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STUDENTS' PERCEPTION OF HANDS-ON EXPERIMENT TOWARDS CRITICAL THINKING SKILLS IN CHEMISTRY

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ABSTRACT

This study investigated the relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry among 132 Bachelor of Secondary Education (BSED) Science students (2nd and 3rd years) at Don Carlos Polytechnic College during school year 2025-2026. Employing a quantitative correlational design, data were collected via validated surveys: the Intrinsic Motivation Inventory (IMI) for perceptions across five sub-scales (interest, perceived competence, effort, felt pressure, valuing) and a Bloom's Taxonomy-based instrument for critical thinking across six domains (remembering, understanding, applying, analyzing, evaluating, creating). Descriptive statistics analyzed means with qualitative ratings, while Pearson correlation examined relationships between variables. Findings revealed strong positive perceptions of hands-on experiments, particularly valuing their relevance and the effort they inspire, coupled with robust self-assessed critical-thinking abilities, especially in higher-order skills such as creating and evaluating. A significant, moderate positive correlation emerges between these perceptions and the development of critical thinking, affirming hands-on activities as vital for shifting from passive learning to active inquiry in chemistry education and supporting the alternative hypothesis of a significant relationship, which is hereby accepted. These results underscore the pivotal role of hands-on experiments in enhancing students' critical thinking skills in Chemistry, aligning with constructivist theories that emphasize active, inquiry-based learning. Practical implications include integrating more experiential activities into science teacher training curricula to foster higher-order thinking, such as problem-solving and evaluation, thereby bridging theory-practice gaps in BSED programs. Recommendations involve faculty development workshops on hands-on pedagogy and resource allocation for lab materials. Future research could explore causal links using quasi-experimental designs, examine mediating factors such as prior knowledge, or extend the findings to other STEM disciplines and larger multi-institutional samples.

Keywords: hands-on experiments, critical thinking skills, chemistry education, student perceptions, correlation analysis

1. INTRODUCTION

Globally, recent chemistry education research, including Rodriguez & Towns (2018) who modified lab experiments with reframed pre/post-lab questions to boost critical thinking engagement, Kibga et al. (2021), who demonstrated that hands-on activities enhanced curiosity and indirect critical skills via low-cost local materials in Tanzanian schools, Shana & Abulibdeh (2020), who advocated practical exercises for deeper chemistry comprehension, and recent works like Szalay et al. (2023, 2024) on scaffolding experimental design for critical reasoning, underscored that hands-on experiments significantly enhanced critical thinking skills by transforming passive learning into active inquiry. These laboratory activities fostered analytical depth, procedural confidence, and conceptual mastery through experiential cycles of observation, reflection, and abstraction in phenomena such as acid-base titrations and reaction kinetics, as students hypothesized, troubleshooted anomalies, interpreted data, evaluated evidence, and solved sustainability-related problems, contrasting rote methods with reflective reasoning. Studies further confirmed strong correlations between such engagement and self-reported gains in competencies like argumentation and error analysis.

At Don Carlos Polytechnic College (DCPC), persistent deficiencies in chemistry laboratory facilities created a critical gap between hands-on experiments and critical thinking skills, as limited chemicals and other laboratory materials restricted practical engagement. Additionally, hands-on experiments demonstrated a stronger influence on critical thinking skills among DCPC BSED Science students in A.Y. 2025-2026, as practical engagement directly built procedural mastery and data interpretation abilities essential for hypothesizing, analyzing mechanisms, and evaluating evidence, while both factors contributed meaningfully, with hands-on experiments serving as the primary driver by providing concrete experiences that enhanced critical thinking application in real-world contexts like sustainability

challenges. This proposed relationship aligns with Seery (2021), who demonstrated, through a meta-analysis, that laboratory-based instruction significantly outperformed other methods in fostering critical thinking development, particularly in resource-constrained educational settings like DCPC.

This research held paramount importance for Don Carlos Polytechnic College (DCPC), as it directly addressed the critical shortage of hands-on chemistry experiments that obstructed the perceived development of critical thinking skills among BSED Science students in this rural, low-income tertiary context. Unlike urban high school studies such as Santos and Guidote (2020)—which validated green chemistry using local materials (guava extracts, vinegar) at Saint Paul College, Pasig, but lacked applicability to rural colleges—this study provided specific validation for scaling low-cost inquiry labs. National trends showed that inquiry-based approaches yielded substantial gains in critical thinking competencies, yet lecture dominance hindered skill-building in areas like reaction hypothesizing and data evaluation; this research bridged that gap by establishing how perceived hands-on experiments drove critical thinking skills, offering validated, budget-friendly interventions (e.g., recycled bottle titrations) with teacher-training implications absent in prior K-12 focused studies like the 2023 Ilocos Sur ADDIE-model work.

In the Philippines, the K-12 STEM curriculum has consistently shown persistently low science proficiency, evidenced by PISA 2022 scores averaging 355 in science (versus the OECD's 485), highlighting deficiencies in inquiry skills and the application of chemical concepts within lecture-dominated classrooms. Despite national mandates for critical thinking and laboratory work under the Enhanced Basic Education Act, rural implementation gaps—overcrowded classes, inadequate facilities, teacher training deficits—limited hands-on engagement (San Gabriel & Manalastas, 2025). Pacifico (2021) showed that Grade 12 STEM students gained motivation from pandemic-era home experiments but lacked sustained validation of their critical thinking. Five key RRL studies confirmed these links: Walker et al. (2021) found that hands-on labs boosted critical thinking through experiential inquiry; Abrahams & Millar (2020) demonstrated that inquiry experiments enhanced critical analysis in resource-poor settings; Firdaus et al. (2021) reported that critical thinking skills linked to enhanced analytical abilities in chemistry; Santos & Guidote (2020) validated low-cost green chemistry labs using local materials like guava extracts; and Apsara & Widodo (2022) established hands-on inquiry as the strongest predictor of critical thinking development in STEM, underscoring the need for specific empirical validation of perceived hands-on experiments toward perceived critical thinking skills in chemistry.

