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Optimizing learning effectiveness through literacy-oriented teaching materials with quantum teaching in food and nutrition data analysis courses

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ABSTRACT

This study aimed to optimize learning effectiveness in the Food and Nutrition Data Analysis course through the development of literacy-oriented teaching materials with a Quantum Teaching approach. The research employed a Research and Development (R&D) method using the 4D model: Define, Design, Develop, and Disseminate. The Define stage involved a needs analysis of 60 nutrition students, revealing that 88.5% required interactive teaching materials with step-by-step practical guidance. In the Develop stage, the teaching materials were validated by content and media experts, yielding scores of 91.25% and 89.50%, respectively, which fall into the "very feasible" category. The Disseminate stage involved limited implementation in one class, showing an increase in average student engagement scores from 73.40 to 88.20 and comprehension test scores from 71.85 to 87.45. These findings demonstrate that the developed materials effectively enhance student participation and mastery of data analysis concepts. This innovation addresses the gap in practical-oriented learning resources for nutrition students, aligning with curriculum demands and 21st-century learning skills. The developed materials are expected to improve competence in analyzing food and nutrition data, thereby supporting academic success and professional readiness.

INTRODUCTION

In the 21st century, higher education requires students to master a wide range of literacy skills, not only traditional reading and writing but also digital literacy, data literacy, and scientific literacy (Şanlıer et al., 2024). In nutrition education, these skills are essential for evaluating and applying evidence-based information, processing nutrition data, and addressing community nutrition issues effectively (Çelik & Semerci, 2022). The Food and Nutrition Data Analysis course reflects this need, as students must be able to interpret complex data, use analytical software, and apply statistical methods. However, research shows that many students struggle to understand basic concepts and carry out data analysis. This is often due to the lack of systematic, interactive, and relevant teaching materials that fit their learning needs (Islam et al., 2024; Silva Rego et al., 2022).

One teaching approach that can improve student engagement and understanding is Quantum Teaching. This method combines active, contextual, and enjoyable learning strategies using the TANDUR framework (Tumbuhkan, Alami, Namai, Demonstrasikan, Ulangi, Rayakan—Grow, Experience, Name, Demonstrate, Repeat, Celebrate) (Risti et al., 2021). Studies in various fields have found that Quantum Teaching can increase learning motivation, classroom participation, and academic performance (İnalcik & Angin, 2021; Mortazavi et al., 2021). However, its use in creating literacy-based teaching materials for food and nutrition data analysis has not been widely studied (Ayaz et al., 2020).

Integrating literacy-based teaching materials with the Quantum Teaching approach can help fill this gap. These materials can help students not only access and understand nutrition information but also critically analyze and apply it in real situations (Weerasekara et al., 2020). Combining literacy skills with Quantum Teaching strategies can strengthen both theoretical knowledge and practical abilities in food and nutrition data analysis. This is especially important in Indonesia, where nutrition problems require graduates who are skilled in data analysis to create effective solutions (Chao et al., 2020).

Although some studies have developed interactive teaching materials or applied Quantum Teaching separately, few have combined them with a focus on improving nutrition data analysis skills (Ashraf et al., 2019; Kemaloğlu & Kemaloğlu, 2024). Putra & Triwahyuni (2025) created interactive modules but did not use Quantum Teaching, while Pradini et al. (2023) and Muthuswamy & Pavithra, (2024) applied Quantum Teaching in general learning without connecting it to nutrition data analysis. This shows the need for research that combines both approaches to improve learning outcomes in nutrition education.

Therefore, this study aims to develop literacy-based teaching materials with a Quantum Teaching approach for the Food and Nutrition Data Analysis course and to evaluate their feasibility and effectiveness in improving nutrition students' competencies. The findings are expected to contribute to the development of innovative learning models aligned with nutrition education curricula and to serve as a reference for lecturers and material developers in improving the quality of higher education teaching resources.

RESEARCH METHODS

The study was conducted at the Nutrition Study Program, Faculty of Engineering, Universitas Negeri Medan, from March to November 2025. Research activities followed the 4D (Define, Design, Develop, Disseminate) model through classroom and laboratory sessions. A total of 60 nutrition students participated in this study, determined based on Lemeshow's sample size calculation formula. All participants were eighth-semester students of the Nutrition Study Program who had completed the Food and Nutrition Data Analysis course, making them eligible to assess the developed teaching materials. The sampling technique employed was accidental sampling, involving students who met the inclusion criteria and were available during the data collection period.

