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ORIGINAL

The Dragon Fruit Advantage: Exploring University Students' Experiences and Perceptions of a Targeted Nutrition Education Module

La Ventaja del Fruto del Dragón: Exploración de las Experiencias y Percepciones de Estudiantes Universitarios sobre un Módulo de Educación Nutricional Específico

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ABSTRACT

Introduction: nutrition literacy plays a vital role in shaping healthy dietary habits, particularly among university students who are developing lifelong food behaviors. Functional foods such as dragon fruit provide a culturally relevant entry point for improving students' understanding of nutrition and promoting healthier eating patterns.
Objective: to evaluate the effectiveness of a Dragon Fruit Nutrition Education Module in enhancing nutrition literacy and improving dietary behaviors among university students.
Method: a mixed-methods design was used with fifty students participating in a multimodal intervention that integrated classroom instruction, hands-on cooking workshops, and digital reinforcement through mHealth tools. Nutrition literacy—comprising functional, interactive, and critical components—was assessed pre- and post-intervention. Dietary behaviors were examined through changes in fruit intake, dragon fruit consumption, and reliance on take-out meals. Qualitative feedback was analyzed using thematic analysis to understand student experiences and contextual factors.
Results: the intervention led to notable improvements in overall nutrition literacy, reflected in enhanced comprehension of nutrition information, improved communication of healthy eating concepts, and stronger critical evaluation skills. Students also reported positive dietary behavior changes, including increased fruit consumption, more frequent inclusion of dragon fruit in meals, and reduced dependence on convenience foods. Qualitative findings highlighted increased awareness, high engagement through experiential learning, motivation to adopt healthier behaviors, effective technological reinforcement, and environmental facilitators and barriers.
Conclusion: the module effectively strengthened nutrition literacy and encouraged healthier eating habits among university students. Its experiential and technology-supported design demonstrates strong potential for integration into university-based nutrition education programs.

Keywords: Nutrition Literacy; Dragon Fruit; Dietary Behavior; University Students; Food Education; Functional Foods.

RESUMEN

Introducción: la alfabetización nutricional desempeña un papel fundamental en la formación de hábitos alimentarios saludables, especialmente entre los estudiantes universitarios que están desarrollando

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comportamientos alimentarios para toda la vida. Los alimentos funcionales, como el fruto del dragón, ofrecen un punto de partida culturalmente relevante para mejorar la comprensión de la nutrición y promover patrones de alimentación más saludables.
Objetivo: evaluar la eficacia de un Módulo de Educación Nutricional sobre el Fruto del Dragón para mejorar la alfabetización nutricional y los comportamientos dietéticos entre estudiantes universitarios.
Método: se utilizó un diseño de métodos mixtos con cincuenta estudiantes que participaron en una intervención multimodal que integró instrucción en el aula, talleres prácticos de cocina y refuerzo digital mediante herramientas de mHealth. La alfabetización nutricional—compuesta por componentes funcionales, interactivos y críticos—se evaluó antes y después de la intervención. Los comportamientos dietéticos se examinaron mediante cambios en la ingesta de frutas, el consumo de fruto del dragón y la dependencia de comidas para llevar. La retroalimentación cualitativa se analizó mediante análisis temático para comprender las experiencias de los estudiantes y los factores contextuales.
Resultados: la intervención generó mejoras notables en la alfabetización nutricional general, reflejadas en una mayor comprensión de la información nutricional, una mejor comunicación de conceptos de alimentación saludable y habilidades más sólidas de evaluación crítica. Los estudiantes también reportaron cambios positivos en sus comportamientos dietéticos, incluyendo un aumento en el consumo de frutas, una inclusión más frecuente del fruto del dragón en las comidas y una menor dependencia de alimentos de conveniencia. Los hallazgos cualitativos destacaron una mayor conciencia, alto compromiso a través del aprendizaje experiencial, motivación para adoptar hábitos más saludables, refuerzo tecnológico efectivo y facilitadores y barreras ambientales.
Conclusión: el módulo fortaleció eficazmente la alfabetización nutricional y fomentó hábitos alimentarios más saludables entre los estudiantes universitarios. Su diseño experiencial y apoyado por tecnología demuestra un fuerte potencial para su integración en programas universitarios de educación nutricional.

Palabras clave: Alfabetización Nutricional; Fruto del Dragón; Comportamiento Dietético Estudiantes Universitarios; Educación Alimentaria; Alimentos Funcionales.

