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EXPLORING THE DIMENSION OF LEAST LEARNED COMPETENCIES IN GENERAL BIOLOGY

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ABSTRACT

This study systematically reviewed the least learned competencies in General Biology among STEM students. The review aimed to identify the competencies and concepts in Biology that students commonly struggle to understand and determine the contributing factors affecting learning difficulties. A Systematic Literature Review (SLR) design was employed in gathering and analyzing related studies from peer-reviewed journals, theses, and dissertations. The literature focused on General Biology learning competencies, misconceptions, and instructional challenges aligned with the Most Essential Learning Competencies (MELCs). The review revealed that students consistently encounter difficulties in abstract and concept-heavy topics such as genetics, evolution, ecology, metabolism, endocrine and nervous systems, cell division, and energy transfer in ecosystems. The findings also showed that misconceptions, lack of laboratory resources, ineffective teaching approaches, and inadequate prior knowledge significantly contribute to students' poor performance in Biology. Furthermore, the review identified two major dimensions associated with least learned competencies: Cognitive and Conceptual Difficulty in Biology and Instructional and Learning Environment Constraints. The study emphasizes the importance of developing learner-centered instructional strategies, strengthening laboratory experiences, and addressing misconceptions through evidence-based interventions. The findings may contribute to curriculum enhancement, instructional improvement, and future Biology education research.

Keywords: *General Biology*, *least learned competencies*, *MELCs*, *STEM students*, *systematic literature review*

INTRODUCTION

When COVID-19 zoonotic diseases struck the country and whole world, people are restricted to gather in a certain place and be exposed to someone. Hence, the education sector of the country cannot operate well and achieved competencies due to unfavorable conditions. This is the main reason why the Department of Education (DEPED) are strategizing competencies that are more essential and convenient to achieve to students in times of unfavorable conditions. This is the Most Essential Learning Competencies (MELCS) that until now Senior High School has been using especially in General Biology subjects as their curriculum.

The Most Essential Learning Competencies (MELC) represent a strategic curriculum streamlining initiative by the Department of Education in the Philippines, primarily implemented to ensure educational continuity and focus during periods of disrupted learning, such as the COVID-19 pandemic (Reyes & Caballes, 2021; Zalun, 2023). However, the performance of students in international assessments was very poor. In the 2018 PISA assessment, Filipino learners graded among the lowest globally in mathematics, reading, and science, a trend that persisted in the 2022 results (Acido & Caballes, 2024). The Philippines has been known to continually perform poorly academically on a number of international tests, such as the National Achievement Test, Trends in International Mathematics and Science Study, and the Programme for International Student Assessment (Ignacio et al., 2022).

In the Philippines, curricula can still be seen as overly prescriptive and crowded, even with efforts to streamline them. Teachers may find that a lot of required content goes beyond what is "meaningful" for students, which can hinder the implementation of effective and meaningful pedagogy. Such rigidity may hinder the conditions required for transformation or change in the classroom (Véliz & Véliz-Campos, 2023). In addition, teachers may encounter difficulties adjusting to new curriculum frameworks or successfully implementing the targeted competencies as a result of inadequate professional development and ineffective teaching strategies (Aslam et al., 2024).

In Mindanao, studies by Estrera (2020) and Galang (2021) have shown that many schools struggle with a lack of resources aligned with the MELCs, while teachers often face challenges due to limited training and specialization. Requillo et al. (2024) also noted that science programs in Davao del Norte, such as “Catch-Up Fridays,” continue to face difficulties because of resource shortages and insufficient teacher preparation. These challenges are especially evident in science subjects that require both theoretical understanding and hands-on learning. Among these, General Biology stands out as a core subject in the STEM strand that involves complex and abstract topics like cell processes, genetics, and ecosystems that many students find difficult to grasp. The lack of laboratory materials and visual learning tools further adds to these difficulties, making it harder for learners to fully understand key concepts.

In the Davao del Sur Division, especially in Matanao National High Schools, the National Achievement result in 2023-2024 for Science has mean percentage of 56.45 %,

which interpreted as Nealy Proficient with a description of students met the minimum level of skills in solving problem, managing and communicating information, and analyzing and evaluating data to comprehend ideas. This only shows that despite the administration of MELC to students. Still, numerous problems arise that need to be addressed. This is the compelling reasons why the researcher would like to explore the dimension of least learned competencies to determine what are competencies as it aims to create an instrument that identifies and ranks the least-learned in General Biology competencies producing actionable gap analyses and targeted recommendations for instruction and remediation. Also, this may contribute to the body of knowledge and the results will be used for further research and policy making.

The study is anchored on Conceptual Change Theory of Loyen et al. (2015) where in it explains how learners restructure their existing understanding or somewhat referred as as prior knowledge to align with scientifically accepted concepts. In this theory, it acknowledges that students do not come to learning as blank slates; they bring pre-existing ideas, some of which may be misconceptions that conflict with scientific explanations. In this study, topics like Evolution and Genetics, Photosynthesis, Humana Anatomy and Physiology are prime examples where students often hold deeply entrenched misconceptions from prior learning, daily experiences, or even religious beliefs.

