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Developing and Validating Customized Supplementary Materials to Enhance Laboratory Learning in Environmental Science and Agroforestry Programs

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ABSTRACT

Laboratory instruction plays an essential role in science and technical education, yet many institutions continue to rely on generic, non-contextualized materials that inadequately support diverse student learning needs. Addressing this gap, the project *"Enhancing Laboratory Learning: Crafting Customized Supplementary Instructional Materials"* aims to design and evaluate innovative, discipline-specific resources that reinforce experiential learning in Environmental Science and Agroforestry programs. Grounded in constructivist and experiential learning theories, the project focuses on developing real-life, tangible instructional models—including microscope specimens, insect samples, tree bark sections, and soil layer displays—intended to strengthen students' conceptual understanding of ecological and agroforestry systems. The initiative specifically seeks to improve comprehension, increase engagement, and cultivate environmental stewardship among learners. A quantitative research design was employed, utilizing a structured survey questionnaire distributed to 296 respondents from BS Environmental Science and BS Agroforestry programs. The survey assessed teaching effectiveness, laboratory activities, and laboratory facilities. A root cause analysis (RCA) was also conducted to identify underlying issues affecting laboratory learning experiences. Customized instructional materials were validated by experts in Entomology, Science Education, and Agriculture to ensure scientific accuracy, curriculum alignment, and pedagogical appropriateness. Results indicate that while teaching effectiveness was consistently rated "Always," laboratory activities received only "Neutral" ratings, reflecting limited hands-on engagement and insufficient instructional resources. Laboratory facilities were rated "Disagree," revealing deficiencies in equipment availability, accessibility, and technical support. These findings highlight the need for supplementary instructional materials that compensate for facility limitations and enhance practical learning opportunities. Expert validation yielded exceptionally high ratings (overall WM = 4.78 for content quality; 4.70 for usability and acceptability), confirming the materials' accuracy, relevance, logical organization, inclusivity, and eco-friendliness. The curated display—featuring seeds, insects, soil horizons, and bark specimens—was particularly commended for integrating multisensory and

multimodal elements that promote deeper comprehension and systems-level thinking.Overall, the study demonstrates that customized supplementary instructional materials significantly enhance laboratory learning by enriching student engagement, supporting diverse learning styles, and mitigating common resource constraints. These findings underscore the transformative potential of context-specific instructional innovations in strengthening science education within resource-limited academic environments.

Keywords: Customized Instructional Materials, Laboratory Learning, Supplementary Learning Resources

I. INTRODUCTION

Laboratories, a core component of practical education, are vital for reinforcing theoretical concepts through experiential learning. However, the effectiveness of these laboratory sessions is significantly influenced by the quality and relevance of the instructional materials provided to students. Despite their importance, many laboratory activities depend on standard, one-size-fits-all instructional materials that may not fully meet the diverse learning needs of students or align with specific curriculum objectives (Bennett & O'Neale, 2018).

The project "Enhancing Laboratory Learning: Crafting Customized Supplementary Instructional Materials" addresses the broader educational need for comprehensive and tailored instructional resources to enhance learning experiences. Effective education, particularly in science and technical fields, relies not only on theoretical instruction but also on practical, hands-on experiences that foster critical thinking and problem-solving skills (Hofstein & Lunetta, 2004). This project aims to bridge this gap by developing customized supplementary instructional materials tailored to the unique requirements of individual laboratory activities across various disciplines, including biology, chemistry, physics, engineering, and environmental science.

By embarking on this project, the goal is to empower educators with a versatile toolkit of supplementary instructional materials that can be customized to meet the diverse needs of students and enhance the effectiveness of laboratory learning experiences. Through collaboration with subject matter experts, instructional designers, and educators, a range of resources including interactive simulations, video tutorials, concept maps, worksheets, and hands-on activities will be developed (Blumenfeld et al., 1991). These materials will be rigorously evaluated and refined through iterative feedback processes to ensure their efficacy in supporting laboratory learning across various disciplines and educational settings. Ultimately, the project endeavors to elevate the quality and impact of laboratory education by providing educators with the resources they need to facilitate meaningful and engaging learning experiences for all students.