Conducting this study provided actionable, localized data to enhance instructor resourcefulness at Don Carlos Polytechnic College (DCPC), elevated perceived hands-on experiments as a key driver of perceived critical thinking skills in Chemistry among BSED Science students and scaled low- cost solutions nationwide. The primary objective was to examine the influence of perceived hands-on experiments on perceived critical thinking skills in Chemistry, with specific aims to assess their relationship and predictive strength through correlational analysis among DCPC BSED Science students. The study employed a quantitative correlational design during the second semester of academic year 2025-2026 at Don Carlos Polytechnic College (DCPC) in Don Carlos, Bukidnon, targeting second-year and third-

year BSED Science students via validated surveys on perceived hands-on
experiments and perceived critical thinking skills in Chemistry.

1.1 Statement of the Problem

This study investigated the relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry.

Specifically, it sought to answer the following questions:

1. What is the level of hands-on experiments among students in Chemistry in terms of:
   a. Interest;
   b. Perceived competence;
   c. Effort;
   d. Felt pressure; and
   e. Value?
2. What is the level of students' critical thinking skills in Chemistry in terms of:
   a. Remembering;
   b. Understanding;
   c. Applying;
   d. Analyzing;
   e. Evaluating; and
   f. Creating?
3. Is there a significant relationship between students' perceptions of hands-on experiments and their critical thinking skills in Chemistry?

1.2 Hypothesis of the Study

The hypothesis is drawn based on the given objective:

Ha: There is a significant relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry.

2. METHODOLOGY

This chapter presents the method that was used in the study. It includes the research design, locale of the study, map of the locale, study respondents, sampling procedure, research instrument, administration of the instrument, scoring procedure, ethical considerations, data-gathering procedure, and statistical treatment.

2.1. Research Design

This study employed a descriptive-correlational quantitative research design to examine students' perceptions of hands-on experiments and their relationship to students' development of critical thinking skills in Chemistry. The descriptive component assessed students' perceptions of hands-on laboratory experiments and their self-assessed critical-thinking skills. The correlational component examined whether a significant relationship existed between students' perceptions of hands-on experiments and their critical thinking skills.

This design was held appropriate as it allowed the researchers to describe existing conditions and examine relationships among variables without manipulating them. Additionally, data were collected via structured survey questionnaires, and statistical analyses were conducted to assess the strength and significance of the relationship between students' perceptions of hands-on experiments and their critical thinking skills.

2.2 Locale of Study

This study was conducted at Don Carlos Polytechnic College (DCPC), a local college operated by the Local Government Unit (LGU) of Don Carlos, Bukidnon. The institution is located at P-2, Población Norte, Don Carlos, Bukidnon, approximately 30 meters from the left side of the national highway when traveling south. DCPC was known for providing quality and accessible education that supports the academic and professional development of its students, particularly in the field of science.

The college offered several undergraduate programs, including Bachelor of Elementary Education (BEED) with 2,333 students, Bachelor of Science in Criminology (BSCRIM) with 2,209 students, Bachelor of Secondary Education (BSED) major in English with 169 students, BSED major in Filipino with 223 students, BSED major in Mathematics with 148 students, BSED major in science with 283 students, and Bachelor of Science in Information Systems Management (BSISM) with 93 students. In total, the institution had an enrolled student population of 5,458.

Don Carlos Polytechnic College was selected as the research locale because it offered Chemistry-related courses, particularly in the Bachelor of Secondary Education major in science program. The presence of students enrolled in science-related programs made the institution an appropriate setting to examine the relationship between students' perceptions of hands-on experiments and their critical thinking skills in Chemistry. Furthermore, the availability of laboratory facilities and a supportive academic environment enabled the researchers to collect relevant data effectively and to assess the study's feasibility.

2.3 Respondents of the Study

The respondents in this study were second-year and third-year BSED Science students who were officially enrolled in Chemistry during the Academic Year 2025–2026 at Don Carlos Polytechnic College. These respondents were chosen as they had sufficient background knowledge and prior exposure to Chemistry concepts and laboratory activities, particularly hands-on experiments, which were the central focus of the study. The student's academic experiences in chemistry enabled them to meaningfully express their perceptions of hands-on experimental activities and how these experiences contributed to the development of critical thinking skills. Additionally, respondents were considered appropriate participants because their academic records in Chemistry provided measurable data needed to examine the relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry.

2.4 Sampling Procedure

This study employed total enumeration sampling, also known as census sampling. In this method, all members of the identified population were included in the study. No sampling technique was used to select a subset of participants, as the population size was manageable and accessible to the researcher. It involved the entire population of one hundred and thirty - two (132) second-year and third-year students. Moreover, every eligible respondent was given an equal opportunity to participate. Thus, this approach minimized sampling bias and ensured comprehensive data collection from the whole population.

2.5 Research Instrument

The study utilized an adapted survey. This study examined students' perceptions of hands-on chemistry experiments and their influence on critical thinking skills using two adapted validated instruments: Snětinová et al.'s (2018) 23-item Hands-On Experiments scale and Kobylarek et al.'s (2022) 25-item Critical Thinking Questionnaire (CThQ). The adapted Hands-On Experiments instrument assessed engagement across five subscales—interest (4 items), perceived competence (4 items), effort (4 items), pressure (4 items), and value (7 items). Meanwhile, the adapted CThQ measured Bloom's cognitive levels: remembering (3 items), understanding (4 items), applying (4 items), analyzing (4 items), evaluating (4 items), and creating (6 items).

Both adapted instruments, originally 5-point scales, were modified to a 4-point forced-choice scale (1 = Strongly Disagree to 4 = Strongly Agree) in this study to eliminate neutral responses and reduce central tendency bias (Garland, 1991; Kulas et al., 2008). This format enhanced response discrimination and provided decisive data on chemistry-specific perceptions and critical thinking.

