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Vocational and Mathematical Knowledge: Designing Hybrid Literacy Tasks in the Context of Food Security

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ABSTRACT

Mathematical literacy in vocational contexts requires instructional tasks that effectively bridge academic content with job-specific knowledge. This case study examines the design and impact of hybrid literacy tasks—integrating national food policy narratives with exponential number problems—within a food security context relevant to agribusiness education. The study adopted a case study approach and collected data from teachers and students at an Indonesian agribusiness vocational school through Focus Group Discussions (FGDs), student worksheets, and pre-test and post-tests. FGDs established a functional framework connecting food security elements to mathematical content and essential work skills. The study found that the hybrid task design successfully facilitated students' reasoning by establishing the context as a source of analogy, which encouraged imitative reasoning (identifying similarities) to solve subsequent, more complex problems. This experience significantly improved students' computational fluency in representing large numbers using various power forms, a key vocational skill for food security analysis. The intervention resulted in a high average n-gain score in mathematics learning. The research demonstrates a practical model for bridging vocational and mathematical knowledge through transdisciplinary hybrid task design. The findings suggest that educational practices in vocational settings should leverage vocational contexts as functional mechanisms—not mere settings—to cultivate mathematical literacy and computational work skills.

Keywords: Exponential Numbers, Food Security Context, Hybrid Tasks, Imitative Reasoning, Vocational Mathematics

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1. INTRODUCTION

Mathematical literacy is commonly understood as comprising contextual application, mathematical content knowledge, reasoning and problem-solving processes, and broader competencies required in contemporary life (OECD, 2019). As studies on mathematical literacy continue to develop, identifying relevant and meaningful contexts for learning has become increasingly important. Agriculture represents one such context, particularly within vocational education settings (Vallera & Bodzin, 2020). Evidence from FAO-based frameworks suggests that food insecurity is linked to poorer health outcomes and has become a significant global sustainability challenge (Beyene, 2023; Pérez-Escamilla, 2024). In Indonesia, agribusiness is a major vocational specialization designed to equip students with the competencies needed in the agricultural sector and the broader labor market (Menteri Pendidikan Kebudayaan Riset dan Teknologi, 2022). Consequently, mathematics learning in vocational high schools should support the development of vocational competencies, including students' dispositions, knowledge, and practical skills related to food security (Kemendikbudristek BSKAP, 2022). Therefore, employing food security as a learning context offers a meaningful way to strengthen mathematical literacy among agribusiness students (Fatimah et al., 2023, 2026).

Effective mathematics learning in vocational settings needs to reflect the mathematical demands embedded in occupational practice. This perspective is captured in the concept of Vocational Mathematical Knowledge, which emphasizes the relationship between mathematical understanding and workplace-specific skills and procedures (Bakker, 2014; Heusdens et al., 2016). Integrating vocational practice into mathematics teaching presents difficulties. A notable disparity exists between the theory of mathematical literacy and its instructional implementation (Yang et al., 2020), frequently leading to tasks that do not correspond with the principles of accessibility, challenge, and utility needed for vocational learners (Sawatzki, 2017). Additionally, educators require a blend of mathematical and vocational knowledge to successfully create tasks that foster 21st-century skills such as transdisciplinarity and computational thinking (Hawkins & Neubauer, 2015). To address this challenge, this study adopts the hybrid task framework (Kuntze et al., 2017), in which a single task integrates two complementary learning goals. Previous studies suggest that hybrid tasks enhance conceptual understanding, critical thinking, and mathematical problem-solving through authentic learning experiences (Rahmawati et al., 2022; Smirnov et al., 2023). Accordingly, this study integrates vocational knowledge on food security with exponential functions, making the vocational context an essential part of students' mathematical reasoning rather than merely a contextual backdrop.

Earlier studies have examined the mathematical requirements of vocational high schools in agribusiness, recognizing arithmetic as a fundamental task in multiple industries (Fatimah & Solihah, 2020). Although current studies validate the necessity for contextual integration, they have yet to offer a solid and validated framework for creating hybrid tasks that systematically link national food policy narratives to specific mathematical concepts (e.g., exponential numbers) and examining the resulting impacts on students' reasoning.