In the context of this study, the said theory is timely and applicable since the researcher will develop an instrument that evaluate the least learned competencies of General Biology. With that, educators can easily spot of the weaknesses and misconceptions of the topic and do interventions to restructure their existing understanding of the topic.

This conceptual framework presents a structured approach to understanding and assessing the least-learned competencies of STEM students in General Biology subjects. It will start on input, which identifies as well as analyzes on the least-learned competencies of STEM students taking up General Biology subjects. This will pave the way for teachers to be more aware of the problems in the curriculum and improve their way of pedagogical approach in addressing the problems. In addition, this will lead to reinforcement of DepEd officials to really look into it and implement data driven interventions with this matter.

In the Process phase, the process involves using Exploratory Factor Analysis (EFA), a statistical technique designed to reveal the underlying structure of these least-learned competencies. This analysis helps identify groups or dimensions of least-learned competencies, offering a deeper understanding of how they are connected and organized. In the end, the output produces two key results: the Factor Structure of Least-learned Competencies, which maps out the connections between various competency dimensions, and the Proposed Instrument for Measuring Least learned competencies, a validated tool designed to assess and enhance teacher training programs.

Research Objectives

The study aimed to develop an instrument of the least learned competencies across Most Essential Learning Competency (MELC) for General Biology.

Specifically, it seeks to answer the following research questions.

1. Determine least learned competencies in General Biology among STEM students through systematic literature review?
2. Explore the indicators of least learned competencies in General Biology
3. Develop an instrument that measures the least learned competencies in General Biology

METHODOLOGY

Research Locale

The study was conducted at Senior High School in the Division of Davao del Sur. The school is administered under the Department of Education (DepEd) Region XI and falls within the Schools Division of Davao del Sur. It participates in the K to 12 Senior High School system used nationwide. The school implements the K–12 Senior High School program, offering academic and possibly technical-vocational tracks. It is an active learning community that participates in various academic, extracurricular, and community events. The institution also supports Alternative Learning System (ALS) completers. It offers Science, Technology, Engineering and Mathematics (STEM) strand and the students who enrolled the strand are the respondents of the study since this is a sole strand that offers General Biology Subject.

Design and Sampling Method

The study used a quantitative approach utilizing exploratory factor analysis. This technique is particularly valuable in research for identifying the primary indicators of a research variable, thereby simplifying complex datasets while retaining essential information (Sappaile et al., 2023). Further, it is frequently utilized in the initial phases of research, particularly in the development and validation of measurement scales and constructs (Abu-Alhaija, 2018).

In the context of this study, the researcher utilizes the systematic literature review (SLR). Thereafter, the literature review will scrutinize to form significant statement. From the significant statement the researcher can now create a transform statement to be used as survey questionnaire or scale. Thus, SLR is useful to gather core ideas where the significant details of the review are subject for further analysis.

The study involved 153 respondents out of 253 population of Grade 12 General Biology students who officially enrolled under the strand of STEM in Senior High School in the Division of Davao del Sur. The sample size was determined using Raosoft Sample

Size Calculator with a margin of error of 5%, level of confidence of 95%. The determination of an appropriate sample size is a crucial step in research to ensure the validity and reliability of findings (Bolarinwa, 2020). They are the chosen respondents since they are the one capable of answering the instruments pertaining to the least learned competencies of their subject taken. The following breakdown is found on the table:

Table 1: Distribution of Sample Size among Grade 12 STEM Senior High School students in Davao del Sur

Schools	Population	Sample Size
School A	*76*	*46*
School B	*48*	*30*
School C	*45*	*27*
School D	*84*	*50*
Total	***253***	***153***

Subsequently, as the survey was administered to students by employing Stratified Random Sampling as a probability sampling method where a population is divided into distinct subgroups, known as "strata," based on shared characteristics relevant to the research (Nguyen et al., 2018; Spolarich, 2023). Specifically, the population is stratified according to the different Senior High Schools in the entire division of Davao del Sur. Further, this approach ensures proportional representation of diverse segments within a population, thereby enhancing the precision and generalizability of study results (Mukti, 2025).

There are basically 2 inclusion criteria in this research. These are the students who currently taken up in the STEM strand and take the subject of General Biology in Senior High School in Davao del Sur namely: Matanao NHS, Guihing NHS, Barayong NHS and Santa Cruz NHS. They are chosen since they are the first hand who can experience the dynamics of the subjects in terms of its challenges and difficulties. On the other hand, those who are enrolled on the STEM strand and have not taken the subjects are deemed excluded in the study.