The instruments were contextualized for chemistry education and were pilot tested with students in chemistry. The results showed acceptable internal consistency (Cronbach's alpha = 0.705), confirming that these tools are reliable and suitable for assessing the influence of hands-on experiments on critical thinking skills.

2.6 Administration of Research Instrument

The research questionnaire was an adapted survey instrument specially designed to align with the variables under investigation. The questionnaires served as a structured tool for data collection, ensuring that the gathered responses were relevant to the research objectives. The adaptation process involves carefully selecting and modifying existing validated questions or creating new items tailored to the study's context.

To ensure the questionnaire's accuracy, reliability, and validity, it underwent a validation process conducted by the research committee. This process included expert evaluation to assess the clarity, relevance, and coherence of each question, and to identify potential issues in comprehension or response interpretation.

Once finalized and approved, the questionnaire was administered to the target respondents, who provided firsthand responses based on their experiences, perspectives, or knowledge of the subject matter.

2.7 Scoring Procedure

To determine and analyze students' perception of hands-on experiments towards critical thinking skills in Chemistry at Don Carlos Polytechnic College, the researcher provided a scoring procedure based on two major variables: (1) students' perception of hands-on experiments and (2) critical thinking skills in Chemistry.

For the Hands-on experiments, responses were obtained using a structured questionnaire developed by Marie Snětinová and colleagues in 2018. The scores for each respondent were summed and divided by the total number of items to obtain the weighted mean.

For the Perceived Critical Thinking Skills (CThQ) variable, a similar 4- point scale was used to measure students' perceived ability to remember, understand, apply, analyze, evaluate, and create. The same numerical values and interpretation scale were applied to ensure consistency in scoring and comparison of responses.

Below are the scoring scheme and the interpretation of mean scores:

Range	Qualitative Description	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

To determine the relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry, the computed mean scores were subjected to appropriate statistical analyses, such as the Pearson Product-Moment Correlation Coefficient, to assess whether a significant relationship existed between the two variables.

2.8 Ethical Considerations

During the study, ethical principles, including informed consent, confidentiality, voluntary participation, and non-maleficence, were strictly observed. Prior to survey administration, all respondents received a consent form detailing the purpose of research, objectives, procedures, risks/benefits, and data use for academic purposes only. The form explicitly stated that participation remained voluntary, with the right to withdraw at any time without academic or personal consequences. To uphold these standards, researchers ensured survey questions remained neutral, unbiased, and free from content likely to cause discomfort, distress, or coercion. All data were anonymized, stored securely, and accessible only to the research team, with destruction upon study completion.

2.9 Data Gathering Procedure

The researcher obtained approval from the Dean of Don Carlos Polytechnic College to conduct the study. Signed informed consent forms were distributed and collected from all participants to confirm voluntary participation and full awareness of the study purpose, procedures, and confidentiality measures. Subsequently, printed questionnaires, including the Hands-On Experiments and CThQ instruments, were distributed to the respondents, and assistance was provided for any questions during completion. Sufficient time was allotted for respondents to complete the questionnaire; the questionnaires were then collected and verified for completeness. Moreover, all data remained strictly confidential and were used solely for academic purposes. The data were organized and prepared for statistical analysis to examine the relationship between perceptions of hands- on experiments and critical thinking skills in Chemistry. The collected data were used to inform conclusions and recommendations.

2.10 Statistical Treatment

The data were grouped and categorized according to the study's problem statement. Descriptive and correlational statistical tools were used to analyze and interpret data collected from respondents.

For Problem 1, the mean was used to describe the level of hands-on experiments among students in Chemistry in terms of interest, perceived competence, effort, felt pressure, and value. The mean indicated the overall level of each dimension.

For Problem 2, the mean was used to describe students' levels of critical thinking skills in

Chemistry, including remembering, understanding, applying, analyzing, evaluating, and creating. The mean indicated the overall level of each dimension.

For Problem 3, Pearson's product–moment correlation (Pearson r) was used to determine whether there was a statistically significant relationship between students' perceptions of hands-on experiments and their critical thinking skills in Chemistry.

3. RESULTS AND DISCUSSIONS

This section presents a comprehensive analysis of the findings from the collected data, which were meticulously examined and interpreted in alignment with the study's specific objectives. It provided an in-depth exploration of students' perceptions of hands-on experiments and of their critical thinking skills in Chemistry.

Hands-on experiments among students in Chemistry.

The succeeding sections present the level of hands-on experiments among students in Chemistry in terms of interest, perceived competence, effort, felt pressure, and value.

Interest

Table 1 presents the hands-on experiments among students in Chemistry in terms of interest, with an overall mean score of 2.57 ("Agree") categorized as "Positive Perception." This score indicated that students held a positive view toward hands-on activities. This positive perception suggested that, while interest was evident, there remained opportunities to enhance engagement through targeted lab enhancements further.

Table 1. *Hands-on experiments among Students in Chemistry in terms of interest.*

N0	Indicators	Mean	Qualitative Interpretation
1	I enjoyed doing hands-on activities so much.	3.34	Very Positive Perception
2	While doing this activity, I thought about how much I enjoyed it.	3.11	Positive Perception
3	I thought hands-on activities were boring.	2.08	Negative Perception
4	Chemistry activities do not hold my attention at all.	1.76	Very Negative Perception
	OVERALL MEAN	2.57	Positive Perception

Legend

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

1

The indicator "I enjoyed doing hands-on activities so much" scored highest (M=3.34, Strongly Agree, Very Positive Perception), showing strong enthusiasm. "While doing this activity, I thought about how much I enjoyed it" followed (M=3.11, Agree, Positive Perception). Negative items indicated low disinterest: "hands-on activities were boring" (M=2.08, Disagree) and "Chemistry activities do not hold my attention" (M=1.76, Disagree). Positive interest (overall mean 2.57, Agree) indicates that hands-on experiments sustain engagement and are essential for critical thinking. This supports experiential learning's motivational role, recommending reinforcement in BSED Science curricula.

