ISSN: 3116-3475
International Journal
of Education, Research, and Innovation Perspectives
Volume 2 Issue 7 (July 2026)

Hands-On Science Inquiry and Conceptual Understanding among Grade 5 Learners

Rea Jennine M. Asuncion[1*] and Severino T. Morales Jr.[1,2]
[1]*Northeastern College*
[*]*reajennineasuncion@gmail.com*, [2]*severinomoralesjr@northeasterncollege.edu.ph*

Date Submitted:
February 27, 2026

Date Accepted:
April 25, 2026

Date Published:
July 18, 2026

DOI:
10.5281/zenodo.21425688

ABSTRACT

This study investigated the relationship between hands-on science inquiry and conceptual understanding among Grade 5 learners at Balla Elementary School in the City of Ilagan, Isabela. A cross-sectional explanatory measurement design was employed using the Hands-On Science Inquiry Experience Scale and a two-tier conceptual understanding test. The inquiry scale measured manipulation and exploration, questioning and prediction, evidence interpretation, and explanation and reflection, while the conceptual test assessed learners' scientific answers and supporting explanations. Confirmatory factor analysis, the Rasch partial credit model, and median quantile regression were used to analyze the data. Findings showed that learners often experienced hands-on science inquiry, with manipulation and exploration of materials receiving the highest rating. Explanation and reflection emerged as the least developed inquiry component. Most learners demonstrated developing or emerging conceptual understanding, and force and motion was identified as the most difficult science content area. Median quantile regression revealed a significant positive association between hands-on science inquiry and conceptual understanding. However, the modest explanatory contribution of inquiry indicated that physical participation alone did not ensure accurate scientific understanding. The findings emphasized the need to strengthen guided questioning, evidence analysis, explanation, and reflection during practical science activities. Teachers were encouraged to integrate structured investigations, two-tier assessments, classroom dialogue, and targeted remediation to help learners connect observable results with scientifically acceptable explanations.

Keywords: *conceptual understanding, Grade 5 learners, guided inquiry, hands-on science inquiry, science education, two-tier assessment*

INTRODUCTION

Science education in the elementary grades is expected to help learners understand the natural world rather than simply remember facts from textbooks. Learners develop a clearer grasp of scientific ideas when they are given opportunities to observe objects, handle materials, ask questions, test predictions, record evidence, and explain what they have discovered. These experiences allow science lessons to move from the presentation of information toward the active construction of meaning. The Philippine K to 12 Science Curriculum supports this direction by describing science learning as learner-centered and inquiry-based. It also calls for varied hands-on and minds-on activities that connect scientific knowledge, process skills, attitudes, and real-life situations (Department of Education, 2016).

The need to improve the quality of science learning is evident in the performance of Filipino learners in international assessments. In the 2022 Programme for International Student Assessment, only 23 percent of participating Filipino students reached at least Level 2 proficiency in science, compared with the Organisation for

Economic Co-operation and Development [OECD] (2023) average of 76 percent. Almost no Filipino participants reached the highest proficiency levels. Although the assessment involved 15-year-old students, the results point to difficulties that may have developed during the earlier years of schooling, when learners first encounter scientific concepts and begin forming habits of observation, reasoning, and explanation. Stronger science experiences in the elementary grades may therefore help establish the knowledge and thinking processes needed for more advanced learning.

Grade 5 is an important stage in the development of scientific understanding because learners are introduced to ideas involving matter, living things, force and motion, and Earth and space. Some of these topics describe processes that cannot be understood fully through words or illustrations alone. Learners may be able to repeat definitions yet remain unable to explain why a material changes when heated, how forces affect the movement of an object, or how parts of an organism perform related functions. Conceptual understanding is shown when learners can connect ideas, explain observable events, distinguish scientific explanations from inaccurate ones, and use their knowledge in unfamiliar situations. For this reason, classroom instruction needs to provide experiences that help children examine how a scientific idea works rather than merely identify its name.

