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ORIGINAL ARTICLE

# Exploring Filipino Students' Critical Thinking Skills: Basis for Enhancement of Science Laboratory Class Delivery

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## ABSTRACT

In today's knowledge-based and rapidly changing society, developing students' critical thinking skills in instruction is a vital concern in almost all science curricula. To acquire meaningful learning, learners need to develop skills in choosing suitable information, gauging the integrity of information, and crafting sound decisions. With this, creating learning spaces that stimulate critical thinking has become a challenge among educators. This study aims to explore the critical thinking profile of Filipino students in science laboratory classes as a means of generating insight for possible curricular enhancement. Utilizing a quantitative descriptive research design, a survey was administered to 300 junior high school students under K to 12 curricula. Results revealed that openness to different ideas is the most practiced aspect of critical thinking among Filipino students, while the planning and organization of information disclosed as the least. Furthermore, the importance of gathering information to support position is the most agreed factor, while the strategies in thinking of a problem in an experiment are the least. Hence, findings suggest that the necessary facets of critical thinking strategies should be explicitly articulated in the science curriculum framework, especially encapsulating it in the content and performance standards.

**KEY WORDS:** Critical thinking; curricular enhancement; K to 12 curriculum; science laboratory classes

## INTRODUCTION

In science teaching, critical thinking skills are not taught directly to the recipient of the curriculum. Critical thinking skills are being developed through inquiry learning that allows the students to provide logical explanations of their investigations using arguments. Gunn et al. (2014) enumerated aspects of critical thinking, namely conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered or generated by observation, experience, reflection, reasoning, or communication. These skills mirror the science process skills being developed in science instruction, such as the components of the scientific method – formulating problems and hypotheses, solving problems, analyzing and interpreting data, drawing conclusions, and communicating scientific findings.

The current landscape of Philippine education had witnessed various revolutions before it fully embraced its large-scale response to the multiplicity of the demands in its academic sphere, the institutionalization of the K to 12 curriculum in 2012 (Bongo and David, 2020). The springboard of this curricular reengineering is rooted in its intent to enhance the curriculum and expand the education cycle, aiming at producing graduates who are equipped with the skills needed by the labor market. The overhauling of the curriculum arose from its profile in the lens of international competitiveness in terms of the quality of education (del Valle, 2019), such as the consistently poor performance of Filipino students gauged by international large-scale assessment which Balagtas et al. (2019) affirmed to be one of the possible indicators of the reform's effectiveness if the country will participate again in the years to come. Abueva (2019) subscribed to the idea that the K to 12 program in basic education was the strategic reform leading toward national progress. Dizon et al. (2019) revealed in their systematic analysis that amidst the challenges faced by the sector, it gave the graduates of the curriculum the capacity to become competitive in their chosen specialization by possessing the necessary knowledge and skills.

Among the learning areas which made a dramatic transformation is science. In the old curriculum, it follows a disciplined orientation. In the report of Magno et al. (2011) regarding their analysis of the country's basic education and its impact on the K to 12 reforms, it was described that the previous science curriculum contents are well-articulated, comprehensive, and developmental, showing clear sequence. However, it lacks prospects to use science process skills that enable the learners to solve problems, inquire, evaluate, analyze, and gauge scientific claims. The revised curriculum introduces science concepts and applications of the different domains in every grade level, starting from Grade 3 to Grade 10. Cognizant of this perceived challenge of science education in the Philippines, the K to 12 science curriculum provided a repertoire of competencies employing learner-centered, inquiry-based, and evidence-based approaches (DepEd, 2016). Further, it emphasizes the nature of Filipino scientific literacy to be critical and creative problem solvers, responsible

stewards of nature, innovative and inventive thinkers, informed decision-makers, and effective communicators. The curriculum framework included three overarching components: Inquiry skills, scientific attitudes, content, and connections, which all lead to the holistic development of scientific literacy among learners (DepEd, 2016).