Consequently, this study offers an in-depth examination of mathematics learning by specifically emphasizing the development and execution of hybrid literacy tasks related to food security. Its purpose is to emphasize how the elements of mathematical literacy (context, content, processes, and skills) are purposefully integrated in these designs. This study specifically contributes by: (1) creating a functional framework for designing hybrid tasks that merge policy context and exponential content, (2) examining how context aids students' imitative and analogical reasoning, and (3) assessing the influence of task-solving experiences on computational fluency and educational outcomes. In light of these goals, the subsequent research questions were addressed: (RQ1) What structure is essential for developing impactful hybrid mathematical literacy tasks that merge food security themes, exponential concepts, and vocational skill sets? (RQ2) In what way does the contextual framework in hybrid tasks enhance students' mathematical reasoning (e.g., analogical or imitative reasoning)? (RQ3) What effects do these hybrid tasks have on students' mathematical learning outcomes (n-gain) and their growth in computational fluency?

2. RESEARCH METHOD

This research employed a descriptive case study approach (Hancock & Algozzine, 2006) to thoroughly examine the planning, execution, and effects of a hybrid mathematical literacy task in a vocational environment. The case location was a public vocational high school focused on agribusiness and agrotechnology in Ciamis Regency, Indonesia. The study was conducted at a public vocational school offering a food crops and horticulture program. The school was selected based on accessibility considerations and its suitability to represent the agribusiness vocational context under investigation. Four teachers participated in the study, including two mathematics teachers and two agribusiness vocational teachers. Their involvement in a series of Focus Group Discussions (FGDs) was essential for refining and validating the proposed hybrid task framework presented in Table 1. The main participants consisted of 24 tenth-grade students (6 females, 18 males) focused on crop agribusiness. Students were split into seven cooperative teams (G1 to G7) to finish the assignment. This cooperative framework was essential for witnessing the fluid group reasoning process.

Table 1. Procedures for Designing and Investigating Hybrid Mathematical Literacy Tasks

Research Phase	Activities
Initial Exploration	Focus group discussions involving mathematics teachers and agribusiness teachers were conducted to: (a) examine vocational curriculum standards and learning processes in Indonesia; (b) identify the role of mathematics in agribusiness vocational education; and (c) explore mathematical literacy components related to food security as a basis for task development.
Task Development	Discussions with four mathematics teachers were carried out to: (a) formulate learning objectives; (b) develop mathematical literacy tasks situated in food security contexts; and (c) identify the student participants from the agribusiness food crops and horticulture program.

Research Design Selection	A descriptive case study approach was adopted to provide an in-depth account of the design process and classroom implementation of hybrid mathematical literacy tasks.
Classroom Observation	Students' activities, interactions, and strategies were observed while they engaged in the mathematical tasks.
Student Interviews	Semi-structured interviews were conducted with selected students to gain insight into their approaches to solving representative tasks.
Documentation Collection	Data sources included completed student worksheets as well as video and audio recordings collected during learning activities.
Data Analysis and Interpretation	Observation records, interview transcripts, and student work were analyzed to identify patterns related to mathematical understanding, reasoning, representation, and vocational work-skill knowledge.
Reporting of Results	Findings were synthesized and organized according to the research objectives and research questions.
Validation of Findings	The findings were compared with previous studies and discussed with mathematics and agribusiness teachers to strengthen the credibility of the interpretations.

The data gathering employed a multimodal strategy to guarantee triangulation. Initially, Focus Group Discussions (FGDs): Held with educators to outline the connection between the food security curriculum and mathematics material, which is essential for creating hybrid assignments (RQ1) (as illustrated in Table 2 and Figure 1). Second, Pre-tests and Post-tests: Administered to individual students to assess advancements in their understanding of exponential numbers. Learning outcomes were assessed using the normalized gain (n-gain) score method to evaluate the effectiveness of the intervention (RQ3). Third, Student Worksheets and Observation Notes were utilized to monitor the procedural steps followed by the groups, examine computational mistakes, and recognize the influence of context in problem-solving. Fourth, students were interviewed during standard problem-solving instances (specifically G1, G4, G6, G2, G7) to understand their thought processes and confirm imitative and analogical reasoning strategies (RQ2).

The analysis was conducted in two stages. First, learning improvement was assessed using normalized gain (n-gain) scores derived from students' pretest and posttest results. Secondly, qualitative data (worksheets, observation transcripts, and interviews) underwent thematic analysis. This analysis focused on students' cognitive processes to identify reasoning patterns, which were subsequently categorized according to Lithner's framework (Lithner, 2008, 2017), particularly instances of imitative reasoning and analogy-based problem-solving strategies influenced by the context of food security. This combined analysis provided a comprehensive understanding of how the hybrid task design supported mathematical processes and vocational computational skills.

