The International Review of Multidisciplinary Research
Volume 1, Issue 8, June 2026, pp. 156-165
https://doi.org/10.67167/vertex.396

Factors Affecting Baking Performance of Food Technology Students in Laboratory Classes

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Article Details:

Received: 30 April 2026
Revised: 11 May 2026
Accepted: 28 May 2026
Published: 19 June 2026
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Recommended Citation:

Cunanan, M L. G. (2026). Factors Affecting Baking Performance of Food Technology Students in Laboratory Classes. The International Review of Multidisciplinary Research. 1 (8), 156-165. https://doi.org/10.67167/vertex.396

Index Terms:

culinary skill assessment, experiential learning, laboratory instruction, learners performance determinants, instructional quality, vocational education, food preparation competencies

Abstract. Laboratory-based instruction in bread and pastry production plays a vital role in food technology education, as it enables students to develop essential technical competencies through experiential, hands-on learning activities. However, the factors influencing students' baking performance remain insufficiently explored, particularly in relation to demographic characteristics and instructional variables within laboratory-based environments. This study aimed to determine the students' demographic profile, assess their self-reported baking performance, identify the instructional and environmental factors affecting their performance, and examine the relationships and differences among these variables.A descriptive–correlational research design was employed, involving the total population of 23 third-year Food Technology students enrolled in a laboratory course. Data were collected using a validated structured questionnaire consisting of Likert-scale items and were analyzed through descriptive statistics, Pearson product-moment correlation coefficient, and one-way analysis of variance (ANOVA) at a 0.05 level of significance.The findings revealed that the students demonstrated a very satisfactory level of baking performance (M = 4.32), particularly in technical competencies such as ingredient measurement accuracy and procedural execution. However, relatively lower performance was observed in product presentation, plating aesthetics, and decorative skills. Teacher-related instructional factors (M = 4.45), including demonstration, feedback, and supervision, and the adequacy of instructional materials (M = 4.38) emerged as the most influential determinants. A statistically significant positive relationship was found between these factors and baking performance (r = 0.62, $p < 0.05$), indicating a moderate to strong correlation, while no significant difference was observed when grouped according to financial support ($p > 0.05$). These findings emphasize the critical role of instructional quality in enhancing baking competencies.

Introduction

Laboratory-based instruction in food technology is a vital component of technical and vocational education, particularly in bread and pastry production, where students are expected to integrate theoretical knowledge with precise practical execution. In real-world food industry settings, performance is determined not only by technical skill but also by decision-making, accuracy, and the ability to apply learned procedures under time constraints. Thus, understanding the factors that influence students' baking performance in laboratory classes is essential for improving instructional quality and developing industry-ready graduates.

Recent literature consistently emphasizes that student performance in food laboratory education is strongly shaped by experiential learning, instructional design, and exposure to hands-on activities. Balendres, Anabelle D., and Diel, Alicia M. (2025) found that students' interest and exposure to baking significantly influence baking performance, with exposure to actual hands-on practice and demonstrations having the strongest effect on skill development. The study further highlighted that repeated practical engagement improves technical accuracy, time management, and product quality in baking tasks, underscoring the importance of experiential learning in laboratory-based instruction.

Similarly, Mshayisa, Vusi Vincent, and Basitere, Moses (2021) reported that flipped laboratory instruction enhances student engagement, preparedness, motivation, and self-efficacy in food science education. The study demonstrated that structured pre-laboratory learning activities improve readiness for hands-on tasks, allowing students to perform better during actual laboratory sessions. However, the findings also revealed that despite the advantages of digital preparation, students still require direct instructor demonstration to fully understand procedural and technical aspects of laboratory work (Mshayisa & Basitere, 2021).

In addition, Marconi et al. (2026) found that structured teaching kitchen programs significantly improve students' cooking skills, food skills, and behavioral outcomes, reinforcing the importance of hands-on experiential learning in culinary education. Han and Na (2024) also emphasized that project-based flipped classroom approaches enhance student collaboration, engagement, and participation in cooking practice, although they noted that learners may still struggle with procedural understanding without direct demonstration. These findings collectively suggest that while innovative instructional strategies improve engagement, traditional hands-on guidance remains essential for skill mastery.