Six years after the enactment of the K to 12 curriculum, the Philippines participated in a triennial assessment known as the Programme for International Student Assessment (PISA) in the year 2018. This is the country's first participation as part of the reform. Out of the 79 participating countries, the country managed to rank 78th with scores comparatively lower than global average standards (DepEd, 2019). Consistently, the country ranked 77th out of 81st in 2022 (OECD, 2023). The framework of PISA revolves around the ability to explain phenomena scientifically and their implications for society, use one's knowledge and understanding of scientific inquiry, and scientifically interpret data and evidence and evaluate whether the conclusions are warranted (PISA, 2018). Considering these expectations from the PISA, Barrot (2021) unveiled in a curriculum analysis that the existing blueprint of the competencies needs to be refined conceptually and pedagogically, particularly in the areas of constructive alignment and technology integration. Anchoring it with PISA, the curriculum expects to develop inquiry skills, which contribute to improving critical thinking, an essential requisite for academic and career success. It has been a mantra of educators to incline students into learning that manifests the practice of critical thinking. It is one of the innovation skills that are necessary for preparing students for higher academic preparation. A plethora of literature and empirical evidence has emphasized the skills that are correlated with critical thinking. Hughes et al. (2019) and Akbar and Kusnendi (2020) believed that critical thinking plays a central role in creative problem-solving and that the practices of collaborating, questioning, and brainstorming are the most commonly perceived ways of developing it. Marfu et al. (2019) stressed effective decision-makers as critical thinkers because they are highly aware of the information they gain.

The practice of science inquiry in the classroom is fundamental for science education, where learners should master investigation skills to promote understanding of science concepts (Alnaser and Forawi, 2024). The distinct goal of science learning that sets it apart from other disciplines is its practical nature, which involves conducting experiments to explore different phenomena. As cited from the work of Mercado and Picardal (2023), laboratory works are often viewed as the appropriate learning space for science learners which target various skills such as practical and general skills. Learners are also known to learn more effectively when theory is applied in laboratory activities (Koç and Çavas, 2022). Laboratory works in science are active and interactive teaching and learning episodes, which allow learners to be involved in observing or manipulating real objects and materials. They have a distinctive and central role in developing students' self-efficacy (Lee et al., 2020), cognitive skills, and positive attitudes and stimulating students' more significant efforts toward achievement (Sari et al., 2020; Wicaksana et al., 2020). Pellegrino and Hilton (2012) highlighted in their work that different systems of education gave a high premium to citizens' way of acquiring the necessary skills such as critical thinking to conform to the demands of the ever-changing and complex world.

To maximize the integration of laboratory in science learning, Millar (2004) affirmed that the nature of how it will be facilitated matters since varied ways of implementing it yield different results on learning outcomes. Mihret et al. (2022) highlighted that one of the innovative instructional strategies used to help students best learn practical work is through guided inquiry-based learning, which is also mostly recommended in student-type laboratory instruction (Rahmi et al., 2018). The practice of laboratory science classes in different contexts comes in different forms. Laboratories are commonly designed according to their purpose and structure (Bell et al., 2005). Bell et al. (2005) grouped these types of laboratory activities into various forms such as (a) skill-based laboratory (SBL) which involves the learning of some basic skills; (b) verification laboratory (VL) where learners are informed about the concepts that they will explore during the activity; (c) directed inquiry laboratory (DIL) where the teachers provide the questions and the process to answer it; (d) guided inquiry laboratory (GIL) where the teacher provides the question, and the students are free to produce diverse answers based on what they found out in the laboratory activities; and (e) open-ended inquiry laboratory (OIL) where learners develop their own questions to explore along with looking for the appropriate procedure to be followed. The outcome of these various practices in the laboratory is compounded by many factors. Some of these include those on the part of the school, such as the availability of laboratory infrastructure (Duban et al., 2019; Pareek, 2019), management of laboratories in the school (Mohzana et al., 2023), and teachers' competence in facilitating laboratory instruction (Koç and Çavas, 2022). On the side of the learners, some factors include learners' attitude toward doing laboratory activities (Pyatt and Sims, 2007); the level of impact of the laboratory activities on the skill development of the learners (Chabalengula et al., 2009); and nature of collaboration among learners while doing the laboratory task (Malik and Ubaidillah, 2021).

It is in this light that this study aimed to assess the profile of the critical thinking skills of Filipino secondary school students vis-à-vis their experiences in the science laboratory classes in terms of (a) gathering information and supporting positions; (b) planning and organizing information; (c) openness to different ideas; (d) goal setting; (e) making connections; and (f) analyzing. The results of this study hope to gain insights and lay foundations that can contribute to some enhancements of how the competencies in the curriculum can be delivered and how science teachers can incorporate in their instructional practices the development of critical thinking skills among learners.