INTRODUCTION

Nutrition literacy—commonly defined as the capacity to access, understand, evaluate, and apply nutrition information to support informed dietary decisions—has gained prominence as a determinant of health in increasingly complex food environments.[1,2] Yet despite widespread exposure to nutrition messages, many individuals struggle to translate information into practice, suggesting that nutrition literacy encompasses more than knowledge acquisition; it also reflects critical appraisal skills and the ability to navigate competing sources of dietary guidance. University students exemplify this challenge. As young adults transitioning to autonomous living, they frequently encounter structural and psychosocial barriers to healthy eating, including limited food budgets, time constraints, and pervasive marketing of convenience foods.[3,4]

Evidence consistently demonstrates that this population exhibits gaps not only in dietary knowledge but also in the application of that knowledge—manifested in low fruit and vegetable intake, suboptimal meal planning, and patterns linked to long-term non-communicable disease risk.[5,6] However, much of the existing research treats “nutrition literacy” in generalized terms, often overlooking how students engage with specific foods, particularly those that are culturally relevant, nutritionally dense, or underutilized despite potential health benefits. This gap limits our understanding of how nutrition literacy operates in real-world decision-making.

By shifting from broad assessments of dietary knowledge to a focused examination of students’ understanding and perceptions of particular nutrient-rich foods—such as dragon fruit—research can more effectively illuminate where misconceptions arise, how food-specific literacy shapes consumption behavior, and what targeted educational strategies may be needed.

Globally, there has been growing recognition that food literacy—encompassing the knowledge, skills, and behaviors needed to select, prepare, and consume food—plays a central role in supporting healthier dietary patterns.[7,8] Among university students, improving nutrition literacy has been associated with a range of positive behaviors, including higher fruit intake, reduced dependence on take-out foods, and improved meal planning abilities.[9,10] Cross-sectional studies across diverse contexts such as China, Saudi Arabia, and Korea similarly show that greater nutrition literacy corresponds to healthier dietary practices within this population.[7,11,12] However, much of this work conceptualizes nutrition literacy at a broad, abstract level, leaving unanswered questions about how students engage with specific foods and how targeted, food-focused interventions can catalyze tangible dietary change.

Against this backdrop, dragon fruit (Hylocereus spp.) offers a strategic case for investigation. Although not the only nutrient-rich fruit available, it is a culturally relevant, regionally accessible, and economically

important commodity in many Asian settings—yet remains underutilized by young adults. Nutritionally, dragon fruit provides a distinct profile of antioxidants, fiber, vitamin C, and bioactive compounds linked to metabolic health benefits.[13] Despite these attributes, intake among university students is low, often due to limited awareness, misconceptions about its nutritional value, and unfamiliarity with how to prepare or incorporate it into daily meals.[14] These characteristics make dragon fruit an illustrative example of how gaps in food literacy extend beyond general knowledge to the practical, evaluative, and applied dimensions of nutrition literacy.

Focusing on a single food such as dragon fruit is therefore not an arbitrary choice but a deliberate strategy to interrogate how students translate nutrition information into practice. A targeted module allows researchers to (1) examine specific barriers and misconceptions that broad nutrition literacy measures may obscure, and (2) identify whether deepened understanding of one nutrient-dense, culturally relevant food can prompt broader engagement with healthy eating. In this sense, modules centered on specific foods can serve "dual purposes": they both enhance general food literacy through concrete, experiential learning and simultaneously drive realistic, achievable dietary behavior change.[15]

Nutrition education interventions in higher education increasingly employ multimodal formats—combining lectures, hands-on activities, and technology-enabled tools—to achieve these outcomes.[16] mHealth applications, interactive digital modules, and collaborative learning environments have been shown to improve engagement and reinforce nutrition knowledge.[17] For example, Schaafsma et al.[4] found that student-centered mHealth interventions enhanced comprehension and supported sustained behavior change, underscoring the potential of integrating digital pedagogies into targeted, food-specific nutrition education programs.

Despite growing evidence supporting food literacy interventions, significant gaps remain in programs designed for university students. Many existing initiatives rely on generic nutrition education that does not reflect the cultural food environments or dietary norms of the populations they target, limiting their relevance and impact.[18] In contrast, the present study addresses this limitation by centering its instructional content on dragon fruit—a food that is regionally familiar, widely available in local markets, and embedded in the culinary landscape of many Asian communities, yet still underutilized by young adults. This context-specific focus allows the module to engage students with a food they are likely to encounter in daily life, thereby enhancing cultural resonance and increasing the potential for real-world applicability.

Furthermore, while prior interventions often emphasize knowledge acquisition, they tend to overlook experiential learning—such as hands-on preparation, sensory evaluation, and practical skill-building—that is critical for translating understanding into sustained dietary behavior. The module in this study incorporates structured experiential components that guide students from conceptual knowledge to practical engagement with the food itself, addressing a gap in earlier programs that relied predominantly on didactic formats.

A second methodological limitation in the literature is the prevalence of short-term evaluations that measure immediate post-intervention gains but fail to capture whether behavior changes persist over time.[18] To improve upon these approaches, this study employs a longitudinal assessment framework, collecting follow-up data at multiple time points to track changes in knowledge, attitudes, and self-reported consumption patterns. This design allows for a more rigorous examination of the durability of the intervention's effects and provides insight into how students integrate the learned skills into their evolving dietary routines.