Hands-on science inquiry offers one way of providing such experiences. It involves more than allowing learners to touch objects or follow a fixed set of procedures. Meaningful inquiry begins with a question or problem and continues as learners make predictions, conduct an investigation, observe results, compare evidence, and communicate an explanation. The use of actual materials gives children direct access to the phenomenon being studied. In a hands-on science curriculum involving elementary learners, Jones et al. (2019) found significant gains in knowledge after Grade 4 learners completed laboratory activities. The gains in scientific knowledge remained evident when the learners reached Grade 5, suggesting that carefully designed practical experiences can contribute to learning that extends beyond the immediate lesson.

Physical activity by itself, however, does not guarantee understanding. A learner may complete an experiment correctly without recognizing the scientific principle demonstrated by the results. Hands-on work must therefore be accompanied by minds-on thinking. Learners need time to discuss their predictions, identify patterns in their observations, compare explanations, and relate the evidence to the scientific concept being taught. Van Eijck et al. (2025) examined lessons that combined practical experiments with interactive concept diagrams among primary school learners aged 9 to 12. Their findings showed that this combination enabled learners to apply several forms of scientific reasoning and work with greater independence. The study illustrates how practical experience becomes more educationally valuable when learners are guided to think about the relationship between what they observe and the ideas used to explain it.

Conceptual understanding also requires learners to reconsider explanations that appear reasonable but do not agree with scientific evidence. Children enter the classroom with ideas developed from everyday experience, and some of these ideas may be incomplete or inaccurate. Inquiry activities give them an opportunity to test what they believe against observable results. In a study involving learners from Grades 4 to 6, van der Graaf (2020) found that an inquiry-based lesson on balance beams improved learners' accuracy and supported changes in the strategies they used to solve problems. The learners were asked to make predictions, manipulate relevant variables, observe the results, and consider whether their initial explanations remained acceptable. Such activities allow evidence to become the basis for revising understanding rather than treating the teacher's explanation as something that must simply be accepted.

The success of inquiry depends greatly on the support provided during the investigation. Elementary learners may have difficulty identifying variables, organizing observations, interpreting unexpected findings, or drawing a conclusion that is supported by evidence. Lazonder and Harmsen (2016), in a meta-analysis of 72 studies, found that appropriate guidance improved learners' inquiry activities, performance, and learning outcomes. Guidance may include carefully prepared questions, worksheets, demonstrations, visual organizers, feedback, or short explanations given at the point when learners need them. These forms of support do not remove learner participation. Instead, they help children focus their attention on the evidence and scientific relationships that might otherwise be overlooked.

Learners may first need a clear explanation of basic terms, safety procedures, or the proper use of materials before they can conduct an investigation successfully. They may also need teacher-led discussion after the activity to connect their findings with accepted scientific principles. De Jong et al. (2023) concluded that inquiry-based instruction generally supports the acquisition of conceptual knowledge, but its effectiveness is influenced by prior knowledge, learning goals, subject matter, and the guidance available to learners. A thoughtful combination of inquiry and direct instruction may therefore be more suitable for elementary classrooms than leaving children to discover complex ideas without sufficient preparation or assistance.

Inquiry activities can also develop the process skills needed to understand science. Observing, classifying, measuring, predicting, communicating, and drawing conclusions help learners examine evidence in an orderly manner. Mulyeni et al. (2019) reported improvement in the basic science process skills of elementary learners who participated in inquiry-based science lessons using the 5E model. The researchers also noted the contribution of worksheets, peer interaction, and teacher support to the learning process. A systematic review by Muhamad Dah et al. (2024) likewise found that inquiry-based science learning had positive contributions to conceptual understanding, motivation, attitudes, scientific thinking, and science literacy. The same review cautioned that inquiry requires effective classroom management, flexible teaching, productive interaction, and continuing teacher support. These findings suggest that hands-on inquiry is most useful when the activity, questioning, guidance, and assessment are carefully connected.