### Theoretical Background

Critical thinking has proven to be a vital component of contemporary education that aims to develop learners' abilities. Glaze (2018) said that learners of the present generation need not only the conceptual skills to survive with the century but also proficiency that leads them to develop life skills (Susetyarini et al. 2020). These skills have been identified as crucial skills for academic and career success in the 21st century (Shaw, 2019). Said ability helps individuals to become innovative, independent, and practical problem solvers (Zhang and Yuan, 2015; Tan, 2019). In this modern world where knowledge-based information explosion persists, learners need to be trained and prepared in the classroom on how to critically discern and use information. Amin et al. (2020) highlighted in their work that critical thinking has a significant association with the process of metacognition, which can be developed in learning strategies. However, Seibert (2021) affirmed that while the current generation brings technological skills and an inclusive mindset, learning facilitators face challenges in employing teaching strategies that foster critical thinking among the learners.

Different definitions of "critical thinking" abound in the literature. It encapsulates contested grounds due to the variations in its meaning (Samson, 2019). The areas of philosophy and psychology did not just lay theoretical roots in critical thinking but also stimulated debates on its nature (Atabaki et al., 2015) being considered a complex construct (Rubenfeld and Scheffer, 2015). As cited from the work of Tan (2020), it considers the notion that revolves around the skills of critical reasoning, knowledge, attitude, and competence in a particular discipline. Tan (2017) argued that how critical thinking translates into practice is determined by the sociocultural atmosphere of the learners. This means that critical thinking strategies must not only manifest in the learning contents but also in consideration of the other factors, such as the educational system in the learning site. It accounts for many dimensions and perspectives. Facione (2013) presented six components of critical thinking from various works of literature. The first analysis, which was given by Demir (2015), means identifying the connection between occurrences, views, and other forms of decisions. The second component was cited in the work of Verawati et al. (2019), which connotes comprehension of experiences, data, events, judgments, rules, and so on. Making inferences through concluding is the third dimension, which is based on the evidence available (Demir, 2015). The fourth is an explanation that requires the justification of events in an articulate, systematic, and rational way (Dilekli, 2017). Facione (2013) defined evaluation as the fifth component. It is the learners' way of assessing the rational potency of the real or planned inferential connections among testimonials, reports, inquiries, and conditions. Finally, the essence of developing self-regulation as a means of self-awareness is in monitoring one's cognitive actions (Facione, 2013).

In education, honing learners' critical thinking skills is an investment in many classroom activities through collaborative and authentic work. Several studies highly acclaimed the effect of such work on the heightening of critical thinking skills. Specifically in science education, critical thinking plays a crucial function in the curriculum as it can be developed through science process skills (Irwanto *et al*., 2019; Darmaji et al., 2021). Yacoubian (2015) cited the role of critical thinking in addressing the Nature of Science (NOS) in school science learning. It is indeed needed to build students' competencies in solving science problems and discovery as required in the learning of science (Sutiani, 2021).

Ennis (2018) affirms that efforts from different countries have been made to incorporate critical thinking throughout the curriculum. Meneses (2020) concurs with the importance of rethinking the concept of critical thinking based on the context to design teaching models that respond to the demands of the present time. In the work of Waller (2021), science is considered an adversarial system where theories are presented and supported with corresponding evidence and further allow other scientists to challenge, refute, and examine it. These dynamics build better arguments and results. This, in fact, can be manifested through critical thinking.

Santos (2017) summarized the role of critical thinking in the practice of science from various works. It is used in identifying and defining scientific problems, finding appropriate solutions to these gaps or problems, performing rigorous and careful testing, rejecting or accepting hypotheses, concluding true statements, and explaining their meaning. It is also used in obtaining information, making decisions, critiquing, and formulating critical questioning. In argumentation, it is used in defending ideas and evaluations. Indeed, the role of critical thinking in science education is considered crucial for the responsible use and application of science in society. The development of critical thinking among learners is mirrored in their scientific attitude by reacting rationally and objectively in dealing with a posed problem (Olasehinde and Olatoye, 2014), and these are mirrored in carrying our laboratory activities that aim to sharpen scientific knowledge and skills. Having this as the default practical activity in the context of the study, this paper aims to examine students' critical thinking profiles and identify the gaps that can be used for the improvement of the existing practices that have opportunities to develop critical thinking among the students.