OBJECTIVES

At the end of the activity, the stakeholders should be able to:

1. Create a set of instructional materials utilizing real-life models in agroforestry, focusing on soil layer, plant anatomy, and animal anatomy.

2. Enhance the learning experience of BSAF students, faculty and practitioners by providing tangible, visually engaging models that facilitate better understanding of complex topics such as soil composition, plant structure, and animal interactions within ecosystem.
3. Increase retention and comprehension of BSAF students by integrating hands-on learning experiences using real-life models.
4. Conduct thorough evaluations to assess the effectiveness and impact of the instructional materials on learning outcomes, knowledge retention, and practical skills development of students.

Foster a sense of environmental stewardship and appreciation for the natural world by highlighting the importance of agroforestry in promoting biodiversity, soil conservation, and ecosystem resilience.

II. METHODOLOGY

To determine the effect of Enhancing Laboratory Learning through Crafting Customized Supplementary Instructional Materials, this study uses a needs analysis enable to come up with a device or learning materials that will supplement the same degree of learning as in experienced in laboratory activity.

This study utilizes quantitative type of research in collecting and analyzing data through the usage of survey questionnaire which composed of 4 main parts: the respondent's profile wherein their name was just optional; the teaching effectiveness; laboratory activities; and lastly is the laboratory facilities. The crafted customized alternative instructional materials were sub-divided into 4 section: Microscope specimens, insects, tree barks and the layer of the soil, which then validated by an Entomologist, Science, and Agriculturist Majors Instructors.

Root cause analysis

Root Cause Analysis (RCA) is a systematic process employed in various fields, including education, to identify the underlying reasons behind problems or challenges. In the context of enhancing laboratory learning and crafting customized supplementary instructional materials, RCA serves as a valuable tool for educators and instructional designers to delve into the core issues hindering effective learning experiences.