Finally, qualitative inquiry has been underutilized in past evaluations, resulting in limited understanding of the subjective factors that shape students' engagement with nutrition education.[19] By incorporating qualitative components—such as open-ended feedback and reflective prompts—this study captures the nuanced experiences, motivations, and perceived barriers that quantitative measures alone cannot reveal. These insights help elucidate the mechanisms through which culturally grounded, experiential nutrition modules influence long-term behavior, thereby addressing a critical gap in the existing evidence base. Addressing these gaps, this study investigates the Dragon Fruit Nutrition Education Module, a targeted intervention designed to enhance nutrition literacy, practical food preparation skills, and dietary behaviors among university students.

The overarching objective of this study was to evaluate the impact of a dragon fruit–focused nutrition education module on university students' nutrition literacy and related dietary behaviors. To achieve this objective, the study examined not only changes in students' fruit consumption patterns but also their perceptions and experiences of engaging with the module, providing a comprehensive understanding of how the intervention influenced knowledge application, motivation, and practical dietary decision-making. By integrating quantitative and qualitative approaches, this research contributes to the growing literature on food literacy interventions in higher education and offers evidence-based insights for curriculum development, health promotion efforts, and policy initiatives aimed at fostering healthier eating habits among young adults.[20,21]

LITERATURE REVIEW

Nutrition literacy is a multidimensional construct encompassing functional, interactive, and critical competencies needed to understand and use nutrition information effectively.[22] University students are

particularly vulnerable to suboptimal nutrition literacy due to major lifestyle transitions, increased autonomy, varied food choices, and limited structured guidance on healthy eating.[23] Global data continue to show rising levels of poor dietary habits among young adults, including high intake of processed foods and low consumption of fruits and vegetables, contributing to overweight and obesity trends worldwide. In the Philippines, the Expanded National Nutrition Survey similarly reports that fruit and vegetable intake among adolescents and young adults remains below recommended levels, indicating a national concern that warrants targeted interventions.

Evidence from Korea, China, and Saudi Arabia demonstrates that university students with higher nutrition literacy tend to exhibit healthier behaviors, such as reduced fast-food consumption, greater fruit and vegetable intake, and more positive attitudes toward meal planning and food preparation.[7,8,11] However, Ko et al.[1] noted persistent knowledge gaps in nutrient sources, portion sizes, and food safety among university learners, emphasizing the need for structured, campus-based programs. Sociodemographic factors—gender, socioeconomic status, and prior nutrition education—also shape nutrition literacy and food choice behaviors, as shown by Guiné et al.[7] High nutrition literacy not only predicts healthier consumption patterns but also supports students' ability to navigate complex food environments and critically assess digital nutrition information.[10]

The effectiveness of nutrition education initiatives has been widely documented. Manna et al.[5], in a scoping review, found that interventions focused on university students significantly improved food literacy, cooking confidence, and healthy eating behaviors. Jeong et al.[2] similarly reported that a 10-week multimodal nutrition education program resulted in measurable increases in fruit and vegetable intake and reductions in processed-food reliance. Yıldırım et al.[10] evaluated a structured Food Literacy Program that yielded gains in knowledge, confidence in meal preparation, and healthier dietary patterns. Consistently, experiential learning strategies—such as cooking workshops, interactive meal planning, and collaborative learning activities—are shown to reinforce nutrition knowledge and help students apply concepts in real-life contexts.[24,25] Watras[12] demonstrated that a "College Cooking Connection" workshop improved both perceived and actual cooking competence, while Ko et al.[16] highlighted the role of hands-on and peer-supported learning experiences in supporting long-term behavior change.

Technology-assisted nutrition education has emerged as an accessible and flexible approach for university populations. Schaafsma et al.[23] examined an mHealth food literacy intervention and found that students valued mobile apps and interactive online tools for monitoring their dietary habits and reinforcing nutrition concepts. In a similar vein, Russell et al.[28] reported that co-designed digital learning resources improved engagement and understanding among students. These technology-based interventions complement traditional instruction by offering self-paced learning, continuous feedback, and long-term tracking of dietary behaviors.[29]

Targeted, food-specific interventions also show promise. Dragon fruit, noted for its high antioxidant, fiber, and micronutrient content, serves as a relevant and culturally familiar example that can be used to teach nutrient density, dietary diversity, and practical meal planning.[30] Royer et al.[6] emphasized that food-specific literacy modules increase students' awareness and motivation to adopt healthier dietary patterns. Integrating dragon fruit into cooking demonstrations, tasting activities, and meal-planning sessions aligns with experiential learning principles and may enhance student engagement and long-term knowledge retention.[31]

Despite growing research on nutrition literacy and food literacy interventions, gaps remain in understanding how targeted, culturally relevant strategies can support university students' dietary behaviors. Given the increasing burden of poor nutrition in this age group, both globally and nationally, examining students' nutrition literacy is essential for designing effective educational interventions.

