Contextualizing mathematics through agriculture: examining the effects on students' proficiency levels in probability

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ABSTRACT

This study examined the effects of contextualized lessons using agricultural concepts on the level of proficiency of Grade 8 students in probability. The study employed a triangulation method by gathering data through the pretest and posttest results, students' perceptions, and the teacher's reflections. A total of 36 students whose families engaged in agricultural activities were purposefully chosen and were categorized into four proficiency levels: advanced proficient, proficient, approaching proficient, and developing proficient, based on their average grades in mathematics from the first and second quarters. The intervention employed contextualized lessons that integrated agricultural concepts to facilitate the teaching of probability to a group with varied proficiency levels. The findings revealed a significant improvement in students' performance between the pretest and posttest across all proficiency levels. However, the developing proficient group encountered challenges, particularly with simplifying fractions, affecting their overall performance. This study concludes that while contextualizing mathematics using agriculture improves students' engagement, performance, and understanding of probability, students with lower proficiency levels require additional support with mastering fractions skills. Therefore, this study suggested that teachers integrate practical, real-world contexts, like agricultural concepts, and acknowledge its varying effects on students depending on their proficiency levels.

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1. INTRODUCTION

Contextualization is a variety of instructional strategies developed to connect the acquisition of fundamental skills to academic or professional content, emphasizes concrete applications in a particular context that interest learners, connecting the curriculum to a particular setting, situation, or field, making the competencies meaningful for all students [1]–[3]. In mathematics education, contextualization involves presenting mathematical concepts in a real-world situation, making the learning process more meaningful and relevant to students. It also enhances their problem-solving skills and the transfer of learning [4]–[6] and is recommended for developing critical thinking and problem-solving skills, particularly for kinesthetic learners [7]. Research in mathematics education indicates that contextualization enhances students' understanding by engaging them in real-life contexts [8], improves students' performance in mathematics [9]–[12], and enhances their conceptual understanding and problem-solving skills [13], [14].

The Philippine K to 12 curriculum stresses the importance of contextualization and localization in teaching and learning [15]. Regular curriculum monitoring is imposed to ensure appropriate management of mathematics education in the country. Republic Act 1053 mandates the adherence to standards and principles in curriculum development that emphasize contextualization, global perspectives, and cultural sensitivity, allowing schools to modify and enhance curricular offerings to align with educational and social contexts [16]. Hence, developing and revising locally made educational resources are necessary, encouraging teachers to contextual lessons to improve learning outcomes.

In mathematics, students often face difficulties when solving probability problems. These difficulties include understanding the problems, choosing the right strategies, completing the calculation processes, errors arising from misidentifying unknowns, misconceptions about probability, and mistakes in arithmetic operations [17], [18]. Moreover, students commit four concept errors in probability problem-solving: interpreting questions, proving theorems, understanding Bayes rules, and calculating event probability [19], as well as errors in selecting the appropriate formula to solve the problems, understanding what is being asked, and determining the events [20].

Elementary and junior high school teachers recognized that integrating agriculture into the classroom offers situatedness, connectedness, authenticity, and hands-on learning through real-life experiences and concrete examples [21]. Agricultural education equips students with practical skills, including problem-solving, critical thinking, teamwork, leadership, and entrepreneurship, which are beneficial across various careers [22]. Integrative agricultural education demonstrates the interdependence of knowledge and skills through real-world applications, promoting survival skills alongside using mathematical concepts [23]. Research supports the integration of agricultural concepts to enhance students' understanding of farming practices and sustainability issues and improve problem-solving skills and cultural awareness [24]–[27]. Schools must continue to expose students to agriculture in various ways, as this knowledge is essential for understanding agriculture and developing basic gardening skills [28].

In rural areas, where agriculture is a key component of the local economy, contextualizing lessons is essential as students in these areas are introduced to farming activities at an early age because of the active involvement of their parents and relatives in agriculture [29]. Farming becomes integral to their lives as these students help plant, harvest, and care for animals. Contextualizing mathematics using agriculture helps connect mathematical concepts to the student's experiences. Incorporating agricultural concepts improved students' engagement and understanding of concepts by making them relevant and applicable to students' lives [30]. Thus, teachers are encouraged to incorporate agricultural concepts to make teaching and learning more relevant to the students' lives and to relate them to mathematical concepts, specifically 'probability.' Githua and Ricketts [31] support this strategy, revealing that students had lower mean in statistics and probability than in algebra and number systems, and by integrating agricultural examples, teachers can help students understand better and relate to the content standards, leading to better mathematics performance. Teachers can enhance student engagement and improve learning outcomes by connecting lessons to practical, real-world contexts, such as agriculture, thereby demonstrating the relevance of mathematics in everyday life [29].