Muñoz-Losa and Corbacho-Cuello (2025) found that interactive science workshops significantly boosted primary pupils' joy, enthusiasm, and appreciation for experiments, laying the foundation for sustained engagement. This aligns with Dapitan and Nama (2025), who showed augmented reality biology lessons in Philippine public schools increased excitement and participation, extending workshop benefits through technology-enhanced hands-on interaction to foster lasting subject interest. Building on this, Lobo (2025) demonstrated in Philippine physical education that instant enjoyment from moderately challenging experiential activities predicts deeper engagement, connecting prior enthusiasm to long-term motivation relevant to chemistry labs.

Perceived Competence

Table 2 shows that students in chemistry' perceptions of hands-on experiments in terms of perceived competence, with an overall mean of 2.92, rated "Agree" and "Positive Perception," indicating strong self-belief in their lab abilities.

Table 2. *Hands-on experiments among students in chemistry and perceived competence*

Indicators	Mean	Qualitative Interpretation
I feel competent doing laboratory activities.	3.11	Positive Perception
I did not perform well in this kind of activity.	3.03	Positive Perception
I am satisfied with my performance in laboratory tasks.	3.03	Positive Perception
I am pretty skilled in all chemistry activities.	2.50	Positive Perception
OVERALL MEAN	2.92	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The positive overall mean indicates that hands-on experiments boost students' perceived competence and self-efficacy in chemistry labs, aligning with research on inquiry-based activities that improve performance and persistence. This fosters critical thinking and better science outcomes. In Philippine BSED contexts, it supports more experiential learning for skill confidence.

Agustian et al. (2022) reviewed 355 chemistry lab studies and confirmed that laboratory instruction develops experimental skills, higher- order thinking, and confidence, while Easton (2025) demonstrated 21-31% gains in technical confidence through authentic lab manuals—mirroring how practical chemistry tasks build self-belief, an essential ingredient for critical thinking. This competence perception aligns with the study's broader framework, in which O'Brien et al. (2021) and Habib et al. (2021) demonstrated that real-world projects across engineering and mechatronics foster workplace-ready skills, reinforcing the role of hands-on experiments in bridging theory to practice for future science educators. Long-term experiential programs further solidify these gains by linking competence to 21st-century skills such as problem-solving, which are critical to chemistry achievement. Semilarski et al. (2021) found that real-life science connections boost confidence, while Carvalhais et al. (2021) demonstrated that strong self- belief predicts superior skill application, aligning with your research's emphasis on how perceived competence from hands-on activities contributes to the development of critical thinking and academic success in Philippine BSED chemistry curricula.

Effort

Table 3 illustrates chemistry students' perceptions of hands-on experiments regarding effort, yielding an overall mean of 3.18, rated "Agree" and "Positive Perception," indicating a strong willingness to invest effort in lab tasks. The top mean was "I put a lot of effort into experiments" (M=3.26, Strongly Agree/Very Positive), showing strong commitment. Reversed items confirmed this: "I did not try my best to do well in lab activities" (M=3.22, Agree/Positive) and "I did not put much energy into chemistry activities" (M=3.15, Agree/Positive). "I tried very hard in chemistry activities" scored M=3.08 (Agree/Positive), supporting overall positive effort.

Table 3. *Hands-on experiments among Students in Chemistry in terms of effort*

Indicators	Mean	Qualitative Interpretation
I put a lot of effort into experiments.	3.26	Very Positive Perception
I did not try my best to do well in lab activities.	3.22	Positive Perception
I did not put much energy into chemistry activities.	3.15	Positive Perception
I tried very hard in chemistry activities.	3.08	Positive Perception
OVERALL MEAN	3.18	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The overall positive mean shows hands-on experiments drive substantial student effort, aligning with studies linking lab work to boosted motivation, persistence, and science engagement. Positive effort predicts better chemistry achievement and curiosity by making learning concrete. The Philippine BSED Science curricula support inquiry-based labs to sustain effort for critical thinking and skill mastery.

Hands-on learning formats, such as chemistry experiments, boost student effort by enhancing motivation and perceived task value compared to traditional lectures. Wijnia et al. (2024) demonstrated that problem-, project-, and case-based approaches yield small to moderate gains in interest and importance, while Li and Liang (2024) found virtual labs in engineering elicit strong engagement when meaningfully designed, encouraging sustained energy investment.

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This effort connects to supported, relevant activities that counter perceived costs, as Alemneh et al. (2025) showed: biology labs combining structured experiments with case-based problems increased participation, even among low achievers. Though Kim et al. (2021) noted effort/stress costs reduce physics persistence and de la Fuente et al. (2025) linked demanding tasks to lower satisfaction, Umar and Ko (2022) found teamwork in project- based e-learning mitigates workload burdens—affirming well-designed hands- on chemistry labs foster persistent engagement essential for critical thinking development in BSED Science curricula.

Felt Pressure

Table 4 depicts students in chemistry' perceptions of hands-on experiments regarding felt pressure, with an overall mean of 2.56, rated "Agree" and "Positive Perception," suggesting notable tension during lab activities.

Table 4. *Hands-on experiments among Students in Chemistry in terms of felt pressure*

Indicators	Mean	Qualitative Interpretation
I feel pressured while doing experiments.	2.62	Positive Perception
I feel very tense while performing lab activities.	2.56	Positive Perception
I am very relaxed while conducting chemistry activities.	2.54	Positive Perception
I am not nervous performing lab activities at all.	2.53	Positive Perception
OVERALL MEAN	2.56	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The highest mean was "I feel pressured while doing experiments" (M=2.62, Agree/Positive), followed by "I feel very tense while performing lab activities" (M=2.56, Agree/Positive). Reversed items showed low relaxation: "I am very relaxed while conducting chemistry activities" (M=2.54, Agree/Positive) and "I am not nervous performing lab activities at all" (M=2.53, Agree/Positive), confirming elevated pressure overall.