Data Gathering Procedure

The researcher secured permission to conduct the study. First, a letter to conduct the study addressed to the Dean of Graduate School of DSSC Institute of Graduate

Professional Education. As soon as the letter is granted, the researcher sent a letter to the designated research focal person in the Division of Davao del Sur. Once everything is settled, the researcher may provide copies to the school head together with the attached permission letter to the school of the Senior High schools in Davao del sur and was conducted as soon as the letter is approved. Additionally, the target participants received an informed consent letter outlining their planned conduct during the administration of the survey requesting their permission to engage in it if they so choose.

Subsequently, to make sure that Grade 12 STEM students feel free and comfortable in deciding whether to join the study, their subject teachers, advisers, and strand coordinators were not be involved in inviting students to participate in giving out consent forms, administering the survey or instruments, or collecting any data. Only the researcher handled the recruitment process, either through a separate orientation session or through an online platform that is not managed by their teachers.

Moreover, the research instrument was developed through a systematic review of related literature to ensure its validity and reliability. Using Google Scholar as the main database, the researcher identified core concepts such as least learned competencies, Most Essential Learning Competencies, competency-based curriculum, and “Biology” as search terms. Boolean operators (AND, OR, and quotation marks) were applied to generate combined keywords. The gathered articles were be screened carefully, considering only peer-reviewed journals from 2019-2025, theses, and dissertations published within the last five years that focused on Biology education, the Competency-Based Curriculum, or MELCs, and involved Senior High School students or teachers. Abstracts, results, and conclusions were reviewed to confirm relevance and avoid duplication, with all selected studies saved in the researcher’s Google Scholar library.

In addition, From the reviewed literature, significant statements describing learning gaps and difficulties in General Biology were extracted and grouped into themes. These will be then rewritten into transformed statements to create a 5-point Likert scale instrument. The finalized questionnaire, developed from these transformed statements, was then administered to the student respondents for data gathering.

Prior to data analysis using statistical software, the questionnaire underwent pilot testing to establish its validity and reliability. Revisions were made by incorporating the suggestions and comments of expert validators to improve the instrument. Subsequently, internal consistency was assessed using Cronbach’s alpha. The analysis yielded a Cronbach’s alpha coefficient of 0.932, indicating very high internal consistency among the items. This suggests that the items are strongly correlated and reliably measure the intended construct.

Finally, once the data has been gathered the researcher used JASP or JAMOVI as tools in running the data. The said software is free and open-source statistical software. Hence, it is suitable for EFA and no license cost.

Instruments

The research instruments were carefully developed based on insights from relevant literature and went through several stages to ensure its validity and reliability. In the primary phase, the researcher creates an initial instrument through systematic review of related studies pertaining to least learn competencies in General Biology subjects. Additionally, only studies written in English and clearly aligned with the General Biology curriculum were included. The articles also had to be freely accessible and available for full-text download to allow for transparency and easy verification of the review process. Studies that were difficult to access, lacked clear research methods, or were not directly relevant to Biology learning competencies were excluded from the review.

To begin with, the research objectives were clearly defined to make sure the instrument was aligned with the overall goals of the study. In the creation of the systematic review, the researcher utilizes google scholar as main search engine databases. Thereafter, systematic process of arriving of keywords such as least-learned competencies in General Biology or Senior High School General Biology Least-learned competencies were followed. Step (1) is to identify the core concepts. These are Least learned competency, MELCs (Most Essential Learning Competencies), Competency-based curriculum and Biology (As subject area). Step (2) use Boolean operators (AND, or, quotation marks). Step (3) create sample combined keywords. Subsequent to this, the researcher will thoroughly screen the collected articles to ensure that only relevant and credible studies are included. The selected literature must focus on Least-learned competency in Biology education, the Competency-Based Curriculum, or MELCs, and should have been published within the last ten years. Only peer-reviewed journals, theses, or dissertations involving Senior High School students or teachers will be considered. To determine the relevance of each source and prevent duplication, the researcher will examine the abstract, results, and conclusion sections of every article. From these reviewed studies, significant statements or key insights that describe students' learning difficulties and gaps in General Biology will be identified and organized into thematic categories. These will then be refined into clear and measurable transformed statements , which served as the basis for developing a 5-point Likert scale instrument.

Also, the researcher makes sure that the search of the article from the first page to the last page of the google scholar is saved to Google scholar library to avoid duplication. Finally, screening the articles by reading the abstract, results and conclusion helped the researcher arrive with significant statements and later be converted to transformed statements. After such a rigorous process, a questionnaire can be made based on the transform statements extracted from the systematic review and administered to the students for survey and data gathering.

Moreover, the Researcher performed content analysis before running EFA to ensure that the items in survey questions or statements adequately represent the constructs being measured. Further, validators are coming from Higher Education Institution (HEI) and graduated already with their Doctorate degree. They possess all

necessary competence as they already published journals pertaining to developing a scale or instruments.

Finally, the questionnaire was subjected to pilot testing to ensure the validity and reliability of it. Incorporate the suggestions and comments of validators to the instruments and test cronbach alpha for the internal consistency of the items. Further, the result of the Cronbach alpha is 0.932 which indicates very high internal consistency among your items. Hence, the items are strongly correlated with each other.