Mathematical proficiency encompasses the skills, knowledge, and experience needed to effectively engage in mathematics through deep understanding, problem-solving, computation, logical reasoning, and active engagement [32]. It is also the ability to comprehend mathematical functions through conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition [33]. Corrêa and Haslam [32] emphasize assessing mathematical proficiency to develop essential mathematical skills and knowledge, informing teaching practices, and facilitating the holistic development of mathematical proficiency. Hence, this study sought to examine the effects of contextualized lessons, which connect mathematical concepts to real-world applications using agricultural concepts, on students' proficiency levels in rural areas where agriculture is significant.

2. METHOD

2.1. Research design

This study employs the triangulation method to examine the effects of contextualized lessons using agriculture on student's proficiency levels in probability. Specifically, a between- or across-method triangulation design was employed as it gathered qualitative and quantitative data in the same study [34]. In this study, the grade 8 students were exposed to an intervention involving the implementation of contextualized probability lessons. Before the intervention, the student's proficiency levels were determined using their grades in mathematics. For the quantitative component, a pretest and posttest were administered using a researcher-made, twenty-item achievement test to measure students' performance before and after the intervention. For the qualitative component, the students completed a perception questionnaire followed by an interview with selected students, and the teacher's reflections were also collected, providing additional qualitative insights that would help better understand the students' performance in probability.

2.2. Research participants

The participants of the study were 36 grade 8 students from a public school in Pantao Ragat, Lanao del Norte, Philippines, during the school year 2023-2024. Agriculture is the backbone of this municipality's local economy, providing a unique context for the study. As the only educational institution offering both junior and senior high school education, the school has a crucial role in shaping the educational landscape of the municipality. Purposive sampling was used to identify the most heterogeneous group of students among six sections of grade 8 students to ensure representation across different proficiency levels and enhance the study's credibility.

The students' proficiency levels were determined using their average grades from the first and second quarters in mathematics 8. Students were categorized into four proficiency levels: advanced proficient, proficient, approaching proficient, and developing proficient. Six students with grades of 90% and above were classified as advanced proficient, eight students with grades of 85% to 89% were classified as proficient, nine students with grades of 80% to 84% were classified as approaching proficient, and thirteen students with grades of 75% to 79% were classified as developing proficient students.

2.3. Data collection

The contextualized lessons were developed using agricultural concepts and evaluated by three expert panels. Following revisions based on the panels' comments and suggestions, the researchers sought permission from the school principal to conduct the study. Also, they obtained consent from the mathematics teacher to access the students' grades from the first two quarters of mathematics to assess their proficiency levels before the intervention. The students were oriented to the study's objectives with the help of the class adviser and the grade 8 mathematics teacher. A twenty-item researcher-made achievement test pretest was administered before the lessons, and scores were recorded. The teacher then implemented the four contextualized lessons for eight sessions, each lasting 50 minutes. At the end of each lesson, the teacher also wrote reflections on challenges, effective strategies, and the overall effectiveness of the lessons. After the intervention, the students answered the same achievement test from the pretest as the posttest. An open-ended perception questionnaire was also administered, followed by interviews with 12 selected students who provided brief answers to further elaborate their answers.

2.4. Data analysis

The Shapiro-Wilk test, commonly used for sample sizes less than 50, was employed to assess the normality of the data, with a p-value of below 0.05, suggesting a non-normal distribution [35]. Levene's test was used to assess the homogeneity of variance across the different proficiency groups and to determine whether the variances were equal [36]. Given that the normality and the homogeneity of variance assumptions were violated, the median score was used to determine the central tendency of the pretest and posttest scores. The Wilcoxon signed rank test, a non-parametric test, was employed to determine statistically significant improvement from the pretest to the posttest across different proficiency levels. This test was selected because of its robustness when the assumption of homogeneity of variance is violated, as it gives a more accurate evaluation of variations in mean gain scores among various levels of proficiency. The students' scores in the pretest and posttest were interpreted based on a predefined range of scores. A student score ranging from 16.8 to 20 was interpreted as 'outstanding', while a score of 15.2 to 16.790 was very 'satisfactory'. Scores between 13.60 and 15.198 were considered 'satisfactory,' and those between 12 and 13.598 were interpreted as 'fairly satisfactory.' Lastly, a score from 0 to 11.98 indicated that the student 'did not meet expectations'.