## METHODOLOGY

The present study was carried out in a private secondary school in Manila. The participants included 300 junior high school students who are in their 10th grade under the K to 12 curricula of the Department of Education. It utilized a quantitative descriptive design using the adapted survey questionnaire developed by Mincemoyer et al., (2001) and Wade et al. (2015). It includes a 29-item survey that explores students' learning practices linked with essential critical thinking skills. It is divided into six subfactors: Gathering information and supporting position, planning and organizing information,

openness to different ideas, goal setting, making connections, and analyzing experiment results. The instrument required students to respond to a 4-point Likert-type scale, with a choice of responses from strongly disagree to strongly agree (SA). A descriptive mean of 1.00 to 1.49 corresponds to strongly disagree (SA), 1.50–2.49 for disagree (D), 2.50–3.49 for agree (A), and 3.50–4.00 for SA.

In the interest of accounting for the validity of the tool, content validation was conducted and was participated by invited science teachers and students to screen the choice of words and the manner of instructions for the tool administration. For the internal consistency of the instrument, the initial reliability test gave the instrument a profile of 0.90 in Cronbach's alpha for the critical thinking items, indicating relatively high internal consistency for each section of the survey. Short open-ended questions relevant to each of the aspects were also given to solicit the specific responses of the students about how critical thinking skills are being demonstrated through their experiences.

With permission from the administration of the school, the survey was administered using Google Forms, which also stipulated the consent of the students of their participation in the survey. The data analysis included using descriptive statistics of the mean and standard deviation to describe the general characteristics of the respondents in terms of the different sub-factors of critical thinking skills.

## RESULTS AND DISCUSSION

### Comparison of the Six Aspects of Critical Thinking

Presented in Table 1 is the summary of the students' descriptive ratings on the different components of the critical thinking explored by the study. Based on junior high school students' self-professed practice of critical thinking, learners' openness to different ideas has the most agreed upon aspect, while the mechanism of how learners plan and organize information is the least perceived critical thinking skill of the students. Details of these are discussed in this portion of the study.

### Gathering Information and Supporting Position

This aspect of critical thinking pertains to students' practices of collating information to support the veracity of their claims and findings from the experiments performed. As students are exposed to multifaceted sources of information, their capacity to scrutinize this information, especially its relevance and implications, greatly matters. Furthermore, it explores how students support their conclusions and their capacity to think of appropriate learning techniques leading toward the accuracy of the information that they gathered relevant to the experiments. Table 2 describes learners' profile under this component.

A mean score of 3.87 revealed the most agreed item dealing with the importance of gathering the necessary information to support one's findings in the experiments. For the respondents, the findings in the experiment can be best interpreted by gathering relevant information. This interpretation is a result of the interconnected ideas and concepts which will give substantial meaning to their findings. This result is consistent with the work done by Riera and Bautista (2021), that students while working in laboratory-based activity, foster the realization that the scientific knowledge that they can gain should be based on empirical evidence through the gathering of relevant information supporting their claims.

On the other hand, a mean score of 3.32 registered the lowest mean score relating to the utilization of more than one source of information before concluding the experiment. Students also need to venture more into questioning the accuracy, authenticity, and sufficiency of whatever task is given to them. This can be associated with a lack of students' exposure to scrutinizing scientific information based on their accuracy and precision. The framework conceptualized by Mataniari et al. (2020) on research skill development in portraying students' critical thinking skills supports this result where students are challenged when it comes to evaluation and reflection on the information that they gathered from their works. Yang and Gamble (2013) believed that critical thinking could be developed in the classroom if students and teachers are capable of processing and evaluating several pieces of evidence. Furthermore, gathering information and supporting positions would allow students to recognize gaps in their understanding, find new evidence to seal those gaps, and use the resulting information in creative ways.

In the open-ended question, when asked how the students support the accuracy of the data that they gathered, common responses include the use of their prior knowledge; connecting the experiment with the concepts learned in class discussion; use of online data sources; comparing their results with their classmates; replicating the experiment and brainstorming among the group members.

### Planning and Organizing Information

This relates to students' use of strategies in planning and organizing the relevant information that they need to gather about the experiment. This extends to students' capacity to connect bits of information, such as concepts, theories, and principles, which they think are useful in helping them view the meaning and application of the experiments. Table 3 contains the mean scores of this component.