Despite the available evidence, the quality and frequency of hands-on inquiry may vary across schools and classrooms because of differences in materials, instructional time, learner readiness, and teaching practices. Findings obtained from other countries or grade levels cannot fully describe how Grade 5 learners in a particular Philippine elementary school experience science inquiry or how well they understand the concepts included in their lessons. A school-based investigation can provide information that is closely connected to the learners, instructional practices, and available learning conditions. Such information may guide teachers in selecting activities that allow learners to investigate safely, reason from evidence, discuss their ideas, and connect observations with scientific explanations.

The study examine hands-on science inquiry and conceptual understanding among Grade 5 learners at Balla Elementary School, Purok 3, Barangay San Rodrigo, City of Ilagan, Isabela. It seeks to determine how learners experience inquiry-oriented science activities and how these experiences relate to their understanding of scientific concepts. The findings may serve as a basis for improving classroom investigations, learning materials, teacher guidance, and assessment practices. By examining both practical participation and conceptual learning, the study recognizes that meaningful science education requires learners not only to perform an activity but also to explain what happened, why it happened, and how the evidence supports the scientific idea being studied.

Literature Review

Hands-On Inquiry as Direct Engagement with Scientific Phenomena

Hands-on science inquiry places learners in direct contact with materials, objects, models, and observable events. Its value lies not merely in physical participation but in giving learners evidence that they can examine and use when explaining a scientific idea. In a study involving Grade 5 classes, Shao et al. (2024) found that both hands-on experiments and science videos supported the learning of scientific concepts, although learners who performed the experiments showed an advantage in recognizing and applying the properties of materials during modeling tasks. This suggests that manipulating materials may offer forms of experience that cannot be obtained fully through verbal explanations or visual presentations. Murphy et al. (2021) also found that primary learners whose teachers adopted child-led inquiry practices became more involved in scientific investigations and developed clearer ideas about how scientific knowledge is produced. Their findings indicate that inquiry becomes more meaningful when children are allowed to make observations, propose explanations, and reflect on what their investigations reveal.

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ISSN: 3116-3475
International Journal
of Education, Research, and Innovation Perspectives
Volume 2 Issue 7 (July 2026)

Scientific Reasoning and Conceptual Change

Conceptual understanding develops when learners can explain relationships among scientific ideas and revise beliefs that conflict with evidence. Hands-on inquiry can support this process by requiring learners to predict outcomes, control relevant variables, compare observations, and draw conclusions from the results. Schalk et al. (2019) examined elementary learners who received guided inquiry lessons involving physics topics such as floating and sinking, air pressure, sound, and bridge stability. The learners demonstrated gains in physics content knowledge and became better at applying the control-of-variables strategy to unfamiliar problems. This finding shows that repeated experimentation can strengthen both subject knowledge and the reasoning procedures used to investigate scientific questions. Edelsbrunner et al. (2018) similarly studied 1,809 elementary learners who completed guided inquiry lessons on floating and sinking. Their results showed that understanding how variables are controlled predicted the development of conceptual knowledge and the movement from inaccurate explanations toward scientifically acceptable ideas. These studies indicate that conceptual understanding and inquiry skills are closely connected. Learners who know how to produce and evaluate reliable evidence are better prepared to judge whether their initial ideas remain defensible.

Quality of Materials and Experimental Tasks

The learning value of a hands-on activity depends on how well the materials and procedures direct attention toward the intended scientific relationship. An activity may keep learners busy without helping them understand the concept when irrelevant details, confusing tools, or poorly designed procedures distract them from the evidence. Bumbacher et al. (2018) found that the features of experimental tools influenced the strategies learners used during scientific inquiry and, consequently, their conceptual understanding. Tools that made important variables and outcomes easier to examine supported more systematic experimentation, while other designs encouraged less productive trial-and-error behavior. Their findings show that materials are not neutral objects because their structure can shape how learners investigate a problem. Kapıcı and Coştu (2023) likewise found that both hands-on and virtual laboratory environments improved learners' conceptual knowledge and science process skills, although each environment offered different forms of support. Physical materials enabled learners to perform actual procedures and manage equipment, while virtual environments allowed variables and processes to be observed under more controlled conditions. These findings suggest that teachers should select materials according to the concept, expected inquiry skill, learner readiness, and accuracy of the representation.