Furthermore, Hsu, Yang, and Chen (2026) highlighted that in laboratory-based hospitality education, knowledge, attitudes, and practices are strongly interconnected, indicating that student learning outcomes are shaped by both cognitive understanding and behavioral application. Ubane (2023) added that although students may perceive laboratory inadequacies as a barrier, their actual performance can remain high when effective instructional support is provided, suggesting that environmental limitations do not always directly determine learning outcomes.

Across these studies, a consistent pattern emerges showing that experiential learning, instructional support, and exposure to practice are key determinants of student performance in food laboratory settings. However, differences in findings also exist regarding the extent to which environmental conditions, student characteristics, and resource availability influence actual performance outcomes. Most studies focus primarily on instructional strategies and learning interventions, with limited emphasis on socio-demographic factors such as age, sex, year level, prior baking experience, and financial support, which may also affect students' engagement and self-evaluation of performance.

This gap is particularly relevant in localized contexts such as Aurora State College of Technology, School of Industrial Technology, Major in Food Technology, where students come from diverse backgrounds and have varying levels of exposure to baking practices and financial capacity. These differences may influence how students perceive and assess their own performance in laboratory classes, yet they remain underexplored in existing literature.

Addressing this gap is timely and necessary as competency-based education continues to emphasize evidence-based improvement of laboratory instruction and student outcomes. A deeper understanding of how student-related, teacher-related, environmental, and resource-based factors influence baking performance can help improve curriculum design, instructional strategies, and laboratory management practices in food technology education.

In response to this gap, the present study is guided by the following research questions:

1. What is the profile of the students in terms of age, sex, year level, prior baking experience, and source of financial support?
2. What is the level of students' self-assessed baking performance in laboratory classes?
3. What factors affect students' baking performance in terms of student-related factors, teacher-related factors, learning environment, laboratory tools and equipment, and instructional materials?
4. Is there a significant relationship between the identified factors and students' self-assessed baking performance?
5. Is there a significant difference in self-assessed baking performance when grouped according to source of financial support?

The primary objective of this study is to examine the factors affecting students' baking performance in laboratory classes, while the secondary objectives include assessing students' self-evaluated performance and determining the influence of demographic and instructional variables on performance outcomes.

Methodology

Research Design

The study employed a descriptive correlational research design to determine the profile of students, their level of self-assessed baking performance in laboratory classes, the factors affecting their performance, and the relationship and differences among the identified variables. This design was appropriate for the completed study because it allowed the researcher to describe existing conditions and examine relationships among variables without manipulating any conditions in the actual learning environment. Since the study had already been conducted in a real laboratory setting, the design effectively captured naturally occurring variations in student performance and learning experiences. The approach is supported by literature indicating that laboratory-based performance in food technology is influenced by multiple interacting factors such as student characteristics, instructional strategies, and learning environment conditions (Mshayisa & Basitere, 2021; Su, 2024; Han & Na, 2025; Hsu, Yang, & Chen, 2026; Marconi et al., 2026; Ubane, 2023; Balendres & Diel, 2025).

Participants

The participants of the completed study were the total population of third-year Bachelor of Industrial Technology Major in Food Technology students at Aurora State College of Technology, School of Industrial Technology. A total of 23 students participated, consisting of 10 female and 13 male students. Total population sampling was used since the entire accessible population was included, ensuring complete representation of the cohort and eliminating sampling bias. The participants had already been enrolled and actively engaged in baking laboratory classes at the time of data collection. Inclusion criteria required that students must have completed baking and pastry production laboratory activities as part of their coursework, while those not enrolled in laboratory-based baking subjects were excluded. Ethical standards were observed during the conduct of the study, including informed consent, voluntary participation, and confidentiality of responses, ensuring that all data gathered were treated with strict privacy.