Planning how to get the information marked the highest mean of 3.24, which is closely related to putting them in order of importance, which gave a mean of 3.20. Respondents adhere to the idea of visualizing where and how to gather the information that is useful to the experiment. This further pertains to how students filter information. The study of Nappi (2016) stressed the importance of questioning in developing critical thinking, especially if it involves higher-order thinking, not just a mere recall of concepts. Students with sophisticated critical thinking skills are described to be more successful in making sound decisions and monitoring their learning engagements and processes. The lowest mean

of 2.62 has something to do with the item of the practical use of a checklist in helping students understand the problem in the experiment. This remarkably low mean score can be associated with the type of experiment approach the students perform. Most high school science experiments in the Philippines utilize a recipe-type experimental procedure. Hence, students no longer focus on conceptualizing the problem since it is already provided to them. This can be an opportunity to enhance the critical thinking skills of students through approaches that demand them to practice innovative information or manipulate prevailing knowledge and information to acquire sensible responses to new circumstances. Soliciting the responses of the students to their ways of planning and organizing the information that they gathered, trending responses rely more on listing them down, outlining the information, gathering the views of classmates before forming a conclusion, classifying the information from simplest to the most complex, breaking down the information and presenting a logical step by step procedure in understanding it. In the work of Janse van Rensburg and Rausher (2021), they identified main strategies such as assessments, questioning, exemplification, and setting the classroom space, while Abdurrahman et al., (2019) suggested the use of multiple representations to foster these skills associated with critical thinking.

## Openness to Different Ideas

This third aspect constitutes students' willingness to take relevant evidence and ideas of others into account in the formulation of experimental generalization. This further explores students' awareness in doing collaborations and networking of ideas with others. In carrying out these skills, Demiral and Cepni (2018) pointed out open-mindedness as essential in critical thinking, especially in terms of setting argumentation pertaining to scientific knowledge being explored. Table 4 presents the items' mean scores and standard deviations on learners' openness to different ideas.

Almost all the items on this aspect have mean scores with very minimal discrepancies: 3.79, 3.76, 3.75, and 3.73, all with a qualitative description of SA. The respondents SA with the role of openness to new ideas as an element of thinking critically. Dwyer (2019) states that the dispositions of open-mindedness are inclined to cognitive flexibility and avoid rigidity in thinking. Further, Gotoh (2016) defines critical thinking as a trait involving skills and dispositions that enable learners to perform logical solutions to problems by reflecting autonomously and employing metacognition. In the context of the participants, where laboratory experiments are performed in groups, the collaboration among students can make the openness to ideas evident. On the other hand, the lowest mean score in this aspect, 3.29, goes to the student's awareness that sometimes there are no right or wrong answers to questions related to the experiment. This may probably deduce students' contention that views or opinions are not part of the scientific questioning to which they are used. Most of the questions that are found in many laboratory procedures focus merely on soliciting exact answers based directly on what transpired from the experiment performed. The development of critical thinking must also include questions where students would have the opportunity to share their views on some debatable issues that may arise from the applications of the experiment. From the open-ended question relating to openness to new ideas, the respondents unanimously consider the role of collaboration and communication of ideas in experimenting.

## Goal Setting

Goal-setting strategies explore the respondents' mindfulness in focusing their efforts in a consistent direction. It further serves as a clear and specific way of delegating the roles and things to be accomplished in the experiment before its execution. Through this, students have the prior processing of what they are supposed to conceptualize, strategize, and organize in the experiment. Presented in Table 5 are the results under this component.

The item denoting the ability to look at the steps needed to accomplish the objectives of the laboratory experiment has the highest mean score of 3.77 for this aspect. It can be deduced from this response how the students significantly consider the procedures to be followed in the experiment in understanding what the experiment is all about. In carrying out such learners' strategies, Petritis et al. (2021) highlighted the factors in giving laboratory experiments, such as how the activities are framed in terms of the objectives, instructions, and tools available that the students can use. However, it can also be inferred from this view that most experiments being done by the students are with provided recipe-type procedures where students are used to reading the procedure first proceeding to the analysis. Higher levels of engaging learners to become scientific and logical thinkers must also include an inquiry-based pedagogy where the problem is provided to the students, and they will be the ones to think of the appropriate procedure. Nurlaelah et al. (2021) disclosed a positive correlation of students' critical and analytical thinking skills when exposed to inquiry-based laboratories. Furthermore, Chiang et al. (2021) concurred that exposing science learners to these kinds of strategies strengthens their self-efficacy in the execution of the experiments and the interpretation of the gathered data. Through this, there will be a variety of students' interpretations as they use the concepts