3. RESULTS AND DISCUSSION

A. Results

The empirical findings are organized into three cohesive sections, aligned with the research inquiries: the development of the Hybrid Task Design Framework (RQ1), the identified process of student reasoning supported by the context (RQ2), and the measurable effect on computational fluency and educational results (RQ3). The central discovery in these three domains is that intentionally crafting tasks to fulfill a dual, hybrid role—combining vocational policy with mathematical methods—effectively converted the food security context into a practical cognitive tool, rather than just a setting. This practical context mainly grounded students' problem-solving in analogy, swiftly evolving into effective Imitative Reasoning techniques crucial for professional tasks.

1) Framework for Hybrid Task Design

The Focus Group Discussions (FGDs) involving mathematics and agribusiness educators developed the Hybrid Task Design Framework (Figure 1), validating the intentional connection between vocational context and mathematical content. The study's clear learning aim was stated as: "Students can represent numbers using powers," matching the task design with the "Number" component of the curriculum

(Kemendikbudristek BSKAP, 2022). The particular context, Food Availability (based on Law No. 18 of 2012) (Presiden Republik Indonesia, 2012), was chosen because assessments of grain production and stock fundamentally include substantial amounts that necessitate exponential notation for brief numerical expression.

Table 2. **Mapping Food Security Dimensions to Learning Outcomes in the Basic Crop Cultivation Subject**

Food Security Dimension	Description of the Dimension	Related Learning Outcomes
Food Availability	Food production, food reserves, diversification of food stocks, and supporting agricultural facilities and infrastructure.	Understanding fundamental technical processes in crop, fishery, livestock, and agricultural product processing activities; recognizing technological developments and contemporary issues in agribusiness industries.
Food Consumption	Food diversity and nutritional improvement.	Examining technological advancements and emerging global issues associated with agribusiness and agricultural product processing.
Food Accessibility	Distribution systems, marketing channels, trade mechanisms, food stability, and food assistance programs.	Understanding integrated business processes within the agribusiness sector.
Food Safety	Sanitation practices, regulation of food additives, genetically modified food products, irradiation processes, and packaging systems.	Understanding basic technical procedures related to agricultural production and agricultural product processing.

Table 2 above outlines the relationship between components of food security and aspects of vocational learning outcomes. The FGD analysis shows that Food Availability is the most substantial area for developing raw data computation skills and efficiency calculations, which significantly depend on grasping large quantities.

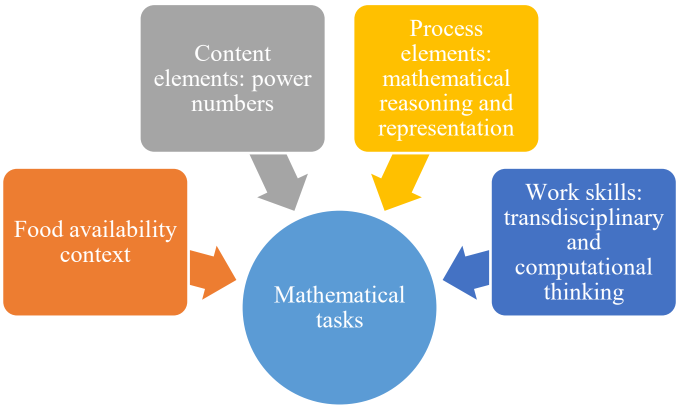

Fig 1. **Conceptual Structure of Mathematical Literacy in Food Security-Based Learning**

Figure 1 presents the conceptual structure of the proposed hybrid literacy task design. In this framework, quantitative reasoning serves as a transdisciplinary bridge connecting mathematical content with vocational knowledge. The mathematical component focuses on exponential-number concepts, while the vocational component emphasizes workplace-related calculations commonly encountered in

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agribusiness activities. This integration informed the development of mathematical literacy tasks that linked food security issues, vocational practices, and mathematical reasoning, as summarized in Table 3.