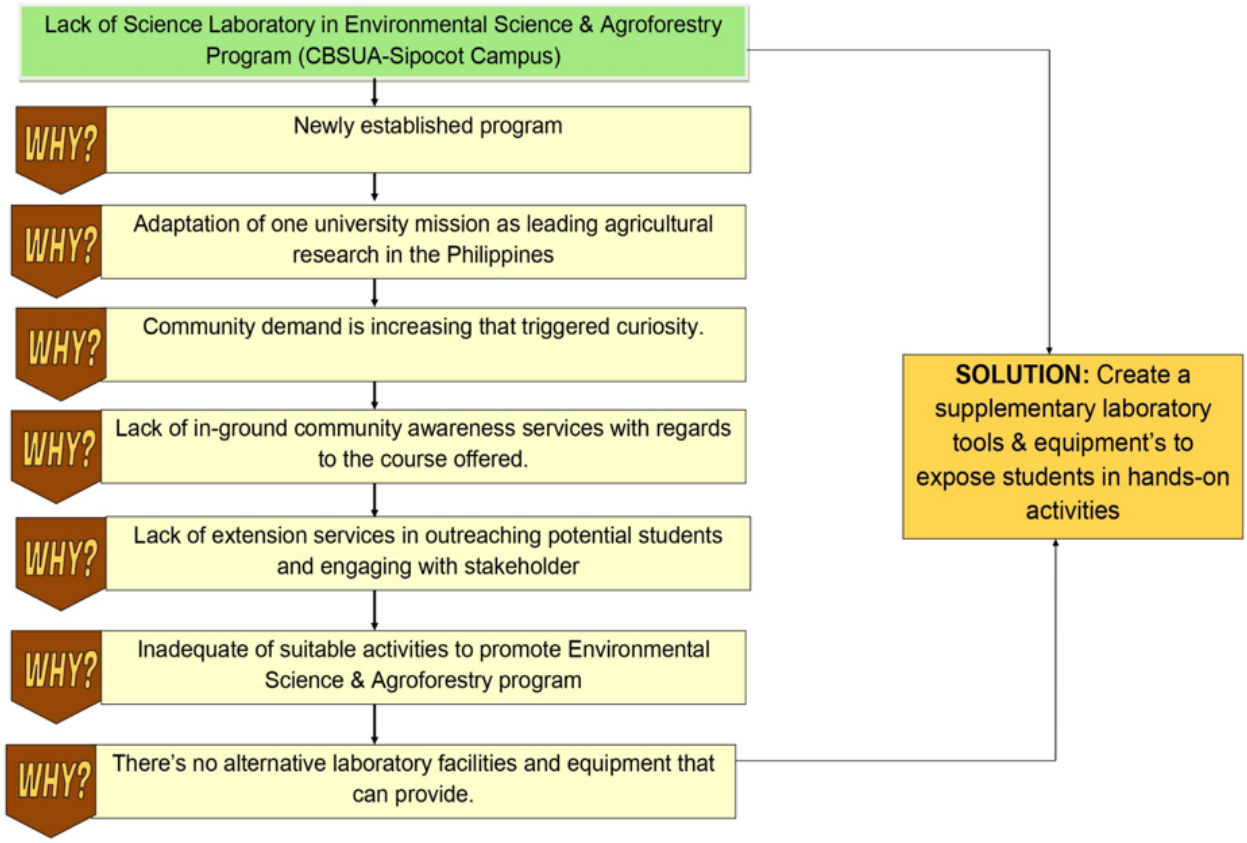

Figure 1. Root Cause Analysis

This study focuses on leveraging RCA methodologies to uncover the fundamental causes impeding laboratory learning outcomes and to tailor supplementary instructional materials to address these root causes effectively. By identifying and understanding these root causes, educators can develop targeted interventions and resources that cater to the specific needs and learning preferences of students.

Through a structured RCA approach, this study aims to not only enhance the effectiveness of laboratory learning but also to empower educators with insights to continuously refine and adapt their instructional strategies. By systematically addressing root causes, educators can create a more conducive learning environment that fosters student engagement, comprehension, and retention, ultimately enriching the overall educational experience.