Accordingly, this study aims to determine the nutrition literacy of university students and to explore how food-specific, experiential strategies—such as the use of dragon fruit—may inform the development of relevant nutrition education programs.

The design of nutrition education interventions is increasingly informed by food literacy frameworks, emphasizing functional knowledge, critical thinking, and behavioral application.[32] Silva[3] grounded the theoretical rationale for enhancing students' food literacy, arguing that interventions should integrate practical cooking skills, food selection competence, and critical evaluation of nutrition information. Shakibazadeh et al.[13] and Omidvar et al.[14] further highlighted the importance of structured, pedagogically sound interventions in promoting literacy outcomes, noting that effective programs blend knowledge acquisition with skill development and behavioral reinforcement.

By synthesizing quantitative and qualitative evidence, the present study aims to contribute to these frameworks by examining not only knowledge gains but also the lived experiences and perceptions of students participating in a dragon fruit–focused nutrition education module. This dual focus ensures that interventions are both effective and contextually meaningful, addressing barriers to healthy eating while fostering motivation, self-efficacy, and sustainable dietary behavior change.

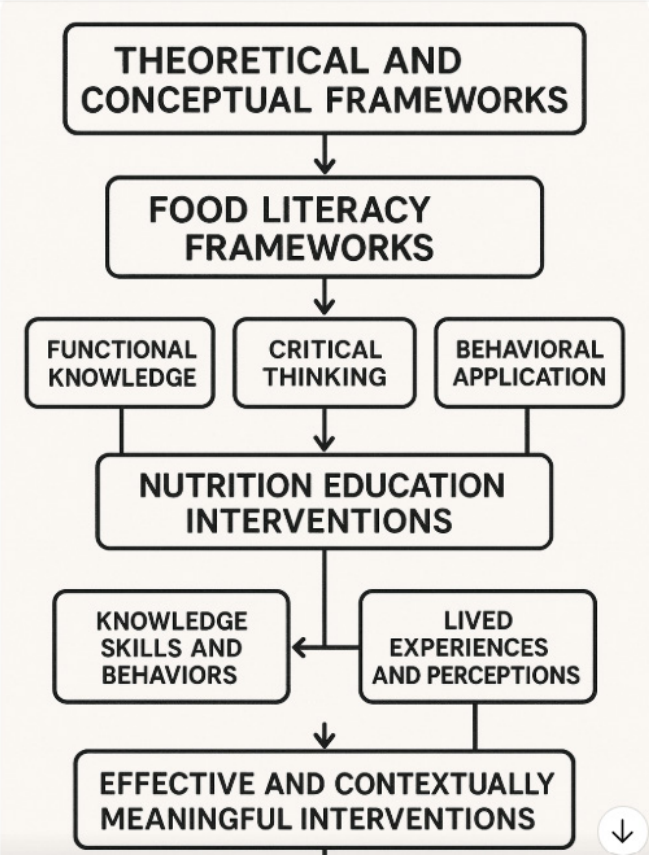

Figure 1. Theoretical and Conceptual Framework of the Study

METHOD

The intervention consisted of three interconnected components—lecture-based instruction, experiential workshops, and mHealth support—designed to enhance students' nutrition literacy and dietary behaviors. The lecture sessions covered core nutrition concepts, including macronutrients and micronutrients, reading nutrition labels, understanding dietary guidelines, and identifying common nutrition-related misconceptions. These sessions established the foundational knowledge upon which the subsequent workshop and mHealth components were built.

The experiential workshops aimed to translate theoretical concepts into practical skills. Each workshop had clearly defined learning objectives, such as: (1) applying nutrition label interpretation to real food products; (2) evaluating daily meal choices using a simplified dietary assessment tool; and (3) preparing nutritionally balanced meal plans in small groups. Collaborative learning was intentionally structured through rotating peer groups, role-assigned tasks, and guided reflection prompts to promote interaction and shared problem-solving. The trust and rapport built during these collaborative activities informed the design of the focus group guides, ensuring that questions encouraged open, candid discussion about students' perceptions and experiences.

The mHealth component delivered weekly nutrition reminders, short quizzes, and infographic-style nutrition tips through a mobile messaging platform (e.g., Messenger or Viber). These materials reinforced workshop learning and encouraged daily application of nutrition principles. To evaluate the engagement and knowledge retention facilitated by this mHealth support, the post-intervention NLAQ included specific items assessing how students applied nutrition information using digital tools, thereby ensuring alignment between the intervention content and outcome measures.

To maintain intervention fidelity, all facilitators followed standardized lesson plans, workshop scripts, and checklists developed for each session. A fidelity monitoring form was completed after every session to document adherence to planned activities, time allocation, and delivery consistency across groups. This procedure ensured that all participants received the same structured intervention and minimized variability in implementation.