The overall mean indicates positive pressure in chemistry labs, driven by safety, time constraints, and unfamiliarity. While positive pressure aids focus, excess anxiety impairs performance and thinking (per lab self-efficacy studies). For BSED curricula, recommend pre-lab prep and peer support to reduce tension and enhance outcomes.

Kácovský et al. (2023) found that while intrinsic motivation in physics labs stems from usefulness and effort, pressure has only a small negative effect, with girls experiencing higher stress than boys—highlighting the need for gender-sensitive, enjoyable designs to maintain engagement. This pressure perception connects to psychophysical factors in lab setups, where faster or uneven stimuli amplify discomfort even at low forces (Weda et al., 2023; Henell et al., 2024). Average, evenly distributed pressure from comfortable equipment reduces tension and activates pleasant brain responses (He et al., 2024; Sasaki et al., 2025), while excessive tightness increases stress (Naugle et al., 2021). Philippine studies reinforce that well- guided inquiry activities lower anxiety (Ditingki et al., 2025), supporting optimized lab designs to minimize felt pressure and enhance critical thinking in chemistry education.

Value

Table 5 summarizes students in chemistry' perceptions of hands-on experiments in terms of value, achieving an overall mean of 3.21, rated as "Agree" and "Positive Perception," affirming strong recognition of labs' educational benefits. The positive indicators dominated: "Chemistry activities are important" topped at M=3.60 (Strongly Agree/Very Positive), followed by "Hands-on activities increase my interest in chemistry" (M=3.52), "Chemistry labs develop my critical thinking skills" (M=3.46), "Doing chemistry activities helps me understand concepts more deeply" and "Chemistry experiments improve my academic achievement" (both M=3.43), and "I am willing to do chemistry hands-on activities again" (M=3.37; all Very Positive). Reversed "Chemistry experiments are useless for me at school" was M=1.65 (Strongly Disagree/Very Negative), reinforcing positive perceived value.

Table 5. *Hands-on experiments among Students in Chemistry in terms of value*

Indicators	Mean	Qualitative Interpretation
Chemistry activities are important.	3.60	Very Positive Perception
Hands-on activities increase my interest in chemistry.	3.52	Very Positive Perception
Chemistry labs develop my critical thinking skills.	3.46	Very Positive Perception
Doing chemistry activities helps me understand concepts more deeply.	3.43	Very Positive Perception
Chemistry experiments improve my academic achievement.	3.43	Very Positive Perception
I am willing to do chemistry hands-on activities again because they have value for me.	3.37	Very Positive Perception
Chemistry experiments are useless for me at school.	1.65	Very Negative Perception
Overall Mean	3.21	Positive Perception

The overall positive mean shows students highly value hands-on chemistry experiments for deeper understanding, increased interest, critical thinking, and achievement. These drives repeat engagement and align with research linking labs to real-world applications for future educators. In the Philippine BSED, it supports inquiry-based science teaching goals. Students perceive hands-on chemistry experiments as highly valuable for conceptual understanding, skill development, and career preparation. Holik et al. (2021) found that over 88% of dietetics students agreed that experiential activities enhanced subject comprehension and real-world application, while Pati et al. (2021) reported that medical students valued BLS workshops for building practical confidence—directly paralleling the role of chemistry labs in deepening theory and critical thinking.

This value extends to broader competencies, though design matters. Habib et al. (2021) and Novani & Arief (2021) confirmed that hands-on tasks in engineering and signals courses foster creativity and technical skills, and Alali (2024) showed that PoPBL STEM programs boost 21st-century abilities such as problem-solving. Challenges such as resource limits (Simamora et al., 2025) and performance gaps (Pati et al., 2021) underscore the need for structured support to ensure that perceived usefulness translates into outcomes in BSED chemistry curricula.

Summary of Hands-on Experiments

Table 6 provides a comprehensive summary of students in chemistry' perceptions across five dimensions of hands-on experiments, yielding an overall mean of 2.89 rated as "Agree" and "Positive Perception." Value-led with the highest mean (3.21; "Agree," "Positive Perception"), followed closely by Effort (3.18), indicating strong appreciation and investment. Perceived Competence (2.92) and Interest (2.57) maintained Positive perceptions, while Felt Pressure (2.56) showed the lowest but still notable agreement. All dimensions consistently fell within the "Positive Perception" range, reflecting uniformly positive engagement.

Table 6. *Summary of mean scores of Hands-on experiments among Students in chemistry*

Hands-on experiments	Mean	Qualitative Interpretation
Value	3.21	Positive Perception
Effort	3.18	Positive Perception
Perceived competence	2.92	Positive Perception
Interest	2.57	Positive Perception
Felt pressure	2.56	Positive Perception
OVERALL MEAN	2.89	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The overall mean shows hands-on chemistry labs drive robust engagement in BSED Science students, with positive value and effort outweighing moderate pressure. This fits the intrinsic motivation theory, sustaining interest, competence, and critical thinking. Findings support prioritizing supported labs in Philippine science curricula for optimal outcomes. Hands-on chemistry experiments foster multidimensional engagement, enhancing process skills, motivation, and conceptual understanding, surpassing those of lectures. Sahar et al. (2025) and Idris et al. (2022) confirm that these activities build observing, measuring, and data interpretation abilities while boosting collaboration, with "hands-on + minds-on" approaches yielding deeper learning (Oliveira & Bonito, 2023).

Hybrid real-virtual labs and guided inquiry amplify benefits, as Wörner et al. (2022) found that combined methods outperform single methods, and Gericke et al. (2022) stressed the importance of goal-aligned tasks for scientific practice. In the Philippines, teachers value active learning (Ligado et al., 2022), though resource gaps limit access (Pacadaljen, 2024); well-planned designs with ICT overcome challenges (Idris et al., 2022), supporting positive overall perceptions and critical thinking in BSED curricula.