Respondents

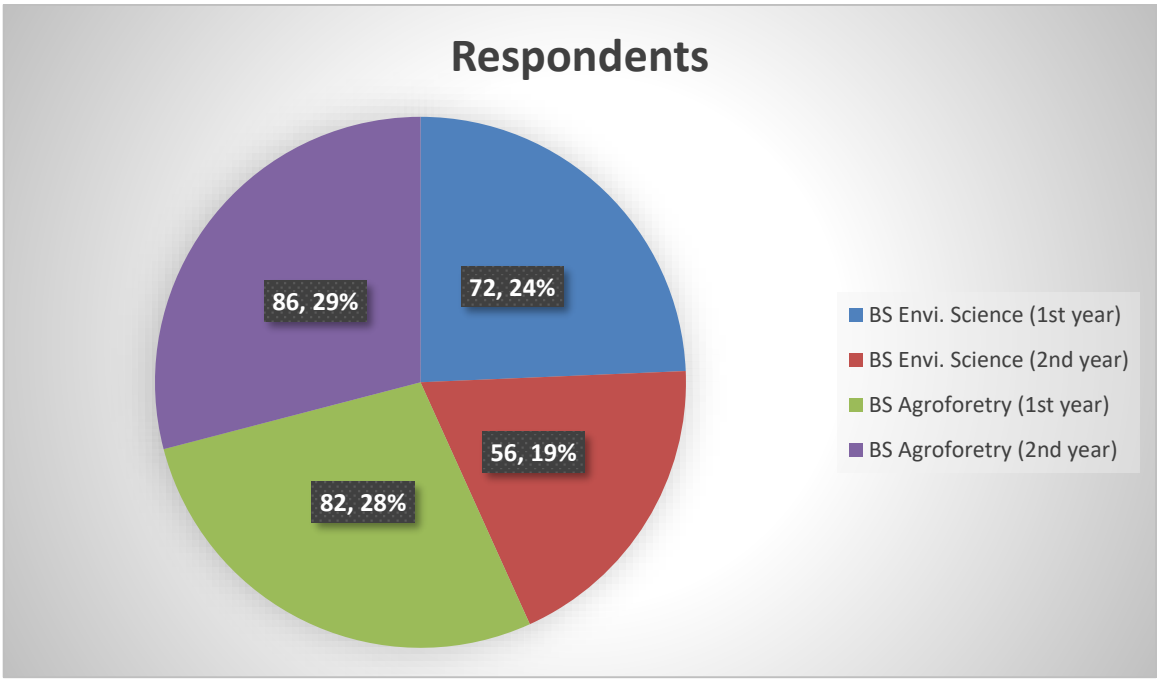

Figure 2. Respondents

The respondents of the study were composed of 72 first year and 56 second year students of BS Environmental Science and 82 first year and 86 second year students of BS Agroforestry, for a total of 296 respondents that will attest their first hands-on experience on the importance of the laboratory activity, which will be supplemented by the Enhancing Laboratory Learning: Crafting Customized Supplementary Instructional Materials".

III. RESULT AND DISCUSSION

In the pursuit of optimizing laboratory learning experiences, the development and implementation of customized supplementary instructional materials have emerged as a promising avenue. This study investigates the effectiveness of customized instructional materials in addressing diverse learning needs and fostering a deeper understanding of scientific concepts among students. By crafting supplementary materials tailored to specific learning objectives and student demographics, we aim to enrich the laboratory learning environment and enhance overall educational outcomes.

Figure 3. Customized Supplementary Instructional Material

The instructional display in the image represents a comprehensive and integrative approach to enhancing laboratory learning through customized supplementary instructional materials. Designed to support students in Environmental Science, Agroforestry, and Biology, the exhibit brings together seed specimens, insect samples, soil layers, and tree bark segments, each accompanied by clear labels, scientific names, and descriptive notes. This multimodal presentation strengthens student understanding by providing concrete, visual representations of abstract scientific concepts, which is particularly beneficial for visual and kinesthetic learners. The seed section, titled "Seed Secrets: An Exploration of Different Types and Characteristics," allows students to compare seed diversity in terms of size, morphology, and ecological function, supporting fundamental skills such as classification and pattern recognition. Meanwhile, the insectarium, "Discovering the Many Faces of Insects," offers preserved insect specimens with taxonomic and ecological information that enhance students' entomological knowledge, enabling them to understand insect adaptations, ecological roles, and agricultural significance such as pollination and pest dynamics.

Complementing these micro-level displays are the soil profile and bark samples, which promote a deeper understanding of ecological and agroforestry systems. The vertical soil horizon model, labeled from organic matter to bedrock, offers a simplified depiction of pedogenesis, nutrient cycling, and soil structure—concepts essential in land-use planning, crop production, and ecosystem management. The bark samples further enrich ecological awareness by illustrating species-specific traits useful in dendrology, forestry, and biodiversity studies. Together, these components guide students toward systems-level thinking by connecting biological diversity with ecological processes.

Beyond its instructional value, the display addresses persistent gaps in laboratory resources, particularly in resource-limited academic institutions. With students previously reporting limited access to laboratory materials and equipment, this curated collection provides a sustainable and replicable alternative that supports continuous learning without overreliance on live or seasonal specimens. Its durability and consistency ensure equitable access to quality materials across multiple cohorts.

Furthermore, the clarity, scientific accuracy, and pedagogical coherence evident in the display align with the strong validation ratings provided by experts in Entomology, Science Education, and Agriculture, who affirmed its curriculum alignment, factual accuracy, and educational usability. Overall, the display exemplifies the transformative potential of customized instructional materials in laboratory education by creating engaging, context-rich learning experiences that bridge theoretical concepts with practical ecological understanding.

A. TEACHING EFFECTIVENESS

STATEMENTS	WM	RANK	INTERPRETATION
1. The teacher effectively communicates complex concepts to students.	**4.347**	3	Always
2. The teacher effectively uses technology to enhance learning experiences like interactive whiteboards, multimedia presentations, simulations, or online learning platforms to supplement traditional teaching methods.	**4.307**	5	Always
3. The teacher effectively manages classroom behavior and maintains a positive learning environment.	**4.329**	4	Always
4. The instructional materials used by the teacher encourage student engagement and participation.	**4.186**	12	Always
5. The teacher provides opportunities for students to interact with and manipulate the instructional materials.	**4.189**	11	Always
6. The instructional materials used by the teacher are accessible and inclusive for all students, including those with special needs.	**4.094**	13	Always
7. The teacher provides constructive feedback to students on their work.	**4.197**	9	Always
8. The teacher demonstrates enthusiasm and passion for the subject matter.	**4.191**	10	Always
9. The teacher integrates real-world examples and applications into lessons to enhance student understanding.	**4.400**	1	Always
10. The teacher encourages student reflection and metacognition to deepen understanding of scientific concepts.	**4.279**	7	Always
11. The teacher integrates real-world examples and applications into lessons to enhance student understanding.	**4.368**	2	Always