Study Design

This study employed a mixed-methods design to evaluate the effectiveness of a targeted dragon fruit nutrition education module for university students. The study employed a mixed-methods design that integrated pre- and post-intervention quantitative assessments of nutrition literacy and dietary behavior with qualitative inquiry into students' learning experiences. The intervention delivered standardized instruction

on core nutrition concepts—such as macronutrient and micronutrient functions, interpreting Nutrition Facts labels, and principles of balanced meal planning—guided by explicit learning objectives for each workshop session. Interactive workshops emphasized applied tasks (e.g., analyzing food labels, constructing healthy meal sets), while collaborative learning was structured through small peer groups assigned to solve nutrition-related case scenarios. The mHealth component was implemented through a dedicated mobile learning platform that provided daily reminders, short educational videos, and self-monitoring prompts. Intervention fidelity was ensured through session checklists, facilitator training, and uniform instructional materials so that all participants received the same content and pacing. This approach allowed for triangulation of findings, providing a comprehensive understanding of both knowledge acquisition and behavioral adoption.[27]

Participants

"A total of 50 undergraduate students participated in the study. A non-probability convenience sampling method was used, with the sample size estimated based on logistical feasibility and the sample ranges reported in similar intervention studies.[32] Participants were recruited through official university email announcements, classroom invitations, and posted study flyers across campus. Although the sample was drawn from a mid-sized Philippine university, the use of convenience sampling introduces potential selection bias and limits external validity; this limitation is acknowledged. A complete demographic table—including mean age, sex distribution, academic year level, and degree program—will be provided in the Results section to describe participant characteristics" students from a mid-sized Philippine university participated in the study. Inclusion criteria included: aged 18–25 years, enrollment in any undergraduate program, willingness to participate in the module, and no pre-existing dietary restrictions that would prevent consumption of dragon fruit or participation in cooking activities. Demographic data collected included age, sex, academic year, living situation, and prior exposure to nutrition education.[29]

Quantitative Measures

Nutrition Literacy Assessment

Participants completed the Nutrition Literacy Assessment Questionnaire (NLAQ)[17] before and after the intervention. The study used the university-adapted version of the NLAQ, which assesses functional, interactive, and critical nutrition literacy across multiple domains using a 5-point Likert scale. The NLAQ has been validated in previous Asian university samples; however, to ensure appropriateness for this population, the instrument underwent content validation by two Filipino nutrition experts prior to data collection. In the present study, internal consistency reliability was assessed, yielding a Cronbach's alpha of 0,89, indicating high internal reliability. A detailed description of the subscales and scoring procedures is included in the supplementary materials.

Dietary Behavior

Dietary behavior was measured through a validated dietary recall questionnaire[11,20] adapted for university students. The instrument was based on a 7-day dietary recall period, asking participants to report the frequency of fruit intake, variety of fruits consumed, and portion size estimates. Dragon fruit consumption was captured using a dedicated item asking respondents to specify (a) frequency of intake within the past week, (b) typical serving size, and (c) mode of consumption, allowing a more precise quantification of dragon fruit–specific dietary behavior. The original source instrument is identified in the references, and minor cultural adaptations (examples of locally available fruits, inclusion of Philippine food serving guides) were applied to enhance relevance and clarity.

Qualitative Measures

Semi-structured focus group discussions (FGDs) were conducted post-intervention with 6–8 participants per group. Discussions explored participants' perceptions of module content, engagement, changes in knowledge and behaviors, and barriers or facilitators to healthy eating.[32] FGDs were audio-recorded, transcribed verbatim, and anonymized.

Qualitative Analysis Plan

Qualitative data were analyzed using thematic analysis following Braun and Clarke's six-phase framework, implemented with explicit methodological transparency. The analysis adopted an inductive, semantic approach, allowing themes to emerge from participants' accounts rather than imposing a pre-existing coding structure. Coding and theme development were conducted by two independent researchers trained in qualitative analysis, who first engaged in familiarization, initial coding, and iterative theme refinement. Discrepancies in coding were resolved through consensus meetings, and an audit trail was maintained to document analytic decisions and ensure dependability.

To enhance trustworthiness, the team employed peer debriefing, regular reflexive discussions on researcher

positionality, and verification of theme coherence against the full dataset. Final themes were supported by representative verbatim excerpts.

Data Analysis

Quantitative data were analyzed using SPSS v28. Pre- and post-intervention differences in nutrition literacy scores and fruit consumption were evaluated using paired t-tests. Descriptive statistics summarized demographic characteristics and frequency distributions.

Qualitative data were analyzed using thematic analysis, following Braun and Clarke's six-step process: familiarization, coding, theme development, reviewing, defining, and reporting.[32] Triangulation of quantitative and qualitative findings ensured comprehensive interpretation.

Ethical Considerations

This study complied with institutional and national ethical standards for research involving human participants. All research procedures adhered to the principles of the Declaration of Helsinki and the Philippine National Ethical Guidelines for Health and Health-Related Research (2017). Before recruitment, students were informed of the study's objectives, the nature of the nutrition literacy intervention, expected activities (pre-post surveys, workshops, and mHealth components), potential risks, and anticipated benefits. Participation was strictly voluntary. Written informed consent was obtained from all participants, and for those below 18 years old, parental consent and student assent were secured in accordance with institutional policy.