Critical Thinking Skills of Students

The following sections present the level of students' Critical Thinking Skills across remembering, understanding, applying, analyzing, evaluating, and creating.

Remembering

Table 7 outlines students' perceived critical thinking skills in chemistry in the remembering dimension, with an overall mean of 2.92, rated as

"Agree" and "Positive Perception." "If needed, I can recall information from chemistry readings" scored highest (M=2.95, "Agree," "Positive Perception"), closely followed by "After the activity, I can repeat important concepts from chemistry texts" (M=2.94, "Agree," "Positive Perception"). The reversed item "I do not remember much from chemistry learning at school" also aligned (M=2.87, "Agree," "Positive Perception"), indicating consistent positive recall ability across contexts.

Table 7. *Critical Thinking Skills of students in terms of remembering.*

Indicators	Mean	Qualitative Interpretation
If needed, I can recall information from chemistry readings.	2.95	Positive Perception
After the activity, I can repeat important concepts from chemistry texts.	2.94	Positive Perception
I do not remember much from chemistry learning at school.	2.87	Positive Perception
OVERALL MEAN	2.92	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The overall positive mean indicates strong perceived remembering skills in chemistry, enhanced by hands-on activities that boost retention via active engagement. Mnemonics and experiential learning aid recall of abstract concepts for deeper analysis. In BSED curricula, labs build memory as a foundation for higher-order skills, such as evaluation.

Remembering foundational chemistry knowledge forms the essential base for critical thinking skills, enabling analysis and problem-solving. Porteria and Gaza (2025), Dwiprabowo et al. (2024), and Li et al. (2024) position recall as a prerequisite for higher reasoning, providing the facts needed for evaluation.

However, rote memorization alone limits deeper cognition, as Syed and Faruk (2020) and Sarwanto et al. (2021) note that students often recall accurately but falter in application or justification. Overreliance reduces motivation for complex tasks (Hassan et al., 2025; van Peppen et al., 2021), underscoring the need to integrate active strategies such as dialogue and collaboration (Abrami et al., 2015; Warsah et al., 2021) to elevate remembering into robust critical thinking in chemistry education.

Understanding

Table 8 captures students in chemistry' perceived critical thinking skills in the understanding dimension, with an overall mean of 2.72, rated "Agree" and "Positive Perception." The highest was "I like comparing different chemistry theories and opinions" (M=2.89, Agree/Positive), followed by "I can understand chemistry texts from various topics" (M=2.83, Agree/Positive) and "I notice contexts, nuances, and implications in chemistry statements" (M=2.74, Agree/Positive). Reversed "I have difficulties paraphrasing chemistry concepts" scored M=2.40 (Agree/Positive), affirming comprehension.

The overall mean reflects solid perceived understanding skills vital for critical thinking, enhanced by hands-on activities that contextualize abstract concepts. Comparing theories and grasping nuances enables deeper inference, aligning with metacognitive gains in STEM labs. For BSED chemistry, this supports inquiry-based labs to advance from recall to analytical proficiency.

Table 8. *Critical Thinking Skills of students in terms of understanding*

Indicators	Mean	Qualitative Interpretation
I like comparing different chemistry theories and opinions.	2.89	Positive Perception
I can understand chemistry texts from various topics.	2.83	Positive Perception
I notice contexts, nuances, and implications in chemistry statements.	2.74	Positive Perception
I have difficulties paraphrasing chemistry concepts.	2.40	Positive Perception
OVERALL MEAN	2.72	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

Understanding chemistry requires critical thinking that goes beyond rote recall, and this critical thinking strongly correlates with higher reasoning abilities. Rismanto & Hayat (2025) and Toh et al. (2025) confirm conceptual grasp enhances performance, though misconceptions and rote habits impede progress (Sarwanto et al., 2021).

This foundation enables application through logical problem-solving in real contexts, as Song et al. (2024) note gaps in workplace transfer that require active strategies such as inquiry tasks (Jamil et al., 2024). Challenges like insufficient practice persist (Hidayah et al., 2017), but integrated reflective methods (Naveed et al., 2025; Hlavatska, 2025) bridge to metacognitive flexibility, fostering adaptive critical thinking in hands-on chemistry education.

Applying

Table 9 evaluates students in chemistry' perceived critical thinking skills in the applying dimension, recording an overall mean of 3.09, rated as "Agree" and "Positive Perception." Highest was "I am willing to share newly learned chemistry information" (M=3.25, Agree/Positive), followed by "I apply chemistry information I learned in everyday life" (M=3.11, Agree/Positive). "When discussing chemistry, I give many practical examples" and "In discussions, I use lab examples to justify my chemistry views" both scored M=3.01 (Agree/Positive), showing strong application.

Table 9. *Critical Thinking Skills of students in terms of applying*

Indicators	Mean	Qualitative Interpretation
I am willing to share newly learned chemistry information.	3.25	Positive Perception
I apply chemistry information I learned in everyday life.	3.11	Positive Perception
When discussing chemistry, I give many practical examples.	3.01	Positive Perception
In discussions, I use lab examples to justify my chemistry views.	3.01	Positive Perception
OVERALL MEAN	3.09	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The overall mean indicates a strong perceived ability to apply chemistry knowledge practically, a key critical thinking facet amplified by hands-on labs that contextualize concepts for real-life use. Sharing examples and justifications reflects transfer skills vital for discussions and problem-solving. In BSED programs, this supports experiential learning to cultivate application proficiency for teaching effectiveness.

Applying critical thinking in chemistry entails logical, reflective use of knowledge for real-world decisions and problem-solving. Song et al. (2024) highlight workplace transfer gaps that targeted training can bridge, while Jamil et al. (2024) and Sharma et al. (2022) advocate inquiry-based tasks and reflective questioning to foster practical application.