3. RESULTS AND DISCUSSION

This study contextualized the lessons by integrating agricultural concepts drawn from students' daily experiences to make abstract probability concepts more relevant. This included real-life agricultural scenarios, such as crop planting and harvesting probabilities, as described in Saga and Buan [29]. The lessons were developed following the analysis, design, development, implementation, dan evaluation (ADDIE) instructional model to ensure they were well-structured, student-centered, and applicable to the students' local contexts [29].

Each lesson started with real-life scenarios that were relatable and relevant to the students. Some of these scenarios involve decision-making and connect concepts to real-life situations, such as a farmer deciding whether to plant crops based on the weather forecast and a rice farmer thinking about changing to corn crops because of the market demand. Mathematical prompts guided students in analyzing and understanding the scenarios. After presenting the scenarios, the teacher asked follow-up questions to help students identify essential information in the problems, begin thinking about how to solve them and understand the practical implications of probability. Collaborative learning activities such as think-pair-share and group work further reinforced the application of probability in agriculture. In groups, students worked together to solve problems presented in agricultural scenarios, applying the concepts they had learned. For instance, students worked on an activity requiring them to analyze and categorize farming-related scenarios, such as pest infestations or weather forecasts, by their probability of occurrence. This encourages critical thinking and the practical applications of the learned concepts.

3.1. Comparison of the students' pretest and posttest scores by group ability

To evaluate the effect of the contextualized lessons using agricultural concepts on students' proficiency levels, the Wilcoxon signed rank test was used to determine statistically significant improvements from the pretest to the posttest across different proficiency levels since the Shapiro-Wilk test showed non-normal distributions for both pretest (W (36)=0.928, p=0.022) and posttest (W (36)=0.904, p=0.004). At the same time, Levene's test revealed a violation of the homogeneity of variance assumption (p=0.013). These results justified the use of non-parametric tests.

The analysis, as shown in Table 1, revealed statistically significant improvements in scores from pretest to posttest across all proficiency levels. The results highlight how integrating agriculture into contextualized lessons improves students' performance and understanding of probability. This result is consistent with the findings of Jackaria *et al.* [37], who studied contextualized lesson plans using Simala writing and found that pupils significantly improved their mathematical writing performance, regardless of ability group. This is also consistent with Ferrer-Jarangue [38], whose study revealed that students' mathematics performance improved from 'satisfactory' to 'very satisfactory' and problem-solving skills moved from 'did not meet expectation' to 'outstanding' after exposure to contextualized culture-based instruction. Similarly, Cambaya *et al.* [39] found improvement in the students' problem-solving skills following exposure to contextualized instruction.

Table 1. Comparison of the pretest and posttest scores among groups

Group ability	Test	N	Median	z-value	p-value
Advanced proficient	Pretest	6	6.50	-2.207	0.027*
	Posttest	6	18		
Proficient	Pretest	8	4.50	-2.527	0.012*
	Posttest	8	15		
Approaching proficient	Pretest	9	5	-2.668	0.008*
	Posttest	9	14.50		
Developing proficient	Pretest	13	4	-3.064	0.002*
	Posttest	13	9		

Note: $*p<0.05$

For the advanced proficient group, the median score showed a significant increase from the pretest to the posttest, indicating a shift from "did not meet expectations" to "outstanding" (z=-2.207, p=0.027). Students demonstrated a positive attitude toward the lessons. The real-life examples and scenarios made the lesson meaningful and simplified complex probability concepts, enhancing their enjoyment and understanding of probability. According to Kristidhika *et al.* [40], students find it easier to comprehend abstract concepts when they can relate to the learning content and connect it to their experiences. The agricultural contextual knowledge of the students significantly influenced the students' understanding of mathematical tasks and vice versa [41]. This finding is evident in this study as student A1 mentioned, "the Agricultural scenarios made me understand the topic easier, and I can apply it in real life." Student A5 also stated that "using agricultural scenarios and examples made the lesson easier to understand than just numbers."