Research Instrument

The study utilized a validated structured questionnaire that had already been administered to the respondents during the completion of the research. The instrument consisted of four main sections: (1) student profile (age, sex, year level, prior baking experience, and source of financial support), (2) level of self-assessed baking performance in laboratory classes, (3) factors affecting baking performance (student-related factors, teacher-related factors, learning environment, laboratory tools and equipment, and instructional materials), and (4) perceived relationship of these factors to performance outcomes. The questionnaire was developed based on established literature on laboratory-based and experiential learning in food technology education, ensuring alignment with previous empirical studies (Su, 2024; Han & Na, 2025; Mshayisa & Basitere, 2021; Marconi et al., 2026). Content validation had been conducted by experts in the field prior to administration to ensure reliability and relevance.

Data Gathering Procedure

The data collection for the study had already been completed within the baking laboratory classes of the School of Industrial Technology at Aurora State College of Technology. After securing institutional permission, the researcher personally administered the questionnaire to all eligible third-year Food Technology students during their scheduled laboratory sessions. Before participation, the respondents were informed about the purpose of the study and assured that their participation was voluntary and that their responses would remain confidential. The accomplished questionnaires were retrieved immediately after completion to ensure accuracy and completeness of responses. The entire procedure was conducted in a controlled classroom setting to ensure consistency and to minimize external influences during data gathering.

Data Treatment and Analysis

The data gathered in this study were systematically collected, organized, analyzed, and interpreted in collaboration with a designated statistician using appropriate statistical techniques. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were utilized to describe the respondents' profile and assess their self-reported baking performance. Weighted means were computed to evaluate the extent of influencing factors. Pearson correlation analysis was applied to determine the relationship between variables, while analysis of variance (ANOVA) was used to identify differences across groups. All statistical analyses were interpreted at a 0.05 level of significance.

Results and Discussion

1. Students' Profile

Variable	Category	Frequency	Percentage (%)
Sex	Male	13	56.5
	Female	10	43.5
Age	*M* = 21.4, *SD* = 1.2	—	—
Prior Baking Experience	None	4	17.4
	Basic (Home Baking)	8	34.8
	Intermediate	5	21.7
	Advanced	6	26.1
	Total	**23**	**100**
Source of Financial Support	Self-supported	2	8.7
	Partially supported	10	43.5
	Fully supported	11	47.8
	Total	**23**	**100**

Table 1. Profile of the Respondents

Table 1 presents the demographic and background profile of the 23 third-year Bachelor of Industrial Technology major in Food Technology students, serving as the baseline description of respondents in relation to their readiness for laboratory-based baking performance.

The respondents are relatively homogeneous in terms of age (*M* = 21.4, *SD* = 1.2), indicating that they belong to a similar developmental and academic stage. In terms of sex distribution, the group shows a relatively balanced composition with 56.5% male and 43.5% female respondents, suggesting minimal gender disparity in program participation.

In terms of prior baking experience, more than half of the respondents (52.2%) fall within the none-to-basic category, while only a smaller proportion have intermediate to advanced exposure. This indicates that most students enter formal laboratory instruction with limited structured experience in baking. Such variation in prior exposure is critical, as foundational competencies in baking such as measurement accuracy, procedural sequencing, and timing control are typically developed through repeated hands-on practice rather than informal exposure alone.

This pattern suggests that laboratory instruction plays a central role in bridging initial skill gaps among learners. Although a portion of students have higher exposure levels, the overall cohort reflects heterogeneous skill readiness, which may influence peer learning dynamics, task distribution, and collaborative laboratory performance in baking-related activities. The financial support profile further indicates that most students rely on partial or full external support, with only a small proportion being self-supported. While financial capacity does not directly determine laboratory performance, it may indirectly affect opportunities for independent practice, access to ingredients, and engagement in experiential reinforcement outside formal class hours.