12. The science teacher employs inquiry-based learning approaches to foster curiosity and exploration among students.	**4.233**	8	Always
13. The teacher incorporates collaborative learning activities to encourage peer interaction and discussion.	**4.299**	6	Always
AVERAGE WEIGHTED MEAN	**4.256**		**Always**

Legend: *4.21-5.00 - Always; 3.41-4.20 – Most of the time; 2.61-3.40 – Occasionally; 1.81-2.60 – Rarely; 1.00-1.80 - Never*

Table 1 shows the Effective teaching in laboratory settings which involves more than just disseminating information; it entails creating engaging and interactive learning environments that stimulate curiosity and critical thinking.

This states that the respondents are always aware about the effective of the teacher to integrate real-world examples and applications into lessons to enhance student understanding which gains the rank 1 having a weighted mean 4.4. these reflects that the students of the Environmental science and Agroforestry program are satisfied in terms of the delivery of their teachers which is being implied by the always interpretations in the table above.

B. INSTRUCTIONS
LABORATORY ACTIVITIES

STATEMENTS	WM	RANK	INTERPRETATION
1. The teacher engages students in laboratory activities such as soil sampling and analysis, crop rotation demonstration, seed germination test, animal and plant anatomy.	**2.694**	6	Neutral
2. The teacher provides clear instructions and safety guidelines before conducting laboratory experiments.	**2.818**	5	Neutral
3. The teacher effectively demonstrates laboratory procedures and techniques to students.	**2.946**	3	Neutral
4. The teacher provides adequate supervision and support to ensure student safety during laboratory experiments.	**2.903**	4	Neutral
5. The laboratory activities provide opportunities for students to develop critical thinking and problem-solving skills.	**2.958**	2	Neutral
6. The teacher encourages collaborative work and communication among students during laboratory activities.	**2.961**	1	Neutral
AVERAGE WEIGHTED MEAN	**2.880**		**Neutral**

Legend: *4.21-5.00 - Strongly Agree; 3.41-4.20 – Agree; 2.61-3.40 – Neutral; 1.81-2.60 – Disagree; 1.00-1.80 - Strongly Disagree*

Table 2 implies the dynamic landscape of scientific education, wherein laboratories serve as crucibles of experimentation, exploration, and discovery. The above figures state the BSES and BSAF students are in neutral point in terms of their laboratory experience. This result only shows that the program should provide students with a hands-on platform to engage with fundamental concepts, experimental techniques, and analytical methodologies in a tangible manner. However, the efficacy of laboratory learning hinges not only on the availability of resources but also on the pedagogical approaches utilized to harness their potential.

This endeavor delves into the art of crafting customized supplementary instructional materials tailored to enhance laboratory experiences. It delves into the symbiotic relationship between theory and practice, elucidating how supplementary materials can bridge conceptual gaps, reinforce theoretical foundations, and imbue practical sessions with depth and context.

LABORATORY FACILITIES

STATEMENTS	WM	RANK	INTERPRETATION
1. The laboratory has sufficient equipment and tools for experiments	**2.381**	6	Disagree
2. The experiment is well-maintained and in good working condition	**2.619**	2	Neutral
3. We have easy access to reference materials and resources needed for experiments.	**2.287**	7	Disagree
4. Technical support is readily available during laboratory sessions	**2.282**	8	Disagree
5. Staff members are helpful and responsive to students needs	**2.725**	1	Neutral
6. The laboratory facilities are accessible to all students including those with disabilities	**2.438**	4	Disagree
7. Adequate accommodations are provided for students with special needs.	**2.518**	3	Disagree
8. Overall, I am satisfied with the laboratory facilities provided for students use.	**2.433**	5	Disagree
AVERAGE WEIGHTED MEAN	**2.460**		**Disagree**