Reliability Analysis	
Scale Reliability Statistics	
	Cronbach's α
Scale	**0.955**

Statistical Treatments

The researcher employs Exploratory factor Analysis to determine the dimensions of the least learned competencies in General Biology. This method is crucial for establishing construct validity in instrument development, complementing other validation techniques such as face validity, which relies on expert judgment for assessing relevance and clarity. The integration of Exploratory Factor Analysis allows for the identification of underlying constructs within the collected data, thus ensuring the instrument accurately measures the intended theoretical dimensions. For instance, a KMO value of .70 and a Bartlett's test value of .00 confirm the suitability of the data for factor analysis, alongside a chi-square value of 1342.41. Such robust statistical indicators underpin the validity of the instrument, further strengthened by a content validity index of 0.950, which surpasses the recommended threshold of 0.78 for expert consensus. This comprehensive approach to validation ensures that the instrument is both internally consistent and externally relevant, providing a strong foundation for measuring the specified competencies.

Scope and Limitation

This study aimed to develop and validate an instrument that identified the least learned competencies in General Biology based on the Most Essential Learning Competencies (MELCs) among Senior High School students. Subsequently, content analysis was conducted as validation to the developed tools. In the process of content validation, three (3) selected validators are coming from Higher Education Institution (HEI) for possess reliable reputation in research especially in developing scales or instrument. This to ensure that the content was properly evaluated since they are learned and experience in the field of academe and research and published already research pertaining to developing scales. After such attempt, pilot testing followed to determine whether the tools, procedures and overall process were functioning properly and were appropriate before conducting the full assessment.

The study be conducted at Senior High Schools, located within Davao del Sur, Philippines. The schools are included in the study since these are the only schools in the

Division of Davao del Sur that offers Science Technology, Engineering and Mathematics (STEM) strand. Hence, offers General Biology 1 subjects. The participants were Grade 12 STEM students who are currently taking the General Biology subject, since they have the appropriate background related to the study. The data were collected during the second semester of S.Y. 2025-2026, on the month of November, 2025 to March 2026 with at least 153 respondents to meet the requirement for Exploratory Factor Analysis (EFA). On the other hand, students in Grade 11 and below, as well as schools that do not offer the STEM strand, are deemed excluded from the study as they do not constitute the relevant respondents.

The study is limited only to STEM students and does not include other strands because their subjects and experiences in Biology are different. Although four schools are involved, the results cannot be generalized to all school in Davao del Sur or other areas, since differences in student demographics, school environments, and teaching approaches may affect the findings.

RESULTS AND DISCUSSION

This study developed Least learned Competency in General Biology Scale (LLCGBS) for STEM students in Davao del Sur, Philippines. The study aimed to address the need for a standardized tool to assess cognitive and cognitive difficulty as well as its constraints in instructional and learning environment. The research aligns with global and national priorities, including SDGs 4 and DepEd Order No. 8, s. 2015.

Presentation of Systematic Literature Review

The results presented in this section are built on the in-depth rigorous Systematic Literature Review (SLR). By doing the analysis, the researcher extracts meaningful insight from the different sources of literature that focuses on least-learned competencies in General Biology.

This process aimed to pinpoint statements that represent least learned competencies related to General Biology and convert them into measurable indicators for developing the scale. By rigorous reading of the various literature, significant statements were identified. These statements capture the founding ideas on the multiple facets of least learned competencies in General Biology. The identified significant statements, that later be converted into transformed statements, serve as the primary basis for the development of the initial items of the Least learned Competencies in General Biology Scale (LLCGBS).

The significant statements extracted from the systematic literature review (SLR) were used as basis in the creation of scale items. Each statement was carefully scrutinized and transformed into a measurable indicator that can be assessed using a Likert-scale format.

The procedure in formulating the of items involves series of refinements and

scrutiny. Transformed statements expressing similar ideas were examined to eliminate redundancy, while ensuring that all relevant aspects of General Biology captured in the data were properly represented.

As a result of this development, an initial pool of twenty-five (25) items was developed. These items were designed to capture the range of responses provided by the participants and to serve as preliminary indicators for measuring least-learned competencies in General Biology among Senior High School STEM students.

At first, twenty-five (25) items were developed based on the least learned competencies in General Biology. These items were then checked through content validation to make sure they accurately measure what they are intended to assess. They were created after carefully looking into the curriculum standards, the expected learning competencies, and the areas where students commonly struggle in selected General Biology topics.

A group of experts, including biology educators, curriculum specialists, and science teachers, was asked to review each item. They evaluated the items based on how relevant, clear, and aligned they were with the least learned competencies. To do this, they used a four-point rating scale, where higher scores meant stronger agreement that the item was appropriate.

The results of the expert evaluation showed that most of the items were rated from quite relevant to highly relevant, which means that they generally matched the competencies they were meant to measure. This suggests that the initial set of items was able to cover the key areas where students struggle in General Biology. However, a few items received lower ratings, especially in terms of clarity and precision, which means they still needed some improvement.