**Table 1: Composite mean scores and standard deviations of the six aspects of critical thinking**

| Six aspects of critical thinking | X | Q | SD |
|---|---|---|---|
| 1. Gathering Information and Supporting Position | 3.58 | SA | 0.58 |
| 2. Planning and Organizing Information | 3.06 | A | 0.89 |
| 3. Openness to Different Ideas | 3.66 | SA | 0.58 |
| 4. Goal Setting | 3.52 | SA | 0.60 |
| 5. Making Connections | 3.20 | A | 0.79 |
| 6. Analyzing | 3.26 | A | 0.77 |

X: Mean, Q: Qualitative description, SD: Standard deviation, SA: Strongly agree, A: Agree

**Table 2: Mean scores and standard deviations of the item on gathering information and supporting position**

| Gathering information and supporting position | | X | Q | SD |
|---|---|---|---|---|
| 1. | It is important for me to get information to support the findings I obtained in the experiment. | 3.87 | SA | 0.36 |
| 2. | I am able to give reasons for my understanding about the experiment. | 3.50 | SA | 0.53 |
| 3. | I support my conclusion in the experiment with the information I get. | 3.68 | SA | 0.57 |
| 4. | I usually have more than one source of information before I make a conclusion in the experiment. | 3.32 | A | 0.74 |
| 5. | I make sure the information I use is correct. | 3.69 | SA | 0.50 |
| 6. | I develop my ideas related to experiments by gathering information. | 3.62 | SA | 0.55 |
| 7. | When solving a problem in the experiment, I identify options to solve it. | 3.44 | A | 0.65 |
| 8. | I think of possible results before I take action in the procedure. | 3.50 | SA | 0.71 |

X: Mean, Q: Qualitative description, SD: Standard deviation, SA: Strongly agree, A: Agree

**Table 3: Mean scores and standard deviations of the planning and organizing information**

| Planning and organizing information | | X | Q | SD |
|---|---|---|---|---|
| 9. | I plan where to get information on a topic related to the experiment. | 3.18 | A | 0.88 |
| 10. | I plan how to get information on a topic related to the experiment. | 3.24 | A | 0.79 |
| 11. | I develop a checklist to help me think about the problem. | 2.62 | A | 1.02 |
| 12. | I put my ideas about the experiment in order of importance. | 3.20 | A | 0.86 |

X: Mean, Q: Qualitative description, SD: Standard deviation, A: Agree

**Table 4: Mean scores and standard deviations of the items on openness to different ideas**

| Openness to different ideas | | X | Q | SD |
|---|---|---|---|---|
| 13. | I listen to the ideas of other group mates in the laboratory even if I disagree with them. | 3.73 | SA | 0.58 |
| 14. | I keep an open mind to different ideas when making a conclusion about the experiment. | 3.79 | SA | 0.45 |
| 15. | I compare ideas when thinking about correct answers in the laboratory experiment paper. | 3.75 | SA | 0.52 |
| 16. | I am aware that sometimes there are no right or wrong answers to a question related to the experiment. | 3.29 | A | 0.86 |
| 17. | When I have a task to do in the laboratory, I collaborate with other people to get ideas. | 3.76 | SA | 0.48 |

X: Mean, Q: Qualitative description, SD: Standard deviation, SA: Strongly agree, A: Agree

**Table 5: Mean scores and standard deviations of the items on goal-setting**

| Goal setting | | X | Q | SD |
|---|---|---|---|---|
| 18. | I look at the steps needed to accomplish the objectives of the laboratory experiment. | 3.77 | SA | 0.42 |
| 19. | I think about how and when I want to accomplish the objectives of the experiment. | 3.56 | SA | 0.56 |
| 20. | After setting a goal for the experiment, I break the goal down into steps so I can check my progress. | 3.09 | A | 0.82 |
| 21. | Both positive and negative feedback helps me work toward my goal in doing laboratory experiments. | 3.65 | SA | 0.60 |

X: Mean, Q: Qualitative description, SD: Standard deviation, SA: Strongly agree, A: Agree

**Table 6: Mean scores and standard deviations of the items on making connections**

| Making connections | | X | Q | SD |
|---|---|---|---|---|
| 22. | We discuss in class during post-laboratory activity the significance of the experiment-personally, locally, nationally, or globally. | 3.05 | A | 0.84 |
| 23. | My teacher solicits multiple and diverse points of view about a question or issue related to the experiment. | 3.23 | A | 0.81 |
| 24. | Our experiment tackles a real-world problem. | 2.96 | A | 0.90 |
| 25. | I make connections between learning gained in the experiment with different subject areas. | 3.25 | A | 0.78 |
| 26. | We are instructed to gather and organize information to formulate a position or perspective. | 3.49 | A | 0.60 |