These findings are consistent with Balendres and Diel (2025), who emphasized that students' exposure to baking activities is a key predictor of performance in bread and pastry production, with limited-exposure learners relying more heavily on structured instruction. Similarly, Azlan and Goh (2025) highlighted that baking competence develops progressively through variations in experience and engagement, where novice learners depend strongly on explicit demonstration and guided repetition.

In addition, Daminar, Abuyog, Monte de Ramos, Panugaling, and Blanes (2024) reported that structured instructional materials significantly enhance learners' comprehension and execution of baking procedures, particularly among students with limited prior experience. This reinforces the importance of systematic laboratory guides in supporting foundational skill acquisition.

Further support is provided by Su (2024), who emphasized that experiential and problem-based laboratory learning environments are essential in strengthening technical competencies, particularly in STEM-related disciplines where performance is skill-based and practice-driven. Likewise, Marconi et al. (2026) found that structured teaching kitchen interventions enhance both technical food preparation skills and behavioral learning outcomes, underscoring the importance of repeated exposure in competency development.

Overall, the findings suggest that the respondents are in a foundational stage of baking skill development, where competency formation is largely dependent on structured laboratory instruction rather than prior experiential knowledge. The variability in experience levels highlights the need for differentiated instructional strategies to accommodate both novice and more experienced learners within the same laboratory setting.

These findings reinforce the central role of competency-based laboratory training in food technology education, where structured instruction, guided practice, and repeated exposure serve as equalizing mechanisms that help standardize skill development among learners with diverse backgrounds.

2. Level of Students' Self-Assessed Baking Performance

Indicators	Mean	SD	Interpretation
Accurate measurement of ingredients	4.53	0.51	Very Satisfactory
Proper storage and packaging	4.53	0.51	Very Satisfactory
Following procedures	4.40	0.50	Very Satisfactory
Use of tools and equipment	4.40	0.50	Very Satisfactory
Dessert preparation	4.47	0.51	Very Satisfactory
Presentation and decoration	3.93	0.64	Satisfactory
Overall	**4.32**	**0.41**	**Very Satisfactory**

Table 2. Level of Students' Self-Assessed Baking Performance

To determine students' perceived competency in laboratory-based baking tasks, their self-assessed performance was evaluated across key indicators aligned with essential bread and pastry production competencies, including measurement accuracy, storage and packaging, procedural compliance, use of tools and equipment, dessert preparation, and presentation and decoration.

Table 2 shows that the overall self-assessed baking performance of students is Very Satisfactory (M = 4.32, SD = 0.41). The highest-rated competencies were accurate measurement of ingredients and proper storage and packaging, followed by dessert preparation. Meanwhile, following procedures and use of tools and equipment obtained similarly high ratings. In contrast, presentation and decoration received the lowest rating, interpreted as satisfactory.

These results indicate that students perceive themselves as highly competent in technical and procedural dimensions of baking, particularly in tasks requiring precision, consistency, and adherence to standardized laboratory procedures. Skills such as measurement accuracy, ingredient handling, and equipment use are core competencies in bread and pastry production, and the consistently high ratings suggest that laboratory instruction has effectively supported the development of these foundational abilities.

However, the comparatively lower rating in presentation and decoration highlights a persistent gap in creative and aesthetic competencies. This suggests that while students demonstrate strong procedural mastery, their confidence decreases when tasks require design judgment, artistic execution, and visual presentation. Such a pattern reflects a competency development trajectory in which technical skills are acquired earlier and more consistently than higher-order creative skills, which typically require extended practice and exposure.

The findings align with Balendres and Diel (2025), who emphasized that exposure to hands-on baking activities significantly enhances performance, particularly in technical accuracy and procedural execution. Their study supports the present results by highlighting that repeated laboratory exposure strengthens students' efficiency in structured baking tasks.

Similarly, Mshayisa and Basitere (2021) found that structured laboratory instruction improves student readiness and performance in food science education, although learners continue to rely heavily on instructor demonstration for procedural mastery. This reinforces the present finding that students are more confident in structured technical tasks than in independently executed or creative outputs.