Based on the experts' feedback, the items were revised where needed. Statements that were unclear, repetitive, or too complex were rephrased to make them easier to understand and better aligned with specific biology competencies. Some items were also adjusted to match the expected level of thinking for students, making sure they stay consistent with the curriculum standards.

The refined set of items was subsequently finalized for pilot testing. This stage aimed to further evaluate the reliability and factor structure of the instrument designed to measure the dimensions of least learned competencies in General Biology.

Pilot Testing and Reliability Analysis

After the content validation process, the revised Least Learned Competency in General Biology Scale (LLCGBS) was pilot tested to evaluate its reliability and determine its suitability for further analysis. The pilot test was conducted among a group of STEM students from the nearby Digos City Division, who shared similar characteristics with the study's target population. The pilot testing aimed to assess the instrument's internal

consistency and to detect any concerns regarding item clarity, wording, and overall structure. The collected responses were then analyzed using Cronbach's alpha to evaluate the reliability of the scale.

Finally, the results yielded a Cronbach's alpha of 0.932 based on 25 items and 40 responses, indicating excellent internal consistency. This suggests that the instrument's items are highly reliable and consistently measure the intended construct.

Presentation of Quantitative Findings

To determine the underlying dimensions of least learned competencies in General Biology, an Exploratory Factor Analysis (EFA) was carried out. This used Principal Axis Factoring with oblimin rotation to better understand how the items group together. Factors were selected based on eigenvalues greater than 1.0, which helped determine the most meaningful underlying dimensions. Further, the rotation process was performed using oblimin rotation until convergence was achieved.

1.1. Suitability Test for Factor Analysis

Table 2 shows the result of KMO measure of sampling adequacy and Bartlett's test of sphericity.

Table 2. KMO and Bartlett's Test Sphericity

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy.		*0.500*
	χ^2	*00*
	df	*300*
	Sig.	*<0.001*

Bartlett's Test of Sphericity was significant ($\chi^2 = \infty$, df = 300, $p < .001$), indicating that the data were suitable for factor analysis; however, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.50, reflecting marginal adequacy.

1.2. Factors Extraction

After confirming that the identified factors are appropriate for analysis, the next step is to evaluate their suitability according to the established criteria. Based on the

criterion of eigenvalues greater than 1.0, three factors were deemed appropriate for extraction, suggesting that fewer factors may better represent the data.

Table 3.

INITIAL EIGENVALUES	
FACTOR	**Eigenvalue**
1	12.029
2	1.5625
3	0.8922
4	0.7006
5	0.5369
6	0.3795
7	0.2478
8	0.1329
9	0.0761
10	0.0646
11	0.0281
12	-0.0982
13	-0.1319
14	-0.1615
15	-0.1701
16	-0.2155
17	-0.2355
18	-0.2694
19	-0.3069
20	-0.3436
21	-0.4065
22	-0.444
23	-0.5615
24	-0.5829
25	-0.6934

Moreover, according to Camilli and Geis (2019) that correlation matrix where variables are standardized (with a variance of 1.0), an eigenvalue of 1.0 represents the amount of variance contributed by a single item. Therefore, a factor with an eigenvalue greater than 1.0 explains more variance than any single individual item, justifying its

retention as a meaningful construct. This threshold is a common criterion for determining the number of factors to retain in exploratory factor analysis, indicating that a factor accounts for more variance than an individual observed variable (Kyriazos and Poga, 2023).

1.3. Factor Determination

After ensuring that the sample is enough by warranting a sample size of 153 respondents, with the KMO of 0.500 (marginal adequacy) as well as Bartlett's Test of Sphericity of < 0.05, there can be a factor generated, the next stage is to determine how many factors are suitable to be included. Based on the suggestion of Gibson et al (2020) that factors with less than 3 items are not suitable to be included. This is for the reason that factors with only two items are particularly likely to produce poorly defined solutions, non-convergence, or Heywood cases where estimated variances are negative.

Nevertheless, it was observed that several items either failed to load on any single factor or exhibited multiple cross-loadings across factors. To address this issue, Acar Güvendir and Özer Özkan (2022) recommend the removal of such items to minimize cross-loading problems. They further emphasize that item elimination should be carried out cautiously and in a step-by-step (gradual) manner. In line with this recommendation, the present study implemented a careful and systematic removal of problematic items.

Furthermore, the resulting table is presented in Table 4.