In the Define stage, a needs analysis was conducted to identified limited practical skills in data analysis software (SPSS, Nutrisurvey, WHO AnthroPlus, Nutriclin) and a strong demand for interactive, technology-based teaching materials. The course syllabus and lesson plans were reviewed to ensure alignment with nutritionist competency standards. During the Design stage, the material structure was developed around key topics such as data collection, processing, statistical analysis, and validity testing. The Quantum Teaching approach was applied by integrating data, digital, and scientific literacy through active learning strategies, case studies, and multimedia elements like QR-linked tutorial videos. The Develop stage involved preparing the full draft, which was validated by subject matter, language, and media experts. Validation results were analyzed using BSNP feasibility criteria, and revisions were made based on expert feedback. In the Disseminate stage, a small group trial with 30 students was conducted to assess usability, engagement, and clarity. Feedback was collected through questionnaires and observations, leading to the final version prepared for ISBN registration and distribution (Indaryanti et al., 2025).

Data collection used questionnaires, interviews, and documentation, while analysis combined descriptive quantitative methods (expert and student mean scores) with qualitative analysis of feedback and suggestions for improvement. The average score was calculated using the formula:

$$X = \frac{\Sigma xi}{N} \quad (1)$$

Where:

- X = Average score
- Σxi = Total score obtained
- N = Number of items

Not only that, but also in qualitative analysis measure relative gains, which was to know increasing score pre-test and post-test compared to the initial score (pre-test). Describes how much improvement occurred relative to the student's initial ability.

$$Relative\ Gain\ (\%) = \frac{PostTest - PreTest}{PreTest}\ x\ 100 \qquad (2)$$

Normalized gain is a measure of improvement that considers both the maximum score (100) and the initial score. This concept is popularly used in educational research Hake (1998) to measure the effectiveness of interventions. Normalized gain provides an indication of the potential improvement that can be achieved from the remaining suboptimal score. Therefore, even if the initial score is quite high, the g value will indicate whether the intervention (teaching materials) is truly effective in bringing students closer to the maximum score.

$$g = \frac{PostTest - PreTest}{100 - PreTest} \qquad (3)$$

Interpretation:

$g \geq 0.70$: High Gain

$0.30 \leq g \leq 0.70$: Medium Gain

$g < 0.30$: Low Gain

RESULTS AND DISCUSSION

Define stage

The needs assessment involving 60 students from the 8th semesters of the Nutrition Study Program revealed important insights into their learning experiences and challenges in the Food and Nutrition Data Analysis course. Overall, students demonstrated a reasonable grasp of the basic concepts, as reflected by an average score of 3.8, yet many acknowledged the need for deeper theoretical understanding, particularly in connecting abstract principles to real data analysis tasks. Their self-assessed skill level, with an average score of 3.5, suggested limited confidence in using analytical software such as SPSS, WHO Anthro/AnthroPlus, and Nutrisurvey. The lowest item score, 2.9 for “difficulty using analysis tools,” further highlighted the need for more structured, practice-oriented exercises.

Students also expressed clear preferences regarding learning methods, showing a strong inclination toward interactive and technology-based approaches. The highest mean score, 4.5, was recorded for statements emphasizing the need for practical, case-based, and multimedia-supported learning, resulting in an overall average of 4.3 in this category. In contrast, the challenges most frequently mentioned were related to time management and the difficulty of bridging the gap between theory and practice, both yielding an average score of 3.4.

Despite these challenges, students displayed optimism and enthusiasm toward innovative learning strategies. The expectations category, with an overall mean of 4.1, showed that most students desired applicable techniques and believed that Quantum Teaching could make the learning process more engaging and effective. Altogether, these findings indicate that while students already possess a foundational understanding of data analysis concepts, they require more interactive, context-driven, and hands-on materials to enhance both their analytical competence and confidence in applying statistical tools independently.