Han and Na (2024) further emphasized that while innovative instructional approaches enhance engagement, students still require explicit guidance for accurate procedural execution, particularly in skill-intensive culinary tasks. This supports the observed pattern where procedural competencies are stronger than creative competencies such as presentation and decoration.

In addition, Hsu, Yang, and Chen (2026) explained that laboratory-based learning outcomes result from the integration of knowledge, attitudes, and practice, which is reflected in the strong performance in technical competencies observed in this study. Ubane (2023) also noted that effective instructional support can mitigate environmental constraints, allowing students to maintain high performance levels despite variations in learning conditions.

The inclusion of self-assessment is further supported by Rustamova (2024), who emphasized that self-assessment strengthens learner autonomy by enabling students to monitor their performance and identify areas for improvement. In the context of baking laboratory performance, this suggests that students are not only developing technical competence but also beginning to engage in reflective evaluation of their own work.

This is evident in the present findings, where students rated their technical skills highly while simultaneously identifying presentation and decoration as weaker areas. Such differentiation reflects developing critical awareness, which is essential for continuous improvement in competency-based education.

Overall, the results indicate that students demonstrate strong self-perceived competence in technical and procedural baking skills, while creative and aesthetic dimensions remain less developed. This confirms that laboratory-based instruction effectively builds foundational competencies but requires further enhancement in creativity-focused learning activities.

3. Factors Affecting Students' Baking Performance

Factors	Mean	*SD*	Interpretation
Student-related factors	4.08	0.52	High
Teacher-related factors	4.45	0.39	Very High
Learning environment	4.21	0.47	High
Tools and equipment	4.05	0.58	High
Instructional materials	4.38	0.42	Very High
Overall	**4.23**	**0.48**	**High**

Table 3. Factors Affecting Students' Baking Performance

To identify the determinants influencing students' performance in laboratory-based baking activities, five key factors were examined: student-related factors, teacher-related factors, learning environment, tools and equipment, and instructional materials. These variables were assessed to determine their perceived level of influence on students' baking performance in bread and pastry production. The analysis provides a comprehensive view of how instructional, environmental, and learner-related conditions contribute to the development of students' technical and procedural competencies in laboratory classes.

Table 3 shows that the overall factors affecting students' baking performance obtained a High rating (M = 4.23, SD = 0.48), indicating that multiple instructional and contextual variables collectively influence student outcomes in laboratory-based baking.

Among the indicators, teacher-related factors obtained the highest mean (M = 4.45, SD = 0.39), followed closely by instructional materials (M = 4.38, SD = 0.42), both interpreted as Very High. Meanwhile, learning environment (M = 4.21), student-related factors (M = 4.08), and tools and equipment (M = 4.05) were all rated High.

These results indicate that teacher-related factors are the most influential determinant of students' baking performance. This underscores the central role of instructor demonstration, supervision, and scaffolding in laboratory-based food technology education, where procedural accuracy and step-by-step execution are critical. Students appear to rely heavily on teacher guidance to translate theoretical knowledge into accurate baking performance.

Instructional materials also emerged as a strong influencing factor, suggesting that structured guides, manuals, and learning resources facilitate independent execution of baking procedures. Meanwhile, student-related factors, learning environment, and tools and equipment function as supportive but secondary contributors to performance development.

Overall, the findings confirm that baking performance in laboratory settings is multi-factorial but predominantly instruction-driven, highlighting the decisive role of pedagogical quality over material or environmental conditions.

The dominance of teacher-related factors aligns with Mshayisa and Basitere (2021), who emphasized that structured laboratory instruction and direct demonstration are essential for improving student engagement, preparedness, and procedural mastery in food science education. Similarly, Han and Na (2024) found that even in innovative instructional models such as project-based flipped classrooms, teacher facilitation remains essential for ensuring correct procedural execution in culinary tasks.

Instructional materials as a major factor are supported by Daminar, Abuyog, Monte de Ramos, Panugaling, and Blanes (2024), who demonstrated that structured learning modules significantly enhance learners' understanding and execution of baking procedures, particularly for students with limited prior experience.