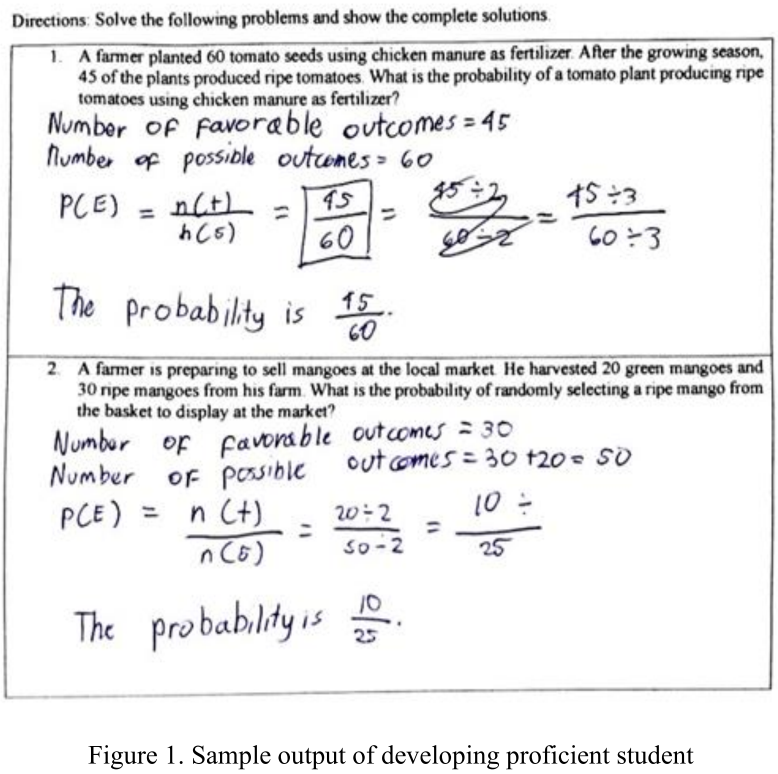
In the teacher's reflections, the teacher emphasized, *"The scenario-based problem helped contextualize probability in a real-world setting relevant to my students. My students engaged in an activity that prompts them to consider situations or examples from their everyday lives."* This statement illustrates contextualizing concepts using agriculture as an effective strategy for enhancing students' understanding and engagement since connecting probability concepts to real-life scenarios made the lessons more meaningful. Enriquez *et al.* [42] found that realistic mathematics education (RME) enhances problem-solving skills and increases student engagement and understanding of concepts by providing meaningful learning experiences in real-life situations. This underscores the significance of integrating real-world applications into probability, fostering deeper understanding among students of varying proficiency levels.

The proficient group also showed a significant improvement, moving from "did not meet expectations" to "very satisfactory" (*z*=-2.527, *p*=0.012). Students in this group shared similar experiences with the advanced proficient group, finding the lessons enjoyable but emphasizing the practicality and real-life application of the concepts. Student P7 remarked, *"It is enjoyable because it is related to real life, and I can use it in the future."* Student P2 also said, *"The examples like farming and harvesting helped us understand the lessons better."* These responses highlighted that the familiar contexts made abstract concepts easier to understand.

There was also a significant increase in the approaching proficient group from "did not meet expectations" to "satisfactory" (z=-2.668, p=0.008). While many of these students expressed enjoyment and found learning probability through agricultural contexts interesting, some encountered difficulties with the mathematical aspects of the lessons. For instance, student AP5 noted, *"Solving probability is a bit challenging because I need to calculate to get the answers and simplify the fraction to the lowest term."* This suggests that while students enjoyed the context, they encountered challenges in performing probability calculations, particularly with fractions. However, the collaborative activities included in the lessons played a significant role in addressing these difficulties. AP1 noted that *"The lessons were interesting because of the group activities. It felt good when we got the answers correctly. They helped me get the correct answer when my answers were wrong."*

The teacher highlighted how the collaborative, think-pair-share, and group activities helped more students feel comfortable and involved. It encouraged all students to participate in the instruction, promoting collaborative learning. The teacher stated, *"The think-pair-share activity motivated my students to participate actively in discussions. I have observed that most students, including those not usually participative in my class, actively participated in the discussions."*

Although the developing proficient group improved from the pretest to the posttest, its posttest performance remained in the "did not meet expectations" category (z=-3.064, p=0.002). Many students in this group reported difficulties with simplifying fractions, echoing the challenges experienced by the approaching proficient group. Figure 1 shows a sample of student output demonstrating an understanding of finding the probability of an event but was unable to simplify its final answer and needed help determining which numbers to divide to simplify the fraction answer. This difficulty is also reflected in their responses to the perception questionnaire. For example, D1 stated, *"I do not like fractions; it was hard,"* and D9 noted, *"I find it hard to solve because of the fraction."* While some students in the approaching proficient group managed to overcome these challenges through peer support, most students in the developing proficient group struggled despite engaging in group work. Only a few students recognized the benefit of collaborating with other students.