RESULTS

Participant Characteristics

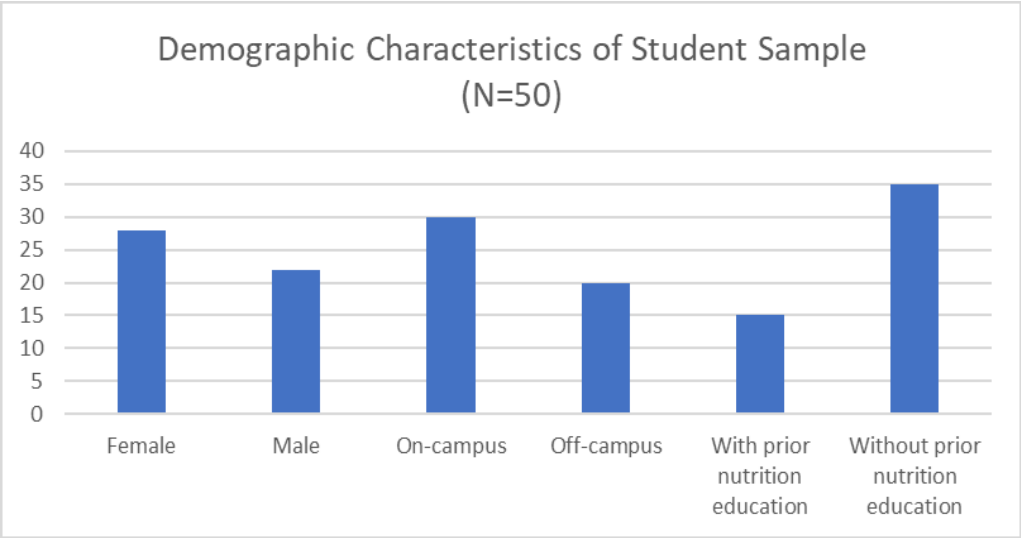

Figure 2. Demographic Characteristic of Student Sample

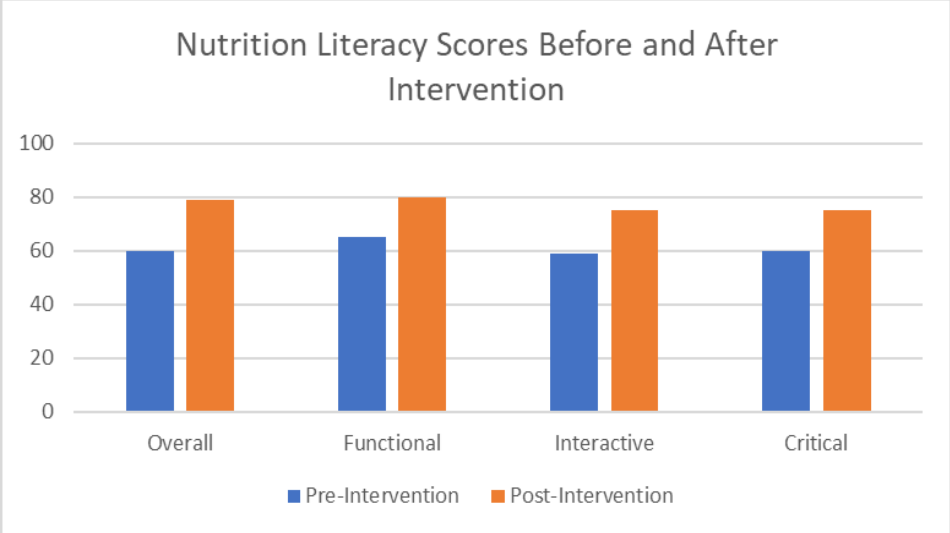

Figure 3. Nutrition Literacy Scores Before and After Intervention

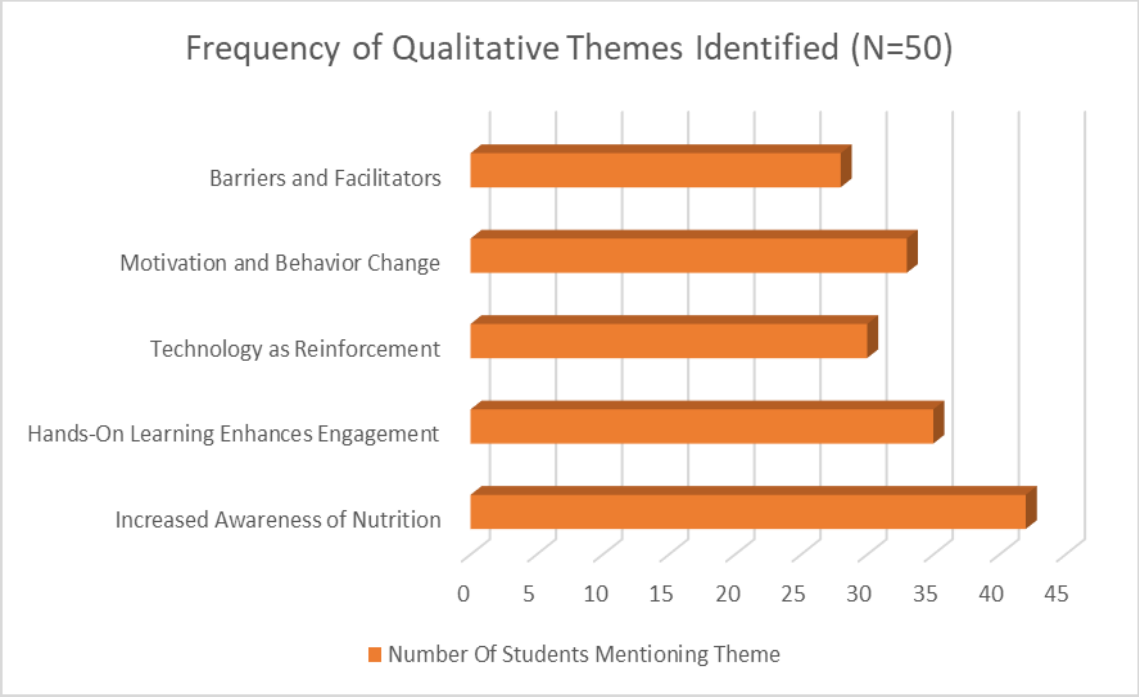

Figure 4. Frequency of Qualitative Themes Identified

The study shows that the nutrition education module effectively improved students' nutrition literacy and dietary behaviors. The quantitative findings demonstrate consistent gains across functional, interactive, and critical literacy, indicating that the intervention strengthened students' ability to understand, use, and evaluate nutrition information. These improvements suggest that a structured, multimodal approach can meet university learners' cognitive and behavioral needs more effectively than traditional lecture-based formats.

Interpretation of Literacy Improvements

The marked increase in overall nutrition literacy indicates that students responded well to the module's design. Unlike programs that focus only on factual knowledge, this intervention incorporated hands-on activities, peer interaction, and digital components, which together acted as mutually reinforcing learning mechanisms. The pattern of improvements across all three literacy domains supports the idea that multidimensional learning opportunities allow students to integrate information more deeply and meaningfully. Studies on university-based interventions have reported similar literacy gains, particularly when programs provide opportunities to apply knowledge through active participation.[22,24]

Theoretical frameworks help explain these observed effects. The Health Belief Model suggests that individuals adopt healthier behaviors when they perceive clear benefits and reduced barriers; increased literacy strengthens both perceptions. Social Cognitive Theory further posits that self-efficacy, modeling, and reinforcement drive behavioral adoption. In this study, students engaged with content in concrete ways—preparing recipes, interpreting labels, and discussing food choices—which likely enhanced confidence and personal agency. These mechanisms help explain why the intervention produced both cognitive improvements and measurable changes in dietary behavior.