Table 3. Design Characteristics of Food Security-Based Mathematical Literacy Tasks

Task	Food Security Dimension	Vocational Context	Mathematical Content	Literacy Process	Expected Work-Related Skill
1	Food Availability	Grain drying and moisture content	Exponential numbers	Interpreting quantitative information and determining water content	Estimating agricultural product quality
2	Food Production	Grain shrinkage during drying	Exponential numbers and percentages	Applying mathematical procedures to production data	Monitoring production efficiency
3	Food Reserves	Conversion from harvested grain to milled grain	Exponential numbers	Mathematical modelling and representation	Managing food reserve calculations
4	Food Consumption	Estimation of regional rice demand	Exponential numbers and multiplication	Quantitative reasoning and interpretation	Forecasting food demand

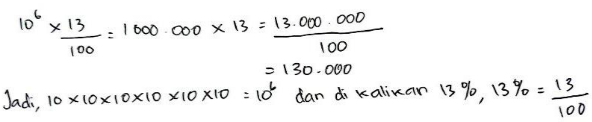
Table 3 presents the key characteristics of the food security-based mathematical literacy tasks. The tasks were organized to reflect increasing levels of contextual and mathematical complexity. Students were initially required to interpret quantitative information embedded in vocational situations and subsequently engage in more sophisticated reasoning, mathematical modelling, and calculations involving exponential-number concepts within agribusiness contexts.

2) Contextual Analogy and Imitative Reasoning

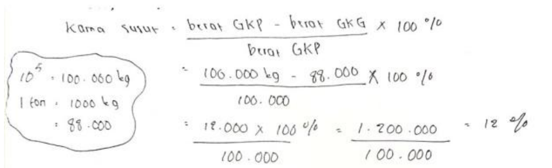
Examination of student performance and interview transcripts indicated that the context was essential in promoting problem-solving, quickly creating a system of Imitative Reasoning (Jonsson et al., 2014; Lithner, 2008, 2017) influenced by analogy.

Early observations validated the uniqueness of the tasks, although students acknowledged their job-related significance. A student from Group 5 (who initially felt uneasy with the new format) remarked: "This is the first occasion I've encountered a math problem that incorporates a law." "However, I now realize that the rice we are assessing is vital for the country's food reserves." This indicates that the policy context effectively gave functional importance to the mathematical issue.

The strongest proof for Imitative Reasoning was the procedural transfer noted between Task 1 and Task 2. A member of Group 2 (who transitioned successfully) described his thinking process: "We revisited the water percentage formula in the initial problem. Even though the equation varies, the reasoning remains identical: determining the disparity between the starting and ending weights. We applied a comparable method in the second issue. The rice scenario remains unchanged, so we are confident that the calculation method isn't very dissimilar. This verifies that the food security context acted as a cognitive anchor, allowing students to effectively apply procedural templates from one problem variation to another, supporting the context's function as a source of procedural analogy.



(a)



(b)

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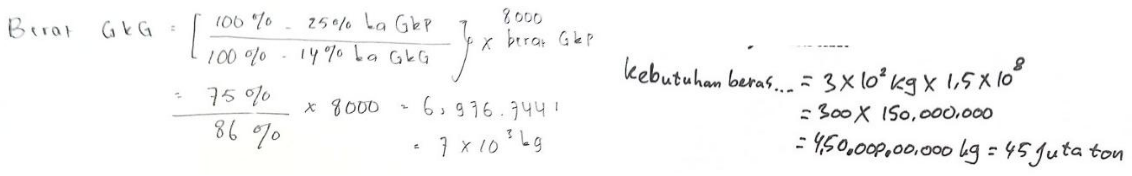

(c) (d)

Fig 2. Examples of student responses to (a) Task 1, (b) Task 2, (c) Task 3, (d) Task 4

Figure 2 illustrates representative student responses to the four hybrid mathematical tasks. In Figure 2(b), the student correctly converted 88 tons into 88,000 kg, substituted the values into the shrinkage formula, and accurately calculated a 12% reduction from harvested dry grain to milled dry grain. Likewise, in Figure 2(d), the student correctly substituted the rice consumption and population values, applied the law of exponents, and obtained the annual rice demand of 4.5×10^{10} kg. In contrast, the responses in Figures 2(a) and 2(c) relied primarily on procedural calculations with limited contextual interpretation and less precise mathematical representation. These findings suggest that students were able to utilize appropriate solution strategies after being prompted by analogy triggers from earlier tasks, enabling them to solve increasingly complex mathematical expressions while maintaining connections to the vocational context.

3) Computational Fluency and Learning Outcomes

The intervention led to a notable improvement in personal mathematical performance, demonstrated by an average n-gain score categorized as high (Figure 3).