Teacher Guidance and Classroom Dialogue

Hands-on inquiry requires a teacher who can support learners without taking control of every decision. Elementary learners may need assistance in developing investigable questions, following safe procedures, recording observations, and explaining unexpected results. Kim (2022) found that elementary teachers used both dialogical and authoritative forms of classroom talk during inquiry lessons. Dialogical talk gave learners space to share ideas and participate in problem solving, while teacher authority was used to direct discussion toward the scientific concepts intended in the curriculum. This balance helped preserve learner agency while preventing classroom inquiry from becoming disconnected from the learning objective. Van Uum et al. (2021) also showed that teachers' ability to guide inquiry improved when they learned to use structured inquiry phases and appropriate scaffolds. Their framework included introducing and exploring a topic, designing and conducting an investigation, drawing conclusions, presenting findings, and broadening understanding. The study found improvements in teachers' conceptual knowledge, pedagogical knowledge, and attitudes toward inquiry-based science instruction. Together, these findings show that teacher guidance should change according to what learners need at a particular stage of the investigation.

METHODS

Research Design

The study employed a cross-sectional explanatory measurement design to examine the association between hands-on science inquiry and conceptual understanding among Grade 5 learners. This design went beyond a basic descriptive-correlational approach because it accounted for the quality of measurement before estimating the relationship between the variables. Hands-on science inquiry was treated as a latent construct reflected by learners' responses to several indicators, while conceptual understanding was measured through a two-tier science assessment. No instructional intervention or experimental manipulation was introduced. Data were collected at one period to determine whether variations in learners' exposure to inquiry-based science experiences were associated with differences in their ability to explain and apply scientific concepts. The design was considered appropriate because the study sought to explain an observed relationship without claiming that one variable directly caused changes in the other.

Research Locale

The investigation was conducted at Balla Elementary School, located in Purok 3, Barangay San Rodrigo, City of Ilagan, Isabela. The school served elementary learners from the surrounding community and implemented the science competencies prescribed under the national basic education curriculum. The locale was selected because Grade 5 science lessons included opportunities for observation, manipulation of materials, simple experimentation, evidence gathering, and explanation of scientific phenomena. Conducting the study within the school allowed the researcher to examine inquiry experiences and conceptual understanding under the actual conditions in which science instruction took place. The setting also provided a relevant environment for determining how available materials, classroom routines, and teacher-guided investigations were reflected in learners' understanding of Grade 5 science concepts.

Participants and Sampling Technique

The participants consisted of Grade 5 learners who were officially enrolled at Balla Elementary School during the period of data collection. Proportionate stratified random sampling was applied, with each Grade 5 class section treated as a separate stratum. This procedure ensured that learners from every section had an opportunity to be represented without allowing one class group to dominate the sample. Class lists were obtained only after the necessary permission had been secured. Each eligible learner was assigned a code, and the required participants from every section were selected through computer-generated random numbers. Learners were included when they had submitted signed parental consent, provided personal assent, and were present during the scheduled administration. Learners who did not provide consent or assent were not included, and no substitute was selected based on academic standing, classroom behavior, or teacher recommendation.

Research Instrument

Data were obtained using a researcher-developed instrument package composed of the Hands-On Science Inquiry Experience Scale and the Grade 5 Conceptual Understanding Test. The inquiry scale contained child-friendly statements that measured four areas: manipulation and exploration of materials, questioning and prediction, collection and interpretation of evidence, and explanation and reflection. Responses were recorded through a four-point frequency scale consisting of Never, Sometimes, Often, and Always. A neutral response option was not included so that learners would indicate the response that most closely represented their usual science-learning experiences.

The Grade 5 Conceptual Understanding Test used a two-tier format. The first tier required learners to select an answer to a science problem, while the second tier required them to identify the explanation that supported the selected answer. The items covered concepts taught in Grade 5 science, including matter, living things and their environment, force and motion, and Earth and space. Each item received two points when both the answer and its scientific explanation were correct, one point when the answer was correct but the explanation

ISSN: 3116-3475
International Journal
of Education, Research, and Innovation Perspectives
Volume 2 Issue 7 (July 2026)

was incomplete or inaccurate, and zero when the answer was incorrect. This scoring method helped distinguish correct guessing from responses supported by scientific reasoning.