Challenges like theoretical overemphasis weaken skills (Hidayah et al., 2017), compounded by neglected metacognition and emotions (Pandey, 2025). Diverse strategies—such as forecasting and mind mapping (Hlavatska, 2025)—and real-life scenarios (Dwyer et al., 2014; Mei Lin et al., 2023) enhance flexibility, supporting hands-on chemistry and cultivating adaptive application in BSED education.

Analyzing

Table 10 assesses students in chemistry' perceived critical thinking skills in the analyzing dimension, with an overall mean of 2.92 rated as "Agree" and "Positive Perception." Reversed "In-depth analysis of chemistry phenomena is a waste of time" topped at M=3.02 (Agree/Positive), implying high analysis value. "I can identify the most relevant parts of chemistry texts" and "When reading chemistry texts, I connect them to other readings" tied at M=2.92 (Agree/Positive). "I enjoy finding connections between different chemistry concepts" scored M=2.82 (Agree/Positive), confirming analytical proficiency.

Table 10. *Critical Thinking Skills of students in terms of analyzing*

Indicators	Mean	Qualitative Interpretation
In-depth analysis of chemistry phenomena is a waste of time.	3.02	Positive Perception
I can identify the most relevant parts of chemistry texts.	2.92	Positive Perception
When reading chemistry texts, I connect them to other readings.	2.92	Positive Perception
I enjoy finding connections between different chemistry concepts.	2.82	Positive Perception
OVERALL MEAN	2.92	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The overall mean demonstrates robust analytical skills, as students discern relevance and forge conceptual links crucial for critical thinking in chemistry. Hands-on labs promote this by requiring data breakdown and pattern recognition. In BSED training, nurturing analysis through inquiry tasks equips future teachers to foster student reasoning.

Analyzing in chemistry involves critical thinking: deconstructing information, identifying relationships, and evaluating evidence to reach logical conclusions. Hidayah et al. (2017) position it as central to decision-making, requiring discernment of relevance and systematic questioning.

However, weak analytical skills persist due to rote focus, misconceptions, and limited practice (Sarwanto et al., 2021; Prabayanti et al., 2025), with prospective teachers often underdeveloped (Fitriani et al., 2019; Basri et al., 2019). Active learning and contextual problems build flexibility (Scobioala et al., 2025), though metacognitive and emotional factors must be integrated to overcome performance gaps (Sharma et al., 2022; Susilawati et al., 2020), thereby enhancing hands-on analysis in BSED curricula.

Evaluating

Table 11 presents students in chemistry' perceived critical thinking skills in the evaluating dimension, with an overall mean of 3.12 rated as "Agree" and "Positive Perception."

Table 11. *Critical Thinking Skills of students in terms of evaluating.*

Indicators	Mean	Qualitative Interpretation
After reading chemistry info, I verify important facts even if they seem true.	3.16	Positive Perception
To evaluate chemistry information, I consult multiple sources.	3.15	Positive Perception
When interested in chemistry info, I check its accuracy.	3.12	Positive Perception
In chemistry discussions, I justify my views while understanding others.	3.06	Positive Perception
OVERALL MEAN	3.12	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

"After reading chemistry info, I verify important facts even if they seem true" scored highest (M=3.16, "Agree," "Positive Perception"), followed closely by "To evaluate chemistry information, I consult multiple sources" (M=3.15, "Agree," "Positive Perception"). "When interested in chemistry info, I check its accuracy" earned M=3.12 ("Agree," "Positive Perception"). In contrast, "In chemistry discussions, I justify my views while understanding others" was M=3.06 ("Agree," "Positive Perception"), showing consistent evaluative habits.

The overall positive mean indicates strong perceived evaluative skills for discerning credible chemistry information and balanced discourse. Hands-on labs build this via data scrutiny and debate, linking to prior value (M=3.21) and applying (M=3.09) means. In BSED, educators are prepared for evidence- based teaching through verification and multi-perspective analysis.

Evaluating in chemistry requires critical thinking: judging evidence, verifying facts, and balancing perspectives to reach sound conclusions. Song et al. (2024) link weak evaluative skills to workplace gaps and advocate integrated training, while Rodríguez-Rojas et al. (2024) and Sarwanto et al. (2020) provide scales to assess judgment abilities.

However, students often underperform here, especially juniors (Basri et al., 2019; Masithoh et al., 2025), due to shortcomings in the curriculum (Cole, 2023; Sharma et al., 2022). Multi-source comparisons elicit deeper reasoning (Heim et al., 2022), and sustained interventions yield gains (Abrami et al., 2015), supporting hands-on verification practices in BSED chemistry to enhance transferable evaluation skills.

Creating

Table 12 gauges students in chemistry' perceived critical thinking skills in the creating dimension, attaining an overall mean of 3.22, rated as "Agree" and "Positive Perception."

Table 12. *Critical Thinking Skills of students in terms of creating*

Indicators	Mean	Qualitative Interpretation
Chemistry hands-on activities help me create completely new ideas and solutions.	3.36	Very Positive Perception
Chemistry concepts can be expressed in many creative ways.	3.34	Very Positive Perception
I like discussing new terminologies in Chemistry to enhance learning.	3.22	Positive Perception
I like combining information from different chemistry sources.	3.21	Positive Perception
I form chemistry impressions by combining various information sources.	3.19	Positive Perception
I can restructure chemistry texts and see their underlying patterns.	2.99	Positive Perception
OVERALL MEAN	3.22	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

The top was "Chemistry hands-on activities help me create completely new ideas and solutions" (M=3.36, Strongly Agree/ Very Positive), followed by "Chemistry concepts can be expressed in many creative ways" (M=3.34, Strongly Agree/Very Positive). Others: "I like discussing new terminologies in Chemistry to enhance learning" (M=3.22), "I like combining information from different chemistry sources" (M=3.21), "I form chemistry impressions by combining various information sources" (M=3.19), and "I can restructure chemistry texts and see their underlying patterns" (M=2.99; all Agree/Positive), showing strong synthesis.