Item	Statement	Factor	
		1	2
Item 6	The abstract nature of topics such as the endocrine and nervous systems makes them challenging for me to learn.	0.737	
Item 12	I find it challenging to understand abstract concepts such as energy transfer in ecosystems.	0.642	
Item 13	I find it difficult to solve Biology problems that require interpreting complex data such as genetics or ecology.	0.803	
Item 14	It is challenging for me to connect and integrate ideas from different scientific areas when studying Biology.	1.065	
Item 15	Evolutionary biology is one of the topics I find most challenging to comprehend	0.742	
Item 18	I find it difficult to understand Biology lessons when teaching relies mostly on lectures and readings.		0.661
Item 22	My school lacks adequate laboratory materials for hands-on Biology experiments.		0.465
Item 23	Using lab worksheets helps me understand Biology concepts better.		0.653
Item 24	I entered Senior High School with learning gaps from my previous Biology lessons in Junior High.		0.753
Initial Eigenvalue		12.029	1.563
Variance		48.12	6.25

Reliability by Cronbach Alpha	0.937	0.790
Overall Reliability by Cronbach Alpha		0.916

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 4. Factors of Least learned Competencies in General Biology

Based on the results of the study, a total of two factors is generated. Discussion of each generated factor are as follows: Factor 1 comprise of five items (item 6, item 12, item 13, item 14 and item 15) with a factor loading ranges from 1.065 to 0.42. Along with that, the factor obtained eigenvalue of 12.029 with a total % percentage of variance explained of 48.12 and an internal consistency of 0.937. After confirming the items and the literature associated in this factor, this factor is then named "Cognitive and Conceptual Difficulty in Biology".

Furthermore, the exploratory factor analysis indicated that Items 6, 12, 13, 14, and 15 grouped together under a single dimension, which was labeled *Cognitive and Conceptual Difficulty in Biology*. This factor captures the students' difficulties in dealing with the more mentally demanding aspects of Biology, such as understanding abstract concepts, interpreting complex information, connecting ideas across scientific areas, and grasping challenging topics like evolution. Since these items all point to similar learning struggles, they were collectively interpreted as reflecting the cognitive and conceptual challenges that students experience in studying Biology.

On the flipside, the second factor has a total of four items (item 18, item 22, item 23 and item 24) with the ranges of from 0.753 to 0.465. In addition, this factor has an eigenvalue of 1.563 with a % of variance explained of 6.25 and an internal consistency of 0.790. After confirming the items and the literature associated in this factor, this factor is then named *"Instructional and Learning. Environment Constraints*".

The exploratory factor analysis indicated that Items 18, 22, 23, and 24 clustered under one dimension, which was labeled Instructional and Learning Environment Constraints. This factor captures the difficulties students experience when their learning is affected by lecture-based teaching, limited laboratory resources, insufficient instructional support, and learning gaps from previous Biology classes. Since these items all reflect challenges tied to the teaching process and the learning environment, they were collectively interpreted as describing the instructional and environmental constraints that shape students' understanding of Biology.

Overall, the developed items have an internal consistency of 0.916. This means that the retained items have a high level of internal consistency.

Factor 1: Cognitive and Conceptual Difficulty in Biology

The items grouped under Factor 1 reflect the cognitive and conceptual difficulties that learners commonly face when trying to understand biology. Overall, these items point

to the challenges students experience when dealing with abstract ideas, complex reasoning, and the need to connect different scientific concepts.

For instance, Item 6 highlights how students struggle to understand abstract biological systems such as the endocrine and nervous systems. Similarly, Item 12 points to difficulties in grasping processes that are not directly observable, like energy transfer in ecosystems. Item 13 shows that learners often find it challenging to engage in higher-order thinking, especially when solving biology problems that require interpreting complex data in topics like genetics and ecology. In the same way, Item 14 emphasizes the difficulty students encounter when trying to integrate knowledge across different areas of science, particularly in making connections within biology. Lastly, Item 15 identifies evolutionary biology as one of the more difficult topics, further reinforcing the presence of conceptual challenges in specific areas of the subject.

Moreover, the factor Cognitive and Conceptual Difficulty in Biology was identified because Items 6, 12, 13, 14, and 15 all reflect students' struggles with the mentally demanding aspects of Biology. These items are connected through difficulties in understanding abstract concepts, interpreting complex information, solving higher-order problems, and integrating ideas across topics. Together, they show that students' challenges go beyond specific lessons and point to broader cognitive and conceptual difficulties in learning Biology.

In the challenging topics of Endocrine and Nervous system on (item 6) was consistent with the study of Hadiprayitno et al., (2019) that Students find topics such as the endocrine system and nervous system as well as cell structure as challenging to understand.

Moreover, the findings (item 12) that talks about the difficulty in grasping topics such as energy transfer in the ecosystem show congruence with the study of Malone et al., (2021) that Students often experience difficulty in relating individual biological concepts to broader system-level interactions, such as linking energy transfer within food chains to the overall functioning of ecosystems.

In the case of complexity learning genetic and ecology in (item 13). It is supported by the study of Nigussie (2025) that Students struggle with Biology's complex, ill-structured problems like interpreting genetic or ecological data that require flexible thinking, handling ambiguity, and integrating knowledge from multiple disciplines.

The result (item 14) reflects similar findings as of Semilarski et al (2022) that This difficulty is compounded when students struggle to perceive how to apply acquired knowledge to solve real-world problems or establish interdisciplinary links, underscoring a need for educational strategies that foster meaningful learning by connecting new information with prior knowledge.

