting that the improvement from pretest to posttest is not only statistically significant but also educationally meaningful. It indicated that the means of the two groups differ by 2.90 standard deviations, with the first group's mean being lower than the second, showing a substantial increase in learners' achievement after the intervention.

As emphasized by Davis (2007), learners acquire and process information through their senses, and when instruction matches these, learning becomes more effective. Similarly, Reid (1987) noted that learners vary in how they understand and retain information, which supports the idea that differentiated strategies, like tactile teaching strategies, can address diverse needs. In addition, according to Oxford (2001), learners tend to perform better when they are comfortable with the mode of instruction. The increase in posttest scores suggests that learners are beginning to adapt to the instructional approach, even if mastery has not yet fully achieved. As supported by Rhouma (2016), learners with different achievement levels may still exhibit similar perceptual learning preferences, suggesting that instructional strategies aligned with these preferences can benefit both high and low achievers. This

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implies that tactile teaching strategies are not only beneficial for specific learners but can be broadly effective in improving overall performance.

Difference in the posttest performance according to learning preferences

The difference in the posttest performance of the Grade 10 Science learners when grouped according to their perceptual learning style preferences is shown in Table 7. This aims to determine whether learners with different preferences performed differently after the implementation of tactile teaching strategies. The results provide insight into how learning preferences may influence learners' science performance.

Table 7

Difference in the posttest performance of the students when grouped according to their learning preferences

Learning styles	Mean score	F value	df	*p*	Decision	Interpretation value
Auditory	21.76	0.716	209	0.612	Failed to reject Ho	Not significant
Visual	20.24					
Kinesthetic	21.32					
Tactile	21.11					
Dual	22.03					
Multimodal	23.00					

Legend: Significant if *p* value is < .05.
Note.: Since there is no significant difference, post hoc Tukey was not performed.

The table shows that the p value is at 0.612 which is interpreted as not significant leading to the decision of failing to reject the null hypothesis. Thus, there is no significant difference in the posttest scores of the learners when grouped according to learning styles. The findings generally mean that a learner's preferred way of learning (e.g., visual, auditory, or kinesthetic) did not have a measurable impact on their final performance. The research cannot claim that one learning style is better than another for the specific material or intervention being tested.

Many researchers argue that tailoring instruction to specific learning styles does not actually improve learning outcomes. This finding supported the idea that learning style preferences do not dictate academic success. As emphasized by Oxford (2001), learners may have preferred modes of learning, but effective instruction depends more on how well teaching strategies are implemented rather than strictly matching these preferences. Similarly, Reid (1987) noted that while learners differ in their perceptual preferences, these differences do not always translate into differences in achievement.

If a new teaching method was used, the lack of difference suggests it was equally effective (or ineffective) for everyone, regardless of how they prefer to learn. This is supported by Davis (2007), who explained that learners process information through multiple senses, implying that instruction that engages various modalities can benefit all learners rather than a specific group.

Furthermore, the results suggested that other variables such as motivation, study habits, prior knowledge, or teaching quality may be more important drivers of achievement than the learners' preferred learning modalities. According to Rhouma (2016), learners with different achievement levels may still share similar learning preferences, indicating that preference alone does not determine performance.

Relationship between posttest performance and learners' learning preferences

This section presents the relationship between the posttest performance of the Grade 10 Science learners and their perceptual learning style preferences. It aims to determine whether learners' preferences are associated with their academic performance after the implementation of tactile teaching strategies. The results provide further insight into whether learning preferences influence learners' conceptual understanding in Science.

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Table 8

Relationship between posttest performance and learning preferences

Variables	F value	df	p value	Decision	Interpretation
Learning Preferences vs Posttest Performance	0.716	209	0.612	Failed to reject Ho	Not Significant

Note: Since the computed p-value is greater than 0.05, the result is not significant; hence, post hoc Tukey was not performed.

The table shows that the p value is 0.612, which is interpreted as not significant, leading to the decision to reject the null hypothesis. This indicates that there is no significant relationship between learners' posttest performance and their learning preferences. This is consistent with the earlier finding that since ANOVA showed no significant difference among groups, it also indicates that there is no significant relationship between learning preferences and posttest performance. This suggests that learning preferences alone may not be a strong predictor of academic performance. Instead, the use of well-designed and engaging instructional strategies, such as tactile teaching strategies, plays a more crucial role in enhancing the conceptual understanding of Grade 10 Science learners. As emphasized by Rhouma (2016), learners with different achievement levels may still share similar learning preferences, indicating that preference alone does not determine performance.

Conclusion

The significant improvement in posttest scores, with a large effect size, indicated the value of using the senses and incorporating tactile and hands-on learning experiences within a structured and learner-centered instructional framework. According to Kolb's Experiential Learning Theory, the manipulative, hands-on experiences provided learners with concrete opportunities for active experimentation and simulation which are essential in the learning cycle (Kolb, 1984). Similarly, Bruner's Discovery Learning and Theory of Instruction emphasizes the importance of enactive learning, where learners learn direct manipulation and interaction with materials, supported by appropriate scaffolding (Bruner, 1961). Furthermore, consistent with constructivist principles, the tactile teaching strategies allowed learners to actively construct meaning through engagement and experience (Piaget, 1970). Overall, the study concludes that while perceptual learning styles may describe how learners prefer to receive information, they are not reliable predictors of academic success. Rather, the quality of instruction, the use of diverse, hands-on teaching strategies, and the provision of scaffolded learning experiences appear to play a more critical role in enhancing the Grade 10 learners' scientific conceptual understanding.

Recommendations

Based on the findings and conclusion, the following recommendations are hereby proposed:

For Teachers. Teachers should integrate tactile teaching strategies, such as hands-on, manipulative activities, simulations, and interactive tasks, as part of a multimodal approach to instruction. These strategies enhanced learning outcomes for learners, not just those with single dominant learning preference.

For Curriculum Planners. Planners should design more structured and detailed pedagogical framework integrating tactile and experiential components that allow learners to actively manipulate, explore, and apply concepts as conceptual understanding is strengthened through experience-based learning.

For Future Research. Future studies may further examine the impact of tactile teaching strategies on conceptual understanding across different subject areas and longer durations. This study shows a strong and significant overall effect but not isolated per learning style.

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