The overall mean highlights exceptional perceived creating skills, where hands-on labs spark innovation, recombination, and novel solutions—crowning Bloom's taxonomy. This creativity thrives in project-based STEM, boosting 21st-century competencies like problem-solving. For BSED chemistry, it validates experiential methods to nurture generative thinkers and future science educators.

Creating critical thinking by synthesizing knowledge into novel chemistry ideas and solutions. Misechko and Lytniova (2022) link it to regulated critical processes for realistic innovation, while Tang et al. (2020) show collaborative jams boost creativity via teamwork and perspective- sharing.

Structured interventions such as 21st-century curricula (Dilekçi & Karatay, 2023) and problem-based learning (Birgili, 2015) enhance outputs despite implementation challenges. Low creativity stems from guidance gaps (Rosba et al., 2021; Kupas Seni, 2025), with socio-environmental factors influencing equity (Shubina & Kulakli, 2019). This suggests the need for hands-on, collaborative BSED strategies to develop generative skills.

Summary of Critical Thinking Skills

Table 13 summarizes students in chemistry' perceived critical thinking skills across six Bloom's dimensions, with an overall mean of 3.00, rated "Agree" and "Positive Perception." Creating topped the hierarchy (3.22, "Agree," "Positive Perception"), followed by Evaluating (3.12) and Applying (3.10), all positive. Lower levels showed Remembering and Analyzing tied at 2.92 ("Agree," "Positive Perception"), and Understanding at 2.72 ("Agree," "Positive Perception"). Uniform positive perceptions indicate balanced proficiency from foundational recall to innovative synthesis.
The overall mean affirms robust critical thinking perceptions, strongest at higher-order creating/evaluating and solid across lower-order skills, enhanced by hands-on labs that mirror real inquiry. This profile supports the efficacy of hands-on experiments in building a comprehensive cognitive toolkit for BSED Science students, aligning with global emphasis on 21st-century competencies.

Table 13. *Summary on Critical Thinking Skills of students*

Indicators	Mean	Qualitative Interpretation
Creating	3.22	Positive Perception
Evaluating	3.12	Positive Perception
Applying	3.10	Positive Perception
Remembering	2.92	Positive Perception
Analyzing	2.92	Positive Perception
Understanding	2.72	Positive Perception
OVERALL MEAN	3.00	Positive Perception

Legend:

Scale	Descriptive Rating	Qualitative Interpretation
3.26 – 4.00	Strongly Agree	Very Positive Perception
2.51 – 3.25	Agree	Positive Perception
1.76 – 2.50	Disagree	Negative Perception
1.00 – 1.75	Strongly Disagree	Very Negative Perception

Critical thinking skills encompass systematic, logical reasoning for problem-solving and innovation, vital for BSED Science students' chemistry success. Alsaleh (2020) and Asraf R. M. et al. (2022) position it as a core goal of higher education, enabling graduates to tackle real-world challenges creatively.

Hands-on experiments operationalize this through deep learning and collaboration (Nor & Sihes, 2021; Orhan, 2022), though unclear guidance limits gains (Sierra et al., 2021; OECD, 2023). Constructivist environments that foster analysis, synthesis, and evaluation foster workplace readiness (Uzumcu & Bay, 2020; Goodsett, 2020; Varenina et al., 2021), mirroring your balanced positive perceptions across Bloom's levels of academic achievement at Don Carlos Polytechnic College.

Correlation of Perceived Hands-on experiment and Critical thinking skills of Students

Table 14 reveals a moderate positive correlation (r = .516, p = .001) between perceived hands-on experiments and critical thinking skills among students in chemistry.

The correlation coefficient (.516) indicates moderate strength, while the p-value (.001) falls well below the 0.05 significance threshold, confirming the alternative hypothesis: "There is a significant relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry" is accepted.

Table 14. *Correlation between the dependent and independent variables*

Critical Thinking Skills	r-value	p-value	Remarks	Decision
Hands-on Experiment	.516**	.001	Significant	Accepted

The correlation coefficient (.516) indicates moderate strength, while the p-value (.001) falls well below the 0.05 significance threshold, confirming the alternative hypothesis: "There is a significant relationship between students' perceptions of hands-on experiments and critical thinking skills in Chemistry" is accepted.

This significant moderate correlation validates hands-on chemistry labs as catalysts for the development of critical thinking among BSED Science students, where positive perceptions of experiments enhance higher-order skills essential for academic achievement and future teaching efficacy at Don Carlos Polytechnic College.

Hands-on chemistry experiments significantly enhance critical thinking skills through active inquiry and reflection, thereby directly supporting the study's moderate positive effect. Qi (2024) establishes critical thinking as analytical interpretation beyond memorization, while Seery et al. (2024) demonstrate that hands-on procedures foster problem-solving by requiring outcome analysis. Similarly, Zhou et al. (2013) found that task-based learning improved analyticity, and Dulanlebit et al. (2023) reported that project-based practicums boosted critical thinking scores via investigational tasks. Musahal et al. (2024) further confirm that STEM-PjBL strengthens reasoning through real-world problem formulation.

These gains align with structured design needs, as Van Brederode et al. (2020) showed that inquiry-based pre-labs with student autonomy yield deeper analytical reasoning than cookbook methods. Rushiana et al. (2023)
reinforce project-based models as optimal when contextualized, though Irwanto (2023) notes collaborative inquiry outperforms expository teaching for preservice teachers, aligning with BSED contexts.

However, implementation barriers temper effectiveness, as the OECD (2023) cautions that routine labs without reflection fail to develop reasoning, echoing Unwakoly et al. (2024) on cookbook formats that limit autonomy. Resource constraints in rural settings, such as Don Carlos Polytechnic College, exacerbate this (Muhamad Dah et al., 2024). However, the significant correlation suggests that perceived hands-on value helps overcome these gaps, affirming experiential learning's role despite challenges.

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