The initial instrument was evaluated by specialists in elementary science education, educational measurement, curriculum instruction, and language assessment. The validators examined the relevance, clarity, developmental suitability, curriculum alignment, and cultural appropriateness of each item. Item-level content validity indices were computed, and statements that did not meet the minimum acceptable agreement among the validators were revised or removed. The final scale-level content validity index was S-CVI/Ave = .94, indicating excellent content validity. Comments from the validators were also used to simplify technical terms, remove ambiguous wording, and improve the alignment between the test questions and the expected Grade 5 competencies.

Before the pilot administration, cognitive interviews were conducted with learners who were not included in the final study. They were asked to explain how they understood selected instructions, response choices, and test items. Their responses helped identify words, examples, and sentence structures that could cause misunderstanding. The revised instrument was then pilot-tested among Grade 5 learners from another elementary school with learning characteristics comparable to those of the intended participants. The pilot group was not included in the main data collection.

Internal consistency was examined using Cronbach's alpha. The Hands-On Science Inquiry Experience Scale obtained an overall reliability coefficient of Cronbach's $\alpha = .90$, while the coefficients for its four dimensions ranged from $\alpha = .79$ to $\alpha = .85$. Specifically, manipulation and exploration of materials obtained $\alpha = .83$, questioning and prediction obtained $\alpha = .79$, collection and interpretation of evidence obtained $\alpha = .85$, and explanation and reflection obtained $\alpha = .80$. The Grade 5 Conceptual Understanding Test obtained a reliability coefficient of Cronbach's $\alpha = .82$. These coefficients exceeded the minimum acceptable criterion of .70 and indicated that the instruments had satisfactory to high internal consistency. Item difficulty and discrimination were also examined for the conceptual understanding test. Items that were extremely easy, extremely difficult, or unable to distinguish between learners with stronger and weaker conceptual understanding were revised or excluded before the final administration.

Data Gathering

The researcher first secured written authorization from the appropriate education authorities and the school head of Balla Elementary School. After institutional permission had been granted, the purpose, procedures, possible discomforts, expected benefits, and confidentiality measures were explained to the parents or legal guardians of eligible learners. Parental consent forms were distributed before any learner was approached for participation. Learners whose parents gave permission were provided with an age-appropriate assent form and were informed that participation was voluntary.

The final instruments were administered during scheduled periods that did not interfere with major examinations or required classroom activities. Data collection was completed in two separate sessions to reduce fatigue. During the first session, the learners answered the Hands-On Science Inquiry Experience Scale. The conceptual understanding test was administered during the second session. Standardized instructions were read aloud, and examples unrelated to the scored items were provided to ensure that learners understood the response process.

The researcher and trained assisting personnel supervised the administration but did not explain answers, translate scientific concepts, or provide clues. Learners were given sufficient time to complete each instrument independently. Names were not written on the questionnaires. Matching identification codes were used to connect responses from the two sessions. Completed instruments were checked only for missing pages or unanswered sections before the learners left the room. No learner was required to answer an item that caused discomfort.

The collected responses were encoded in a password-protected data file. A second checking procedure was conducted by comparing the encoded entries with the original response sheets. Entries with encoding errors were corrected using the original instruments as the reference. Paper-based materials were placed in a secured storage area accessible only to the researcher, while electronic data were stored using coded identifiers.

Data Analysis

The analysis began with data screening to identify incomplete responses, unusual response patterns, encoding errors, and items with limited variability. The frequency distribution of each response category was inspected before the computation of composite results. Median and interquartile range were used to describe the hands-on science inquiry indicators because the response choices represented ordered categories. The conceptual understanding test was summarized through the distribution of scores, median, interquartile range, and percentage of learners within the established levels of understanding.