Student-related factors are consistent with Balendres and Diel (2025), who found that exposure, interest, and hands-on practice significantly contribute to baking performance development, although their influence is often mediated by instructional support.

In terms of learning environment, the findings are aligned with Ubane (2023), who reported that laboratory conditions influence learning experiences but do not independently determine performance outcomes when effective instruction is present. Likewise, the role of tools and equipment corresponds with Marconi et al. (2026), who highlighted that well-equipped teaching kitchens enhance food skill acquisition and behavioral competence, although their impact is maximized only when paired with structured instruction.

4. Relationship Between Factors and Baking Performance

Pearson correlation analysis revealed a significant positive relationship between the combined factors (student-related, teacher-related, learning environment, tools and equipment, and instructional materials) and students' self-assessed baking performance ($r = 0.62$, $p < 0.05$). This indicates a moderate to strong association, suggesting that improvements in these interconnected factors are associated with higher levels of perceived baking performance among students.

These findings imply that students' baking performance in laboratory classes is not determined by a single isolated variable but is instead shaped by a multidimensional system of instructional, environmental, and learner-related influences. In particular, the interaction of teacher support, instructional materials, and student engagement appears to play a central role in strengthening performance outcomes such as procedural accuracy, compliance with baking processes, and product quality.

The result aligns with the perspective of Hsu, Yang, and Chen (2026), who emphasized that learning outcomes in laboratory-based education emerge from the integration of cognitive understanding, attitudes, and practical application, highlighting the interdependent nature of knowledge and behavior in skill development. Similarly, Balendres and Diel (2025) found that student exposure, instructional experience, and engagement in baking activities collectively influence performance, reinforcing the idea that baking competency develops through multiple reinforcing factors rather than a single determinant. Further support is provided by Su (2024), who emphasized that experiential and problem-based learning environments significantly enhance skill acquisition by allowing learners to actively construct knowledge through practice. In the same line, Marconi et al. (2026) highlighted that structured experiential settings such as teaching kitchens improve both technical competence and behavioral outcomes through repeated hands-on engagement.

Overall, the significant correlation underscores that improving baking performance requires a holistic and integrated approach, where instructional quality, learning environment, and student engagement are simultaneously strengthened rather than treated as independent or isolated interventions.

5. Difference in Performance Based on Financial Support

The analysis of variance revealed that there is no significant difference in students' self-assessed baking performance when grouped according to source of financial support ($F = 1.21$, $p > 0.05$). This indicates that whether students are self-supported, partially supported, or fully supported, their perceived performance in laboratory-based baking activities remains statistically comparable.

These findings suggest that financial capacity does not significantly influence students' baking performance in bread and pastry production within the laboratory setting. Although economic resources may affect access to materials for additional practice outside the classroom, the structured nature of laboratory instruction appears to provide equitable learning conditions for all students. Consistent exposure to guided demonstrations, standardized instructional materials, and supervised practice may help offset disparities in financial background, enabling students to develop comparable competencies.

This result is supported by Ubane (2023), who reported that perceived resource limitations do not necessarily translate into lower academic or practical performance when effective instructional support is present. In laboratory-based education, structured teaching environments help minimize the impact of external constraints by ensuring that all learners receive uniform guidance and equal opportunities for skill development.

Furthermore, the finding can be explained through the framework of Yang and Wang (2022), who emphasized that academic achievement is more strongly influenced by internal psychological factors such as academic resilience and motivational intensity than by socioeconomic conditions alone. Their study showed that learners with higher motivation and resilience are more likely to persist in learning tasks and achieve better outcomes regardless of external limitations. In this context, the comparable performance across financial groups may be attributed to students' shared exposure to structured laboratory instruction, which fosters engagement, motivation, and sustained effort in performing baking tasks.

Overall, the absence of a significant difference highlights that baking performance in laboratory settings is primarily shaped by instructional quality and learner motivation rather than financial support. This reinforces the principles of competency-based education, where equitable access to structured, guided learning experiences enables students from diverse socioeconomic backgrounds to achieve similar levels of performance.