Legend: *4.21-5.00 - Strongly Agree; 3.41-4.20 – Agree; 2.61-3.40 – Neutral; 1.81-2.60 – Disagree; 1.00-1.80 - Strongly Disagree*

Table 3 shows the BSES and BSAF student's perspective on the program's laboratory facilities, which stand as the cornerstone of this immersive educational journey. Within these well-equipped spaces, students encounter a dynamic environment ripe for exploration and discovery. The figures above imply the neutral opinion of the respondents whether they experience about the availability of laboratory activities. Wherein, statements like, Staff members are helpful and responsive to students needs and the

experiment is well-maintained and in good working condition ranks as 1 &2 with a corresponding weighted mean of 2.725 & 2,619. While technical supports got the lowest response from the students.

This result only suggests the usage of basic apparatus to state-of-the-art instrumentation or supplementary instructional materials, to offer a diverse array of tools tailored to support a spectrum of scientific disciplines and to address the data being presented by the table above in terms of the laboratory facility deficiency.

C. VALIDATION OF THE CUSTOMIZED SUPPLEMENTAL INSTRUCTIONAL MATERIALS

CONTENT QUALITY

STATEMENTS	WM	INTERPRETATION
1. The instructional material is aligned with the curriculum and learning objectives.	5.000	Strongly Agree
2. The instructional material provides accurate and factual information.	4.800	Strongly Agree
3. The depth of content is appropriate for the intended audience	4.600	Strongly Agree
4. The content includes up-to-date information and examples.	5.000	Strongly Agree
5. The material integrates well with other resources and reference materials	4.600	Strongly Agree
6. The content is logically organized and structured	5.000	Strongly Agree
7. The material includes a sufficient number of examples and illustrations to clarify concepts.	4.600	Strongly Agree
8. The concept is unbiased and free from any form of discrimination or stereotyping.	4.600	Strongly Agree
9. The content provides opportunities for critical thinking and application.	4.800	Strongly Agree
10. The material includes diverse perspectives and addresses a variety of learning styles.	4.800	Strongly Agree
AVERAGE WEIGHTED MEAN	**4.78**	**Strongly Agree**

Legend: *4.21-5.00 - Strongly Agree; 3.41-4.20 – Agree; 2.61-3.40 – Neutral; 1.81-2.60 – Disagree; 1.00-1.80 - Strongly Disagree*

The instructional material in question has undergone a thorough evaluation by a panel of experts, including an Entomologist, a Science major teacher, and an Agriculturist. Their unanimous "strongly agreed" endorsements, reflected in a weighted mean of 5.000, highlight the exceptional quality and effectiveness of the material.

The instructional material has received the highest validation from an Entomologist, a Science major teacher, and an Agriculturist, who all "strongly agreed" on its exceptional quality. They affirmed that the material is meticulously aligned with the curriculum and learning objectives, ensuring that it supports and enhances educational standards. Additionally, they highlighted that the content includes up-to-date information and examples, which significantly boost its relevance and accuracy. Furthermore, the experts praised the logical organization and structure of the content, making it easy to follow and understand. This strong endorsement from such esteemed professionals underscores the material's excellence and effectiveness in educational settings.

The strong endorsements from these diverse and specialized experts, quantified by a weighted mean of 5.000, underscore the instructional material's superior alignment with educational goals, its inclusion of current and relevant content, and its clear and logical structure. This high level of validation confirms its effectiveness and value in enhancing learning experiences.

USABILITY AND ACCEPTABILITY

STATEMENTS	WM	INTERPRETATION
1. The layout and design of the material are clear and visually appealing.	4.400	Strongly Agree
2. The organization of the content makes it easy to find specific information.	4.600	Strongly Agree
3. The material loads quickly and functions smoothly without technical issues.	4.800	Strongly Agree
4. The color contrast and font size used in the material are appropriate and enhance readability.	4.800	Strongly Agree
5. The material is eco-friendly.	5.000	Strongly Agree
6. The design and layout are consistent throughout the material.	5.000	Strongly Agree
7. The material is accessible to learners with disabilities.	4.800	Strongly Agree
8. The material is free of technical glitches (missing information, unclear data and etc.).	4.800	Strongly Agree
9. The material provides adjustable settings (e.g., text size, background color) to cater to difference users preferences.	4.000	Agree
10. I would recommend this material to others.	4.800	Strongly Agree
AVERAGE WEIGHTED MEAN	**4.700**	**Strongly Agree**