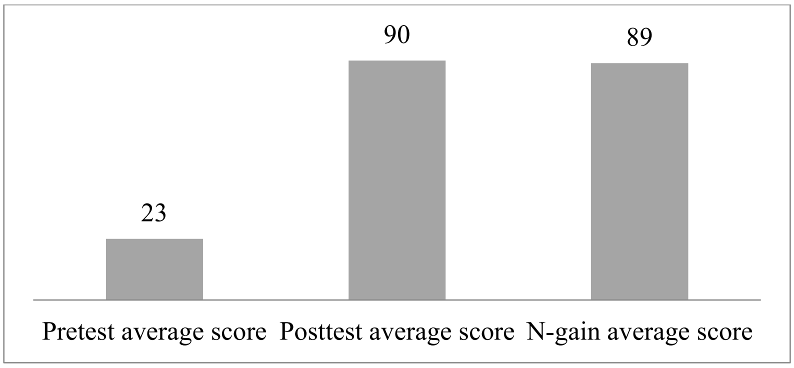

Fig 3. Average Pretest, Posttest, and N-Gain Scores

The elevated mean n-gain score (Figure 3) demonstrates that the hybrid task intervention effectively supported individual proficiency in exponential material. This enhancement was greatly aided by the group's experience in tackling complicated issues. Figure 4 illustrates the average n-gain scores for each group, highlighting the relationship between regular task completion and enhanced learning results.

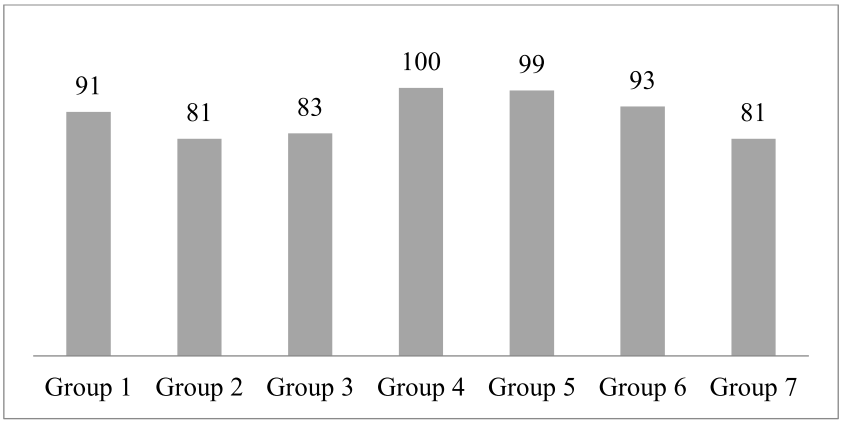

Fig 4. Average N-gain Score for Each Student Group

Groups that effectively completed all tasks (G1, G4, and G6) attained a notably higher average n-gain score (Figure 4), emphasizing the direct connection between continuous procedural success in hybrid tasks and learning success. Moreover, the concluding tasks distinctly showcased the growth of Computational Fluency as a fundamental work skill. Observations indicated that Group 4 students utilized unit conversion through practical vocational reasoning: "Since the per capita consumption figures in other questions are in kg. In agricultural business, it is necessary to change units to a uniform measurement prior to computing the overall inventory.

B. Discussion

This part analyzes the results by exploring the four interrelated elements of mathematical literacy—context, content, reasoning, and work skills—to illustrate the efficacy of the hybrid task design. The research determined that the intentional integration of national food security policy and the essence of exponential numbers constitutes the fundamental aspect of the hybrid tasks (Kuntze et al., 2017). This combined aim—enhancing food security awareness while developing mathematical comprehension—is essential, as activities must encourage coherent and interconnected goal areas (Thanheiser, 2017). The importance of this dual-domain strategy is being increasingly acknowledged in numerous complex and dynamic areas. For example, hybrid optimization methods are needed to manage intricate, multi-objective challenges in cloud task allocation (Sharma et al., 2025), while hybrid task scheduling is essential for reconciling human judgment with machine technology in Industry 5.0 (He et al., 2025). Similarly, recent studies in mathematics education have shown that hybrid instructional designs promote authentic learning experiences, student engagement, and mathematical understanding (Cosentino et al., 2025; Fang, 2026). Together, these findings reinforce the potential of hybrid task design as an effective pedagogical approach for preparing vocational students to apply mathematical knowledge in interdisciplinary workplace contexts (Triantafyllidis et al., 2023).