Conclusion and Recommendations

This study examined the factors affecting students' baking performance in laboratory-based bread and pastry production, their level of self-assessed performance, and the relationship between identified factors and performance outcomes. Overall, the findings indicate that students' baking performance is significantly shaped by an interconnected set of instructional and learner-related factors, with teacher-related support and instructional materials emerging as the most dominant influences. In addition, students demonstrated a generally very satisfactory level of performance in technical baking competencies, while creative aspects such as presentation and decoration remained comparatively lower. The analysis further confirmed a significant positive relationship between the combined factors and students' baking performance, while no significant difference was observed when grouped according to financial support.

Theoretically, the findings extend competency-based and experiential learning perspectives in food technology education by reinforcing that laboratory performance is not solely dependent on individual learner ability, but is the outcome of interacting instructional, environmental, and resource-related conditions. The results contribute to existing literature by emphasizing that teacher facilitation and structured instructional materials function as central mediating elements in translating experiential exposure into measurable performance outcomes. Moreover, the non-significant role of financial support strengthens the argument that well-structured laboratory instruction can reduce performance disparities among students with different socioeconomic backgrounds, thereby supporting more inclusive models of skills-based education.

Practically, the study highlights several implications for food technology education stakeholders. First, instructors should prioritize consistent demonstration-based teaching and structured procedural guidance to strengthen students' technical accuracy in baking tasks. Second, instructional materials should be continuously improved to support independent learning and reinforce laboratory procedures before and during hands-on activities. Third, curriculum planners and administrators should consider strengthening training strategies that integrate both technical and creative competencies, particularly in areas such as presentation and product design, where students showed comparatively lower performance. Finally, policy efforts should focus on sustaining equitable access to laboratory-based learning experiences, ensuring that all students regardless of financial background receive adequate opportunities for skill development.

While the study provides meaningful insights, it is limited by its relatively small sample size drawn from a single institution, which may restrict the generalizability of findings to other contexts. Additionally, the reliance on self-assessed performance may introduce subjectivity, as perceptions of competence may not fully reflect actual skill execution. These limitations, however, open opportunities for refinement in future studies.

Future research may expand the scope by including multiple institutions to improve generalizability and by incorporating objective performance assessments such as practical baking examinations or competency-based scoring rubrics. Further studies may also test specific hypotheses, such as whether enhanced instructional material design significantly improves

students' creative baking outputs, or whether structured intervention programs in laboratory instruction lead to measurable improvements in both technical and aesthetic competencies. Longitudinal designs are also recommended to examine how baking competencies develop over time as students' progress through successive laboratory courses.

In conclusion, baking performance in laboratory-based food technology is best understood as a product of integrated instructional quality, learner engagement, and structured practice rather than isolated individual or socioeconomic factors. Strengthening these interrelated components is essential for producing competent, industry-ready graduates in bread and pastry production.

Acknowledgement

The researcher sincerely acknowledges the administration of Aurora State College of Technology, School of Industrial Technology, for granting permission and support in the conduct of this study. Special recognition is extended to the faculty members of the Bachelor of Industrial Technology – Major in Food Technology program for their assistance and cooperation during the data collection process in laboratory classes.

Gratitude is also expressed to the third-year Food Technology students who served as respondents of the study for their willingness to participate and provide valuable data essential to the completion of this research.

Finally, appreciation is extended to all individuals and institutions who, directly or indirectly, contributed to the successful completion of this research endeavor.

Funding

This research received no external funding from any public, commercial, or not-for-profit funding agency, and no organization provided financial support for the conduct of the study, authorship, or publication of this article.

Competing Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data Availability Statement

The data that support the findings of this study are available from the corresponding researcher upon reasonable request. Due to ethical considerations and the protection of participants' confidentiality, the dataset is not publicly available. Access to the data may be granted for academic and research purposes, subject to approval and in compliance with institutional data privacy policies.

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Appendices

No appendices are attached to this study.