Legend: *4.21-5.00 - Strongly Agree; 3.41-4.20 – Agree; 2.61-3.40 – Neutral; 1.81-2.60 – Disagree; 1.00-1.80 - Strongly Disagree*

An Entomologist, a Science major teacher, and an Agriculturist have given the highest validation to the material, each "strongly agreeing" on its eco-friendliness and consistent design and layout. This unanimous endorsement is evidenced by a weighted mean score of 5.000 for these criteria. The experts emphasized the material's environmental sustainability and the uniformity in its design, both of which significantly enhance its usability and aesthetic appeal.

However, the lowest rating from the validators was attributed to the adjustable settings feature, such as text size and background color, which received a weighted mean of 4.000, corresponding to an "agree" description. This lower rating is mainly due to the customized alternative instructional materials being subdivided into four distinct sections: microscope specimens, insects, tree barks, and the layers of soil. Each section necessitates specific and detailed visual representations, which may have constrained the feasibility of incorporating adjustable settings without compromising the integrity and clarity of the visual content.

IV. CONCLUSION

The project "Enhancing Laboratory Learning: Crafting Customized Supplementary Instructional Materials" aims to improve the quality and effectiveness of laboratory education by creating tailored instructional resources. Laboratories play a crucial role in science and technical education by providing practical experiences that reinforce theoretical knowledge and develop critical thinking and problem-solving skills. However, the reliance on standard, generic instructional materials can hinder the full potential of laboratory learning.

This project addresses this issue by developing customized supplementary materials that cater to the specific needs of various laboratory activities across multiple disciplines such as biology, chemistry, physics, engineering, and environmental science. By collaborating with subject matter experts and educators, the project will create diverse resources including interactive simulations, video tutorials, concept maps, worksheets, and hands-on activities. These materials will undergo rigorous evaluation and refinement to ensure their effectiveness.

The project's objectives include creating instructional materials with real-life models in agroforestry, enhancing the learning experience of students and faculty, increasing retention and comprehension through hands-on experiences, and fostering environmental stewardship. The methodology involves a needs analysis and the use of quantitative research through surveys to gather data on teaching effectiveness, laboratory activities, and facilities. The customized materials will be validated by experts and tailored to address identified root causes of learning challenges.

The results indicate that while students are generally satisfied with the teaching effectiveness, as evidenced by the high rankings for teachers' ability to integrate real-world examples and maintain a positive learning environment, there is a neutral to negative perception of the laboratory activities and facilities. Students feel that laboratory activities do not fully engage them or develop their critical thinking skills, and the laboratory facilities are often inadequate, lacking sufficient equipment, accessibility, and technical support.

In conclusion, the project highlights the need for customized instructional materials to enhance laboratory learning. By addressing the specific needs of different disciplines and improving laboratory resources and support, the project aims to create more engaging and effective learning environments. This approach not only enriches students' educational experiences but also helps them develop essential skills and a deeper understanding of scientific concepts.

REFERENCES

1. Anderson, L. W. (2016). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman. https://www.researchgate.net/publication/235465787_A_Taxonomy_for_Learning_Teaching_and_Assessing_A_Revision_of_Bloom's_Taxonomy_of_Educational_Objectives
2. Bennett, J., & O'Neale, K. (2018). Barriers to Effective Teaching in Laboratories. Journal of Science Education and Technology, 27(4), 1-10. https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.18843%2Frwjasc%2Fv8i3%281%29%2F08?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19
3. Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning. Educational Psychologist, 26(3-4), 369-398. https://doi.org/10.1080/00461520.1991.9653139
4. Hofstein, A., & Lunetta, V. N. (2004). The Laboratory in Science Education: Foundations for the Twenty-First Century. Science Education, 88(1), 28-54. https://doi.org/10.1002/sce.10106