The concept of food security was not just a story; it acted as a mental aid to enhance students' problem-solving abilities. Results indicated that students, who were initially unaware of the policy narrative, swiftly employed the context as a comparison to identify solution approaches. This situation led to the reliable application of Imitative Reasoning (Lithner, 2003, 2008, 2017), particularly defined as "reasoning founded on recognizing similarities." This transfer process, in which strategy selection relies on recognizing surface features akin to those seen in past examples, was frequently noted as students replicated the effective procedural approach of one task to tackle the following one. This discovery holds great importance for Vocational Mathematics (Bakker, 2014). In a professional setting, efficiency is crucial, and effective practice frequently requires the precise application of recognized, standardized procedures (Yeo, 2017). The achievement of students in transferring procedures through Imitative Reasoning aligns seamlessly with the objective of vocational training: acquiring the practical skills required in the workplace (Fatimah et al., 2024). Earlier research additionally indicates that vocational settings greatly enhance student reasoning and problem-solving abilities (Fatimah et al., 2019; Fatimah & Prabawanto, 2020).

The effective transfer of procedural knowledge resulted in an elevated n-gain score and a distinct display of Computational Fluency. The design employed exponential figures to manage the vast scale of data involved in food security analysis, directly promoting Computational Thinking—the capacity to convert extensive data into abstract ideas and grasp data-driven reasoning (Hawkins & Neubauer, 2015). This finding is consistent with recent studies showing that hybrid mathematics learning can foster computational thinking through technology-supported and integrated instructional designs (Helsa et al., 2023). The capability of students to execute precise unit conversions (e.g., tons to kilograms) and accurately replace variables in formulas signifies a proficiency in Transdisciplinarity—literacy and comprehension of cross-disciplinary ideas (Hawkins & Neubauer, 2015). The power-form numbers, when applied within a certain unit, shifted from theoretical mathematical understanding to practical knowledge vital for the agricultural industry. The procedural execution observed, while occasionally relying on experiential reasoning from prior education (Lithner, 2000), was effectively directed by the vocational context of the hybrid task to yield functionally accurate solutions, validating that the mathematics gained practical usefulness for the students. This practical orientation is also reflected in recent studies reporting that hybrid learning supported by problem-based scaffolding strengthens students' mathematical problem-solving in authentic contexts (Setiani et al., 2025).

However, the challenges noted with numerical estimation and the ultimate exponential format (Task 3) underscore a significant educational hurdle. Although the vocational setting effectively enhances procedural fluency, the connection between computational results and suitable mathematical representation (such as standard form or scientific notation) necessitates targeted instructional emphasis. The difficulties encountered by students in rounding and displaying the final outcome indicate that educators should offer targeted reflective prompts centered on their representational decisions to enhance the interaction between computational thinking and formal mathematical representation, as indicated by Kuntze et al. (2017). Moreover, the narrow focus of the context on national food security policies (Table 3) suggests that future studies should extend to global food challenges, where diverse resilience strategies (Yu et al., 2015) will require even more intricate mathematical modeling and interdisciplinary approaches.

4. CONCLUSION

This research effectively examined and validated the issues associated with incorporating mathematical literacy into vocational high school teaching, particularly via the creation and execution of hybrid tasks. The identified elements of mathematical literacy—integrating national food policy narratives (context) with exponential figures (content)—were validated as extremely pertinent. The study demonstrates that this particular design meets the requirement for vocational mathematics to have practical significance, as utilizing exponential forms directly aligns with the succinct depiction of substantial quantities found in food security assessment.

The examination of student feedback validated that the hybrid task structure effectively addressed the issue of connecting theoretical concepts with practical application. The context acted as a useful cognitive resource, assisting students in drawing analogies that supported procedural transfer. This mechanism has been shown to enhance Imitative Reasoning, proving that the design successfully generates the essential procedural templates for students to efficiently tackle intricate, later tasks.

Ultimately, the research verified that this intervention had a positive effect on learning results and job skills. The elevated n-gain scores validated personal learning accomplishments, while the students' steady fluency in unit conversion and formula substitution demonstrated the growth of vital transdisciplinary and computational skills. In conclusion, the results affirm that the strategic formulation of hybrid tasks is a proven and efficient model for converting mathematical knowledge into applicable working knowledge, effectively addressing the competency requirements of the agribusiness industry.

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