Directions: Solve the following problems and show the complete solutions.

1. A farmer planted 60 tomato seeds using chicken manure as fertilizer. After the growing season, 45 of the plants produced ripe tomatoes. What is the probability of a tomato plant producing ripe tomatoes using chicken manure as fertilizer?

Number of favorable outcomes = 45
Number of possible outcomes = 60

$P(E) = \frac{n(E)}{n(S)} = \boxed{\frac{45}{60}} = \cancel{\frac{45 \div 2}{60 \div 2}} = \frac{45 \div 3}{60 \div 3}$

The probability is $\frac{45}{60}$.

2. A farmer is preparing to sell mangoes at the local market. He harvested 20 green mangoes and 30 ripe mangoes from his farm. What is the probability of randomly selecting a ripe mango from the basket to display at the market?

Number of favorable outcomes = 30
Number of possible outcomes = 30 + 20 = 50

$P(E) = \frac{n(E)}{n(S)} = \frac{20 \div 2}{50 \div 2} = \frac{10 \div}{25}$

The probability is $\frac{10}{25}$.

Figure 1. Sample output of developing proficient student

The teacher also stated, *"My student continues to struggle with fractions, which I expected given that they were vocal about disliking fractions. They can calculate the probability of the given problem but struggle when asked to simplify it to its lowest term. So, I had to teach again how to solve and simplify fractions, which is also time-consuming."* This observation underscores the ongoing challenge with fractions that must be addressed in future instruction and anticipated due to students' dislike of fractions. The teacher recognized the need for additional time to reinforce fundamental fraction-solving skills. Overall, the ongoing difficulties with fractions significantly contributed to the developing proficient group's lower scores on the posttest.

4. CONCLUSION

This study examined the effects of contextualized lessons using agricultural concepts on the level of proficiency of grade 8 students in probability. The findings revealed a significant improvement in students' performance from pretest to posttest across all proficiency levels, highlighting the effectiveness of contextualizing mathematics using agriculture in improving students' engagement, understanding, and performance in probability. The advanced proficient group significantly improved from "did not meet expectations" to "outstanding." Students expressed a positive attitude toward the lessons, emphasizing the relevance of real-life agricultural scenarios in simplifying complex probability concepts. The proficient and approaching proficient group also showed a remarkable shift, moving from "did not meet expectations" to "very satisfactory," and finding familiar contexts made abstract concepts easier to understand. However, some students encountered difficulties highlighting the need for support in these areas.

On the other hand, although the developing proficient group performance improved, as indicated in the increased median scores, the students faced persistent difficulties with fractions, which affected their posttest performance. This underscores teachers' need to address fundamental skills, like fractions, to enhance students' performance further. In conclusion, these findings indicate that contextualizing mathematics through agricultural concepts enhances students' engagement, comprehension, and performance in probability. Students are more likely to appreciate the relevance of probability in their own lives by connecting it to real-world applications, which promotes a deep understanding of probability. However, students with lower proficiency levels require additional support in mastering fundamental skills. Therefore, this study recommends that teachers integrate practical, real-world contexts, like agricultural concepts, while acknowledging its varying effects on students depending on their proficiency levels. Teachers should consider differentiated instruction by providing students with higher proficiency levels with more complex problems, while those with lower proficiency levels might benefit from more guided and simpler activities that simultaneously improve fundamental skills, like fractions.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state there is no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study. For student participants under the age of 18, informed consent was secured from their parents or legal guardians, and assent was obtained from the students themselves. Participation was voluntary, and all personal information was anonymized to ensure privacy and confidentiality. All procedures followed the ethical guidelines for research involving human subjects.

ETHICAL APPROVAL

The conduct of this study was reviewed and approved by the College of Education Research Ethics Committee of Mindanao State University-Iligan Institute of Technology. Informed consent was obtained from all participants and their parents or legal guardians before they participated in the study. The privacy, anonymity, and confidentiality of the student participants were ensured throughout the research process.

DATA AVAILABILITY

The data supporting this study's findings are available from the corresponding author, [AS], upon reasonable request. However, the data contain information that could compromise the privacy of student participants and are therefore not publicly available.

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