Integration of Experiential Learning

Students consistently described hands-on cooking workshops as the most engaging component of the module. Their reflections show that these activities helped them understand how to prepare nutrient-dense meals and experiment with new foods such as dragon fruit. These experiences illustrate how experiential learning fosters motivation, retention, and confidence. By moving beyond passive intake of information, students practiced real-world skills that translated into healthier eating behaviors. This aligns with evidence showing that experiential and collaborative learning environments enhance self-efficacy and behavior change among young adults.

The intervention also incorporated social learning processes. Peer demonstrations, group discussions, and shared recipe preparation acted as opportunities for social modeling, consistent with Social Cognitive Theory. These activities supported students in observing, imitating, and internalizing healthy practices. As participants gained confidence, they became more willing to try new foods and modify their eating patterns, demonstrating the value of social reinforcement in nutrition education.

Role of Digital Reinforcement

The digital components—mHealth quizzes, recipe videos, and reminders—played an important role in reinforcing learning beyond formal sessions. Students reported that app notifications encouraged them to include fruits in their meals more consistently, while recipe videos helped them recall preparation steps. These findings reflect broader evidence that digital tools can strengthen habit formation by providing timely cues, feedback, and scaffolding. The integration of technology thus ensured continuity between structured learning and daily dietary decision-making, reinforcing the translation of literacy gains into behavior.