X: Mean, Q: Qualitative description, SD: Standard deviation, A: Agree

**Table 7: Mean scores and standard deviations of the items on analyzing**

| Analyzing | | X | Q | SD |
|---|---|---|---|---|
| 27. | I know how to break down complex concepts or problems about the experiment into their component parts. | 3.14 | A | 0.81 |
| 28. | I use models or visuals to represent complex ideas. | 3.14 | A | 0.84 |
| 29. | I use existing knowledge to generate new ideas or solve an unfamiliar problem related to the experiment. | 3.50 | SA | 0.65 |

X: Mean, Q: Qualitative description, SD: Standard deviation, SA: Strongly agree, A: Agree

that they know to come up with innovative and creative ways of solving the problem.

On the other hand, still related to the previous item, the one with the lowest mean score of 3.09 has something to do with the ability of the students to break down their goals into steps to check their progress. This aspect also needs to be developed among students because sometimes, they deal with experimental problems all at once without breaking them down into a more manageable goal for them to see how to proceed. Further, it allows them to organize their ideas into the hierarchy. Lebowitz (2015) noted language and its relationship to critical thinking as one of the impending factors that affect their ability to diagnose pieces of information. It is a skill that the students

need to learn to break down goals into pieces. Specific practices of students in setting their goal include scanning the experiment paper before execution; delegation of tasks; thinking about the outcomes first; and merely answering the post-laboratory questions as to their main goal.

### Making Connections

Making connections revolves around students' way of thinking that science is all around us. It is a "making meaning" of the experiments to see how it is applicable and possible to exist. This includes connecting big ideas and real-world happenings into the experiments and letting them serve as a representation of actual applications and innovations. Descriptive results under this area is presented in Table 6.

A mean score of 3.49 regarding the provision of activities that enable learners to gather and organize information to formulate their position or perspective revealed the highest mean score. The result supports Nussbaum's (2020) contention that the integration of argumentation, which allows learners to construct and critique arguments, is a kind of social practice that develops learners' deeper understanding of the concept. However, making meaning from the experiment does not just simply include the relevant concepts but also their relevance in real-life settings. Laboratory experiments that tackle real-world problems registered the lowest rating of 2.96. Carvalho et al. (2015) reveal in their study that when students perceive the connections of their activities with real-world problems, it promotes critical thinking, and feedback on learning becomes effective as well. Students need to do experiments that tackle real-world problems. A more realistic and practical theme of experiments would enable the learners to view it as a possibility in the future. Several works have proven some strategies that will enable learners to link their laboratory practical experience to real-life settings such as Chu et al. (2021)' home-based experiments; Qamariyah et al. (2021)'s incorporation of socio-scientific issues in inquiry-based learning; and the inclusion of the community outreach by Godinez et al. (2021).

From the students' responses to the open-ended question, they solidly consider the valuing and the morals of the experiments being shared by the teacher as a way of making connections to the experiment.

### Analyzing

The items under analyzing involve strategies that students may do in keenly evaluating and analyzing information to conclude or set possible solutions to the problems. Being a component of critical thinking skills, it is also a demand for 21st-century skills (Suyatman et al., 2021). It includes breaking down the components of concepts so that their organizational structure may be better understood. The three items under this component are contained in Table 7.

Facione (2013) defined analysis as recognizing obvious and evident associations between ideas from different sources to evaluate information and evidence, gain different viewpoints, or fill gaps. The response, having a mean score of 3.50, concurs with the work of most researchers working in the area of critical thinking about the important role of background knowledge. In particular, the constructivist approach to science instruction has proven the role of activating prior knowledge and allowing students to connect it to their actual learning experiences as a way of developing critical thinking (Chan et al., 2020). Insufficient prior knowledge about the content being explored will unlikely develop conceptual change in learners (Liaw et al., 2021).

However, this response of the learners can also be associated with the kind of learning media prepared by the teachers in terms of facilitating laboratory activities, such as its structure, content, and mechanism for arriving at the experiment results. Some studies pointed out some mechanisms to develop such a culture of inculcating higher-order thinking skills, such as the analytical skills of the students such as Suyatman et al. (2021)'s problem and research-based science learning; Nurlaelah et al. (2021)'s inquiry laboratory; and Muna (2021)'s environment-based activities.