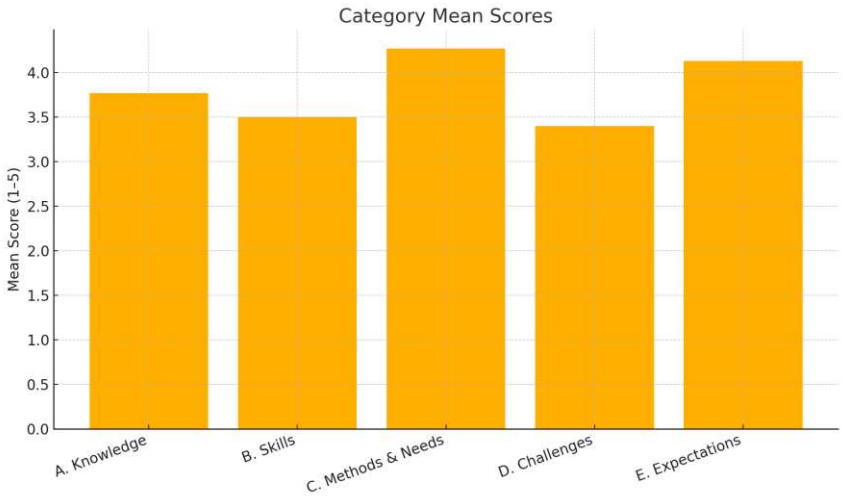

Figure 1. Category Mean Scores of Need Analysis

Analysis revealed that 88.5% of students expressed a need for interactive teaching materials equipped with step-by-step procedural guidance, particularly for statistical software applications (SPSS), anthropometric analysis tools (WHO Anthro/AnthroPlus), and dietary data processing programs (Nutrisurvey). These results show that while theoretical understanding is moderately strong, practical skills and application remain key weaknesses, underscoring the need for a systematically designed teaching material integrating active learning principles.

The findings of this study illustrate that the development of literacy-based teaching materials, integrated with Quantum Teaching principles, effectively addresses the identified learning needs from the Define stage. Specifically, a significant percentage (88.5%) of students expressed the requirement for interactive materials featuring step-by-step guidance. This demand aligns with research conducted by Iringan, (2021), who demonstrated that clear procedural instructions coupled with multimedia support yield substantial improvements in student confidence and performance in applied courses. In the specialized domain of food and nutrition data analysis, where the complexity of statistical software and multidimensional datasets is prevalent, this form of scaffolding becomes indispensable for enhancing practical skills (Fagerlund et al., 2022).

Design Stage

The Semester Learning Plan (Rencana Pembelajaran Semester, RPS) for the Food and Nutrition Data Analysis (ADPG) course was carefully reviewed to ensure that the developed teaching materials were fully aligned with the intended learning outcomes and competency standards for nutrition students. Guided by the results of the needs analysis, the teaching material was structured to provide a comprehensive and sequential learning experience that connects theoretical understanding with practical application. The material begins with an introduction to food and nutrition data analysis, outlining its scope, key concepts, and relevance to professional practice. It then continues with food consumption data collection methods, which cover the procedures for 24-hour recall, Food Frequency Questionnaire (FFQ), and Semi-Quantitative FFQ (SQ-FFQ), enabling students to master data-gathering techniques commonly used in nutrition research.

Subsequent sections focus on anthropometric data analysis, emphasizing the use of WHO Anthro and AnthroPlus software for growth and nutritional assessment, followed by statistical data processing, where students learn to perform descriptive and inferential analyses using SPSS. The material also includes a section on validity and reliability testing, providing theoretical explanations and hands-on applications relevant to evaluating research quality in nutrition studies. Finally, the course culminates with case studies and applied problem-solving, where students are encouraged to integrate all learned components to address real-world analytical challenges. This structure ensures a progressive learning pathway that reinforces conceptual understanding while building essential analytical and data literacy skills for future professional practice.

Each chapter incorporated interactive elements: 1) Step-by-step tutorials with annotated screenshot; 2) QR-coded links to video demonstrations; 3) Practical exercises and self-assessment quizzes; 4) Reflection prompts to reinforce literacy and critical thinking skills. The design was guided by Quantum Teaching's TANDUR model (Grow, Experience, Name, Demonstrate, Repeat, Celebrate), ensuring that the learning process was engaging, contextual, and motivating.

Develop Stage

The draft of the teaching material was subjected to expert validation to ensure its accuracy, clarity, and feasibility before implementation. The evaluation involved two experts—one focusing on material content and the other on media design. The material expert awarded a score of 91.25%, while the media expert provided a score of 89.50%, both of which fall into the Very Feasible category. These results exceed the minimum feasibility threshold established by the National Education Standards Agency (Badan Standar Nasional Pendidikan, BSNP), confirming that the developed material possessed strong content validity, appropriate media quality, and an overall high level of readiness for educational use.

Supporting the development phase, the high validation scores achieved by the materials—91.25% from material experts and 89.50% from media experts—affirm the feasibility and quality of the resources created. These results align with findings from Fitriyah et al. (2020), who asserted that learning materials that merge accurate content with engaging media components effectively heighten learner motivation and retention. The incorporation of the TANDUR framework from Quantum Teaching was instrumental in achieving these favorable ratings; it provides a structured and dynamic method that fosters active involvement and meaningful learning experiences within the context of nutrition education.