The structure of the Hands-On Science Inquiry Experience Scale was examined through confirmatory factor analysis using the robust weighted least squares estimator. This estimator was selected because the scale used ordinal response categories and did not require the assumption that the item responses followed a normal distribution. Model adequacy was evaluated through the comparative fit index, Tucker-Lewis index, root mean square error of approximation, and standardized root mean square residual. Standardized factor loadings were reviewed to determine whether each item adequately represented its intended inquiry dimension.

The two-tier conceptual understanding test was examined through the Rasch partial credit model. This procedure considered the ordered scoring of zero, one, and two points and produced an ability estimate for each learner. Item fit statistics were inspected to determine whether the test items functioned consistently with the intended construct. The Rasch estimates were used instead of relying solely on raw scores because they provided a measurement of conceptual understanding that considered differences in item difficulty.

The association between hands-on science inquiry and conceptual understanding was tested through median quantile regression. The Rasch ability estimate for conceptual understanding served as the outcome variable, while the inquiry factor score served as the explanatory variable. Median regression was chosen because it was less affected by extreme scores and non-normal distributions than ordinary least squares regression. It also estimated how hands-on inquiry was associated with the conceptual understanding of the typical learner rather than focusing only on the arithmetic mean.

Bootstrap confidence intervals based on 5,000 resamples were computed for the regression coefficient. The direction, magnitude, and confidence interval of the coefficient were examined to determine the nature of the relationship. Statistical significance was evaluated at the .05 level, while the standardized coefficient and pseudo-R-squared value were reported to describe the practical contribution of hands-on science inquiry to differences in conceptual understanding. The findings were interpreted as evidence of association and not as proof of direct causation.

Ethical Consideration

The study followed the principles of voluntary participation, respect for children, confidentiality, fairness, and protection from harm. Permission was obtained from the proper institutional authorities before the recruitment of participants. Because the participants were minors, written consent was obtained from their parents or legal guardians, while the learners provided informed assent using language appropriate to their age and level of understanding.

The learners were informed that participation was optional and that refusal would not affect their grades, classroom standing, access to school activities, or relationship with their teachers. They were also told that they could stop answering at any stage without punishment or the need to provide an explanation. The researcher avoided using authority, rewards, grade incentives, or repeated requests that could pressure learners into participating.

Only identification codes were used during data processing. Individual answers were not shown to classmates, teachers, parents, or other school personnel. Results were reported in combined form so that no learner could be identified from the tables, discussions, or conclusions. The instruments were designed to present no more than minimal risk, and all activities remained within the learners' normal educational experiences.

Data were used only for the stated research purpose. Printed instruments were secured in a locked storage area, and electronic records were protected through passwords and restricted access. The data were retained only for the period required by the institution and were scheduled for secure destruction after that period. Any presentation or publication arising from the study maintained the anonymity of the participants and the confidentiality of their individual responses.

RESULTS AND DISCUSSION

Table 1. *Validity and Reliability Results of the Research Instruments*

Instrument or dimension	Validity or Reliability Index	Result	Interpretation
Hands-On Science Inquiry Experience Scale	S-CVI/Ave	.94	Excellent content validity
Overall Hands-On Science Inquiry Experience Scale	Cronbach's alpha	.90	Highly reliable
Manipulation and Exploration of Materials	Cronbach's alpha	.83	Reliable
Questioning and Prediction	Cronbach's alpha	.79	Reliable
Collection and Interpretation of Evidence	Cronbach's alpha	.85	Highly reliable
Explanation and Reflection	Cronbach's alpha	.80	Reliable
Grade 5 Conceptual Understanding Test	Cronbach's alpha	.82	Reliable

The expert validation produced a scale-level content validity index of .94, which indicated strong agreement among the validators regarding the relevance, clarity, developmental suitability, and curriculum alignment of the items. The overall Cronbach's alpha coefficient of .90 showed that the Hands-On Science Inquiry Experience Scale had high internal consistency. Reliability coefficients for its four dimensions ranged from .79 to .85. The Grade 5 Conceptual Understanding Test obtained a coefficient of .82, indicating that the test items consistently measured the intended science construct.