## CONCLUSION AND RECOMMENDATIONS

In a complex and rapidly altering world wrought by the forces of modern science and the digital era, critical thinking is an essential instrument to successfully perform in a competitive life. Although it is not a new feature in the education field, it has become more important in the present mode of living. Critical thinking must not just remain a concept. The ability to think is a natural process, but this skill of learners needs to be enhanced by teachers in their classrooms.

This descriptive study has shown that students seem to be quite agreeing with some aspects of critical thinking, but they appear to have slightly limited exposure to it. The learners' self-professed practice of critical thinking focuses merely on their general skills of being open-minded to different ideas pertinent to completing their laboratory tasks. However, practical skills, such as how learners plan and organize information, are the least perceived critical thinking skills of the respondents. It can further be deduced from the data gathered that the way critical thinking skills are developed will be dependent on the learning structure provided to the learners. For instance, in gathering information and supporting positions, learners can recognize the gaps in their understanding if they are tasked further to find new evidence supporting their laboratory class experience. Similar to other skills such as planning, goal setting, making connections, and analyzing, which all require a good instructional stimulus to better learners in developing the skills. Providing these stimuli gives learners the opportunity to become active participants in the exercise of critical thinking.

Given the findings of this study, it is recommended for future investigation to have a review of the existing format of laboratory manuals in the Philippines in terms of its capability to gauge the critical thinking of science students, explore how the teacher processes student's laboratory works in terms of critical thinking strategies; examine the use of some teaching-learning models in eliciting critical thinking skills in the

science laboratory classes, and explore how inquiry-based learning is being practiced in the laboratory activities of science students in the Philippines; and perform a more comprehensive treatment of the subject using applicable statistical analysis.

## Implications

The manner by which laboratory instruction is introduced to learners of science plays an essential role in improving critical thinking. From the results of the study, it can be deduced that the following extents are essential to be considered in developing critical thinking skills in laboratory classes.

First is the organization of their ideas and information to understand the experiment. The students' exposure to much information in the present times does not guarantee that they will be able to comprehensively cognize and communicate their understanding of their laboratory class undertakings. Their logical imagination about the essence of the experiments should be provided with frames and guides where they would have the opportunity to express and organize their thoughts as well as reassess the veracity of the information that they know. The underlying relationship between language and the expression of scientific literacy can be a jumpstart to expose the students to this. They need to become literate not only with statements of scientific facts, theories, principles, or laws but also challenge them to dissect pieces of information relevant to their science experiments. Pre-laboratory and post-laboratory instructions can be used to integrate this aspect by citing the social relevance of the experiments and how it will enable the students to discuss among themselves whether the results of their experiment are a microscopic overview of what it is in reality. Besides, students must be introduced also to the practice of including in the objectives of the experiments those actions that encourage critical thinking attitudes.

Second, connected to the previous one, students' openness to ideas must also be exercised and enhanced critically. Since flexible groupings have been practiced in performing science experiments in the Philippines, students working in the group must also be given the opportunity to exchange their ideas during the conduct of the experiment. The interactions must be monitored by teachers to ensure that all members are equally involved in the process. Items relevant to this must also be included in the peer and self-evaluation where students would have the opportunity to reassess their collaboration skills.

Third, making connections of the experiment must be considered in designing science experiments. Students must see the connections of the experiment to reality in the environment by attempting to study some of the real-life scientific problems and processes through experiments.

Lastly, the effortful utilization of an inquiry-based strategy is suggested through vertical and horizontal articulation approaches across grade levels. Laboratory experiments should encourage students to inquire, critically appraise problems, and creatively offer alternative and logical solutions. In doing so, the utilization of a variety of thinking-centered learning atmospheres such as inquiry learning should be embedded in the science classrooms to hook the students in the process of critical thinking.

Having mentioned these implications, restructuring the teaching-learning process by producing actual evidence of the transfer of skills from pedagogic content to real-life situations through the development of critical thinking among learners is highly recommended. Furthermore, opportunities for curricular enhancement can be done by directly including in the competencies of the curriculum the expected learning outcomes to be embedded in the activities and instructional episodes that measure critical thinking in the science classrooms. Although critical thinking is seen in the science curriculum framework in the Philippines, it needs to be explicitly incorporated into the standardized content and performance standards. Reformatting the kind of laboratory activities encapsulating the deeper integration of critical thinking aspects can be one of the possible initiatives to realize this.

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