Disseminate Stage

A limited implementation in disseminate stage was conducted after develop stage, and the results showed notable improvements (Table 1). The student engagement score increased from 73.40 (pre-test) to 88.20 (post-test), resulting in an absolute gain of 14.80 points, relative gain of 20.2%, and normalized gain (g) of 0.56. Relative gain indicates that engagement improved by 20.2% compared to the initial level. Meanwhile, normalized gain (0.56) falls in the medium–high category, meaning that more than half of the maximum possible improvement from the initial score was achieved.

Table 1. Pre–Post Outcomes

Metric	Pre	Post	Abs Gain	Rel Gain %	Norm Gain
Engagement	73.4	88.2	14.8	20.2	0.556
Comprehension	71.85	87.45	15.6	21.7	0.554

The comprehension test score improved from 71.85 (pre-test) to 87.45 (post-test), with an absolute gain of 15.60 points, relative gain of 21.7%, and normalized gain (g) of 0.55. Relative gain reflects a 21.7% increase from the students' initial comprehension ability. Meanwhile, normalized gain (0.55) also lies in the medium–high category, showing that the teaching material substantially enhanced understanding relative to the maximum possible improvement.

The substantial gains in both student engagement (an increase of 20.2%) and comprehension (an increase of 21.7%) reported during the Disseminate stage further substantiate the effectiveness of the intervention. According to Hake (1998) benchmarks for normalized gains, values ranging from 0.3 to 0.7 indicate medium to high effectiveness, thus suggesting a significant positive impact of the developed materials in relation to baseline performance. This finding echoes the observations made by Widarti et al., (2024), which documented similar increases in engagement and understanding in STEM subjects when using interactive, context-rich teaching strategies.

In addition, 95% of students rated the teaching materials as "very useful" or "useful," with only 5% neutral and nonnegative. These results confirm that the developed literacy-based, Quantum

Teaching-oriented materials effectively fostered both active participation and conceptual mastery in food and nutrition data analysis. The remarkably high student satisfaction rate (95%) further corroborates the acceptability of the developed materials. Prior studies underscore that positive student perceptions regarding instructional content frequently correlate with elevated intrinsic motivation levels, consequently bolstering learning persistence and performance (Aust et al., 2023; Regueiro et al., 2015). It can be surmised that students' favorable responses stem from the alignment of the educational materials with their expressed needs in the Define stage, particularly in terms of integrating digital resources, practical case studies, and applications relevant to real-world data analysis.

From an educational perspective, merging literacy-based content with Quantum Teaching methodologies effectively addresses two pivotal challenges within higher education. First, it bridges the theory-practice divide by providing applied, context-specific exercises that are essential for skill mastery in complex subjects such as nutrition data analysis. Secondly, it enhances students' data literacy, a critical competency for evidence-based practices in public health and clinical nutrition settings (Regueiro et al., 2015). These outcomes suggest versatility in the approach, indicating that similar methodologies could be beneficial for other nutrition-related courses demanding intricate data handling, such as nutritional epidemiology, dietetics, and community nutrition. Future research endeavors should focus on larger-scale implementations encompassing multiple classes and institutions. Additionally, investigations should explore the long-term retention of knowledge and skills acquired through these innovative educational methods (Permata et al., 2023; Verdian, 2024).

CONCLUSION

This study confirms that the development of literacy-based teaching materials integrated with Quantum Teaching principles can effectively enhance student engagement, comprehension, and overall learning satisfaction in the Food and Nutrition Data Analysis course. The materials were found to be of high quality and feasible for use, as supported by expert validation and positive student feedback.

The integration of literacy-oriented content with an interactive, structured, and context-driven teaching approach proved successful in bridging the gap between theory and practice, while also fostering essential data literacy skills in nutrition students. This pedagogical model offers a promising strategy for improving learning outcomes in other nutrition-related courses that demand analytical competencies. Broader application and continued evaluation are encouraged to further optimize its impact in diverse educational settings.

This study has several limitations that should be acknowledged. The evaluation was restricted to a small-group trial, preventing long-term assessment of learning retention and broader classroom effectiveness. Moreover, the reliance on self-reported questionnaires may introduce response bias. Future studies involving larger, more diverse samples and longitudinal evaluations across multiple courses are recommended to strengthen the external validity and sustainability of the results.

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