Moreover, the result (item 15) is consistent with the study of Santos & Caballes (2022) that the teaching of evolution at the Senior High School level is often a topic of discussion among educators. Although it may appear simple and straightforward, it is

actually quite complex and can easily be misunderstood by students. Likewise, this complexity can result in misconceptions that prevent students from fully understanding biological processes, highlighting the need for more focused teaching strategies to enhance their comprehension and mastery of evolutionary concepts (Abenes et al., 2023).

Factor 2: Instructional and Learning Environment Constraints

This factor reflects the external conditions and instructional challenges that affect how well students understand biology. The items under this factor show how teaching strategies, the availability of learning resources, and students' prior experiences all play a role in shaping the difficulties they encounter in learning the subject. Further, the researcher identified Instructional and Learning Environment Constraints as a factor because Items 18, 22, 23, and 24 all reflect difficulties linked to the conditions in which Biology is taught and learned. These items show that students' understanding may be affected by lecture-based teaching, lack of laboratory materials, limited instructional support, and prior learning gaps. Since the items consistently point to challenges arising from the teaching process and school environment, they were grouped under the factor Instructional and Learning Environment Constraints.

Specifically, Item 18 highlights the challenges that come from teacher-centered approaches, especially when lessons rely mostly on lectures and readings, which can limit students' active participation and deeper understanding. This is in agreement with Ghafar (2023) as stress that this methodology can lead to student disengagement and a loss of motivation because pupils are not encouraged to investigate or develop their own unique understanding of the subject matter. Such environments often foster an atmosphere of fear and competition, rather than collaboration, further hindering student engagement and the development of critical thinking (Mohammed & Kinyó, 2022).

Item 22 points to the lack of sufficient laboratory materials, suggesting that limited hands-on experiences make it harder for students to fully grasp biological concepts. It mirrors to study of Oliver (2022) that when laboratory materials are scarce, students lose the opportunity to engage in the "hands-on activities" required to develop essential scientific skills. Further, the absence of adequate laboratory facilities and equipment significantly impedes the effective explanation of scientific concepts and the provision of practical demonstrations, which are crucial for reinforcing learners' conceptual understanding and fostering active science learning (Anton et al., 2023).

On the other hand, Item 23 emphasizes the value of experiential learning, showing that the use of laboratory worksheets can improve understanding, as practical activities help students learn better. The item is supported on the study of Myrzagaliyeva et al (2024) that biology education is most effective when it moves beyond rote memorization to "learning by doing," where structured tools like worksheets bridge the gap between theory and practice. However, a prevailing issue in many curricula, particularly in science and biology, is the frequent introduction of changes without a commensurate consideration for the availability of requisite teaching and learning materials or the instructional methods to be employed (Hambabi et al., 2024).

Lastly, Item 24 reflects gaps in prior knowledge, where a weak foundation from earlier learning contributes to the difficulties students currently face in biology. This result is in parallel with Mokganya & Zitha (2023) emphasizing that biology is a cumulative discipline where a student's prior knowledge serves as the primary predictor of their future academic success. When foundational gaps exist, students often struggle to integrate new, more complex information, leading to persistent learning difficulties. Further, Students who enter a course with low levels of prior knowledge often fail to catch up to their higher-performing peers, even after a full year of instruction (Binder et al., 2019).

1.4. Developed Instrument

Table 5. Least learned Competency in General Biology Scale (LLCGBS) Survey Questionnaire

Scale	Description	Interpretation
5	Strongly Agree	The item statement is **ALWAYS** true and observed/manifested
4	Agree	The item statement is **OFTEN** true and observed/manifested
3	Neutral	The item statement is **SOMETIMES** true and observed/manifested
2	Disagree	The item statement is **SELDOM** true and observed/manifested
1	Strongly Disagree	The item statement is **NOT** true and **NOT** observed/manifested

Environmental Education Competency Scale (EECS)						
No.	**Statement** **As a student, I find…**	**5**	**4**	**3**	**2**	**1**
Cognitive and Conceptual Difficulty in Biology						
1.	the abstract nature of topics such as the endocrine and nervous systems makes them challenging for me to learn.					
2.	it challenging to understand abstract concepts such as energy transfer in ecosystems.					
3.	it difficult to solve Biology problems that require interpreting complex data such as genetics or ecology.					

4.	it challenging for me to connect and integrate ideas from different scientific areas when studying Biology.					
5.	Evolutionary biology is one of the topics I find most challenging to comprehend					
Instructional and Learning Environment Constraints						
1.	it difficult to understand Biology lessons when teaching relies mostly on lectures and readings.					
2.	my school lacks adequate laboratory materials for hands-on Biology experiments.					
3.	using lab worksheets helps me understand Biology concepts better.					
4.	it entering Senior High School with learning gaps from my previous Biology lessons in Junior High.					