Table 2. *Confirmatory Factor Analysis Results for the Hands-On Science Inquiry Experience Scale*

Model Fit Indicator	Obtained Value	Interpretation
Comparative Fit Index	.951	Good fit
Tucker-Lewis Index	.943	Good fit
Root Mean Square Error of Approximation	.049	Good fit
RMSEA 90% Confidence Interval	.040 to .058	Acceptable precision
Standardized Root Mean Square Residual	.056	Good fit
Standardized Factor Loadings	.64 to .86	Adequate to strong

The four-factor measurement model showed a good fit to the collected responses. The comparative fit index of .951 and Tucker-Lewis index of .943 indicated that the proposed structure represented the response patterns adequately. The root mean square error of approximation was .049, while the standardized root mean square residual was .056. The standardized factor loadings ranged from .64 to .86, showing that the items were sufficiently associated with their intended dimensions. The results supported the treatment of manipulation and exploration, questioning and prediction, evidence interpretation, and explanation and reflection as related but distinguishable components of hands-on science inquiry.

Table 3. *Hands-On Science Inquiry Experiences of Grade 5 Learners*

Dimension	Median	Interquartile Range	Interpretation	Rank
Manipulation and Exploration of Materials	3.25	0.50	Always	1
Questioning and Prediction	2.75	0.75	Often	2.5
Collection and Interpretation of Evidence	2.75	0.63	Often	2.5
Explanation and Reflection	2.50	0.75	Often	4
Overall Hands-On Science Inquiry	2.81	0.54	Often	

Interpretation guide: 1.00 to 1.74 = Never; 1.75 to 2.49 = Sometimes; 2.50 to 3.24 = Often; 3.25 to 4.00 = Always.

The overall median of 2.81 showed that the Grade 5 learners often experienced hands-on science inquiry. Manipulation and exploration of materials obtained the highest median of 3.25, which indicated that learners were regularly allowed to handle materials, observe physical objects, and perform practical science activities. Questioning and prediction and collection and interpretation of evidence both obtained a median of 2.75.

Explanation and reflection received the lowest median of 2.50. Although this result remained within the often category, it was positioned at its lowest boundary. The finding showed that opportunities to explain results, defend conclusions, compare evidence, and reconsider initial predictions were less evident than opportunities to perform the physical parts of an investigation.

Table 4. Rasch Partial Credit Model Results for the Conceptual Understanding Test

Rasch Indicator	Obtained Value	Interpretation
Person reliability	.80	Good
Person separation index	2.01	Able to distinguish approximately three ability groups
Item reliability	.95	Excellent
Item separation index	4.36	Well-defined hierarchy of item difficulty
Item infit mean square range	0.79 to 1.27	Productive for measurement
Item outfit mean square range	0.74 to 1.31	Acceptable item fit
Median learner ability	-0.28 logits	Below the average item difficulty
Interquartile range of ability	1.12 logits	Noticeable variation in understanding
Mean item difficulty	0.00 logits	Rasch reference point

The conceptual understanding test demonstrated satisfactory measurement properties under the Rasch partial credit model. The item reliability of .95 and item separation index of 4.36 showed that the test contained a stable progression from easier to more difficult questions. The person reliability of .80 indicated that the test differentiated learners with varying levels of conceptual understanding.

All test items remained within acceptable infit and outfit ranges. The median learner ability was -0.28 logits, which was lower than the mean item difficulty of 0.00 logits. This result indicated that the test was moderately challenging for the typical learner. The interquartile range of 1.12 logits also showed considerable variation in the ability of learners to answer scientific questions and provide acceptable explanations.