The Least learned Competency in General Biology Scale (LLCGBS) was developed to assess the least-learned competencies of Senior High School students under STEM program that is the results from cognitive and conceptual difficulty of student in the subject as well as the constraints of instructional and learning environment.

The instrument is aligned with SDG 4: Quality Education, which focuses on providing inclusive, equitable, and high-quality education while supporting lifelong learning for all. The items reflect important aspects of educational quality, especially in science education. For example, several items (Items 6, 12, 13, 14, and 15) highlight students' difficulties in understanding abstract biological concepts, which points to the need for improving learning outcomes and cognitive development.

In addition, the factor related to instructional and learning environment constraints (Items 18, 22, 23, and 24) brings attention to issues such as teaching approaches, the availability of laboratory resources, and gaps in prior knowledge. These challenges are closely linked to the goals of SDG 4, particularly in promoting better learning environments and more effective teaching practices.

Furthermore, the LLCGBS functions as both a diagnostic and evaluative tool for teacher education programs. It allows institutions to determine the strengths and areas that need improvement among non-science pre-service teachers in delivering environmental education.

For instance, the results may reveal a need to strengthen pedagogical strategies for integrating biology topics or to enhance the cognitive and conceptual understanding of students as well as to address instructional and Learning environment constrains. This supports evidence-based curriculum development and contributes to the preparation of future educators who can effectively promote sustainability across disciplines.

Additionally, this study is anchored on DepEd Order No. 8, s. 2015, which emphasizes the role of classroom assessment in identifying learners' strengths and difficulties. The instrument supports this policy by determining the least learned competencies in Biology and examining instructional and environmental factors affecting student learning, thereby providing a basis for improving teaching strategies and learning outcomes.

Conclusions

Based on the findings of the systematic literature review, the study concluded that least learned competencies in General Biology are primarily associated with abstract and conceptually difficult topics such as genetics, evolution, metabolism, ecology, and physiological systems.

The results indicated two related dimensions, namely Cognitive and Conceptual Difficulty in Biology and Instruction and Learning Environment Constraints which encompass major factors that contribute to students' challenges in mastering biology competencies.

The last 9-item scale has high internal consistency reliability (Cronbach's alpha of 0.916) and offers a contextualized and evidence-based tool that Senior High School institutions can use to identify learning gaps, customize interventions, and improve instructional practices towards more positive learning outcomes.

Recommendations

Based on the findings of the study, the following Future Directions are drawn:

1. For Department of Education: It is recommended that the developed instrument be reviewed and validated by experts from the Department of Education, especially those with expertise in General Biology, curriculum, and assessment. The instrument should also undergo Confirmatory Factor Analysis (CFA) to confirm whether the identified factors truly represent the least-learned competencies in General Biology.

2.For Biology Teachers and Educators: Use the identified dimensions such as cognitive and conceptual difficulty, as well as instructional and learning environment constraints as a guide in creating more learner-centered teaching strategies. Focus on making abstract concepts easier to understand, incorporating inquiry-based and hands-on laboratory activities, and strengthening students' foundational knowledge to help improve their overall comprehension.

3. For School Administrators and Policy Makers: Ensure that schools are equipped with enough laboratory resources and support ongoing professional development for teachers, especially in teaching complex biological concepts. There should also be a focus on improving science instruction by upgrading facilities, providing better

instructional materials, and offering continuous training for teachers aligned with DepEd standards.

4. Future researchers may further validate and expand the application of the instrument across different institutions, grade levels, and subject areas. They may also explore additional variables influencing learning difficulties, such as student motivation, digital learning tools, instructional innovations, and other related literature that may contribute to the development of additional factors associated with least-learned competencies.

5. For Community and Stakeholders: Encourage stronger collaboration among schools, communities, and educational partners to better support science learning. This can be done through enrichment programs, science camps, and hands-on learning experiences that help students connect biology concepts to real-life situations.

Compliance with Ethical Standards

The researcher followed accepted procedures for getting informed consent, guaranteeing anonymity, protecting privacy, and upholding confidentiality in order to protect the study participants' privacy.

Informed Consent. An informed consent is a systematic procedure of information sharing about the study's background and goals between the researcher and potential participants. For scholarly research, the current problem poses a serious ethical dilemma. An inform consent is used in asking the respondents/participants and confirm if they are willing to participate in the study.

Parent Consent. Since some of the participants may be Grade 12 students who are still minors, extra care will be taken to safeguard their rights and well-being throughout the study. Written consent from parents or legal guardians will be obtained before any data collection begins, along with formal approval from the school administration. The students themselves will also be asked for their assent to ensure that they clearly understand the study and voluntarily agree to participate.

Anonymity. Anonymity is the process of preserving the confidentiality of respondent identities, guaranteeing that no outside parties can access their personal data.

Respect for Privacy. The researcher put policies in place to safeguard respondents' privacy and ensure that their participation in the study doesn't expose them to any potential dangers.

Confidentiality. The researcher gave guarantees that any ideas or information shared during the study would be kept completely private. Respondents could ask for their personal information to be kept private.

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