Table 5. Distribution of Learners According to Conceptual Understanding Level

Conceptual Understanding Level	Rasch Ability Range	Percentage
Advanced	Above 1.00 logits	10.2
Proficient	0.00 to 1.00 logits	23.5
Developing	-1.00 to below 0.00 logits	42.3
Emerging	Below -1.00 logits	24.0

ISSN: 3116-3475
International Journal
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Volume 2 Issue 7 (July 2026)

Conceptual Understanding Level	Rasch Ability Range	Percentage
Total		100.0

The largest proportion of learners was classified at the developing level, representing 42.3 percent of the participants. Another 24.0 percent belonged to the emerging level. Taken together, 66.3 percent of the learners had not yet reached the proficient level of conceptual understanding. These learners showed partial knowledge of Grade 5 science concepts but experienced difficulty explaining the scientific basis of their answers or applying concepts to unfamiliar situations.

Learners at the proficient level accounted for 23.5 percent, while only 10.2 percent reached the advanced level. The results showed that a smaller group could consistently connect scientific evidence with accurate explanations. The distribution also indicated that correct responses on the first tier of the test did not always correspond with correct explanations on the second tier.

Table 6. *Percentage of Fully Correct Two-Tier Responses Across Science Content Areas*

Science Content Area	Fully Correct Responses	Rank
Matter	62.4%	1
Living Things and Their Environment	58.1%	2
Earth and Space	54.8%	3
Force and motion	49.6%	4
Overall	56.2%	

A response was considered fully correct when the learner selected both the correct answer and the scientifically acceptable explanation. Matter obtained the highest percentage of fully correct responses at 62.4 percent. Learners appeared more capable of explaining observable changes in materials and identifying properties that could be directly examined through classroom activities.

Force and motion obtained the lowest result at 49.6 percent. More than half of the responses in this content area contained either an incorrect answer or an explanation that did not support the selected answer. Earth and space also presented difficulty, with only 54.8 percent of responses receiving full credit. The overall percentage of fully correct two-tier responses was 56.2 percent, showing that many learners possessed fragments of scientific knowledge but had not yet developed consistent explanatory understanding.

Table 7. *Median Quantile Regression of Hands-On Science Inquiry on Conceptual Understanding*

Predictor	Regression Coefficient	Bootstrap Standard Error	95% Bootstrap Confidence Interval	Standardized Coefficient	p-value
Constant	-0.30	0.10	-0.50 to -0.11		.003
Hands-On Science Inquiry Factor Score	0.38	0.09	0.20 to 0.56	.34	< .001

Model Statistic	Value
Bootstrap resamples	5,000
Pseudo-R^2	.12
Quantile estimated	.50 or median
Outcome variable	Rasch conceptual understanding ability

The median quantile regression showed that hands-on science inquiry was significantly and positively associated with conceptual understanding. The regression coefficient of 0.38 indicated that a one-standarddeviation increase in the hands-on science inquiry factor score corresponded with an estimated increase of 0.38 logits in the median conceptual understanding ability. The bootstrap confidence interval ranged from 0.20 to 0.56 and did not include zero. The relationship was therefore statistically significant at the .05 level.

The standardized coefficient of .34 indicated a meaningful but not dominant relationship. The pseudo-R^2 value of .12 showed that hands-on science inquiry accounted for approximately 12 percent of the variation in median conceptual understanding. The remaining variation was associated with factors not included in the model. The result supported the presence of a relationship, but it did not establish a direct causal effect.

CONCLUSION

The Grade 5 learners frequently experienced hands-on science inquiry, particularly through the manipulation and exploration of materials, but their opportunities for explanation, reflection, and evidence-based reasoning remained comparatively limited. Their conceptual understanding was generally developing, with notable difficulty in explaining scientific ideas and applying concepts, especially in force and motion. Hands-on science inquiry was significantly and positively associated with conceptual understanding, although the moderate contribution of inquiry indicated that practical activities alone were not sufficient to produce deeper learning. Based on these findings, science teachers should strengthen the reasoning stages of inquiry by giving learners more opportunities to formulate predictions, identify variables, record evidence, compare results, justify conclusions, and reflect on incorrect ideas. Greater instructional attention should be given to difficult concepts through guided investigations, two-tier assessments, small-group remediation, visual representations, and structured classroom dialogue. The school should also support teachers through the provision of suitable science materials, professional development on guided inquiry, and regular review of learners' conceptual difficulties so that hands-on activities consistently lead to accurate scientific understanding.

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