Behavior Change and Functional Food Literacy

The increase in fruit intake, especially dragon fruit consumption, shows that students applied their learning to their everyday diets. By focusing on a locally available, nutrient-rich food, the intervention provided a culturally relevant example that students could easily adopt. Improved functional food literacy enabled students to understand nutrient content, assess health claims, and make informed decisions about including functional foods in their diet. This mirrors findings that higher nutrition literacy is associated with more frequent intake of fruits and nutrient-dense foods.[7,8,9]

The reduction in take-out meal reliance further illustrates the translation of knowledge into action. After learning about the nutritional limitations of convenience foods and practicing healthier alternatives, students were better able to evaluate their choices and adjust their habits. Similar studies have reported reduced take-out consumption following structured nutrition programs, emphasizing the importance of interventions that pair knowledge with practical application.[1,2]

Contextual Barriers and Facilitators

The qualitative findings also highlight important contextual influences. Students noted that fruit cost and availability affected their decisions, while peer support often encouraged healthier choices. These insights underline the need for interventions that consider environmental and social facilitators. Addressing barriers through affordable food options, accessible recipes, and supportive peer environments may enhance intervention sustainability and reach.

Contribution to Literature

This study contributes to existing research by showing that literacy gains across functional, interactive, and critical domains can occur within a short intervention when activities are intentionally sequenced. Earlier work often reports improvements primarily in functional literacy,[32] but the present findings demonstrate that multimodal strategies can also cultivate higher-order skills such as critical evaluation and informed decision-making. The study also clarifies how experiential, social, and digital components operate as mechanisms that support literacy and behavior change, thereby refining current understandings of effective program design.

Public Health and Educational Implications

The improvements in literacy and dietary behaviors have important implications. University students are at a developmental stage characterized by autonomy, academic stress, and irregular eating patterns. Strengthening their nutrition literacy may help them establish healthier habits that persist into adulthood. The results also suggest that embedding short, evidence-based nutrition modules into general education curricula can contribute to long-term well-being among university populations. Promoting functional foods within such modules may further support sustainable dietary improvements.

Future Research

Future studies should examine whether the literacy and behavioral improvements observed here are sustained over time, particularly as students encounter new dietary contexts and responsibilities. Longitudinal research could assess whether increased literacy predicts healthier dietary patterns or biomarkers of health. Expanding the intervention to more diverse student populations and testing digital-only or hybrid versions may also help determine scalability and cost-effectiveness. Finally, exploring community partnerships and environmental supports could strengthen the reach and impact of university-based nutrition programs.

Implications for Higher Education

The findings of this study underscore the feasibility and effectiveness of integrating food literacy modules into university curricula. By embedding structured nutrition education within higher education programs, institutions can equip students with the knowledge, skills, and confidence to make informed dietary choices. Targeting specific nutrient-rich foods, such as dragon fruit, enhances both the relevance and practicality of interventions.[30] Focusing on culturally and locally available functional foods allows students to immediately apply knowledge in daily contexts, bridging the gap between theoretical understanding and real-life behavior.

The results also suggest that multimodal interventions are particularly effective in promoting engagement and sustaining behavior change. Combining classroom-based instruction with hands-on workshops and digital components, such as mHealth quizzes and recipe videos,[24,28] provides multiple learning pathways that reinforce knowledge and support skill development. Hands-on experiences, such as cooking demonstrations, strengthen self-efficacy, while digital tools offer ongoing reinforcement and facilitate self-monitoring outside formal sessions. Such integrated approaches align with experiential learning theory and Social Cognitive Theory, which highlight the importance of active participation, observation, and self-efficacy in achieving lasting behavior change.

Beyond curriculum design, the findings have practical implications for institutional policies aimed at promoting healthy eating. Policymakers and university administrators may consider strategies such as subsidized fruit provision, campus gardening initiatives, or peer mentoring programs to increase accessibility and affordability of nutrient-rich foods. These structural supports can address barriers identified by students, such as cost and availability, ensuring that literacy gains translate into consistent, sustainable dietary behaviors. Peer mentoring, in particular, may leverage social influence to encourage positive eating habits and reinforce knowledge through shared practices and accountability.

Furthermore, integrating food literacy programs into university settings has broader public health implications. Early adulthood is a critical period for establishing lifelong dietary habits, and improving nutrition literacy at this stage can contribute to reduced risk of non-communicable diseases, better weight management, and overall well-being. By fostering both cognitive and behavioral competencies, universities can play a pivotal role in shaping healthier communities, promoting preventive health, and enhancing the impact of functional foods within the diet.

Overall, the study demonstrates that well-designed, contextually relevant nutrition interventions can be both feasible and effective within higher education institutions. By combining classroom instruction, experiential learning, and digital reinforcement and by addressing structural and social facilitators, universities can meaningfully improve students' nutrition literacy and dietary behaviors. These findings provide a strong rationale for scaling such programs and integrating them into broader institutional and public health strategies aimed at promoting lifelong healthy eating habits.

The Dragon Fruit Nutrition Education Module demonstrated significant effectiveness in enhancing both nutrition literacy and dietary behaviors among university students. Participants demonstrated substantial improvements in functional, interactive, and critical literacy, reflecting an enhanced ability to comprehend nutritional information, apply knowledge in daily life, communicate effectively with peers, and critically evaluate health claims. These literacy gains translated into meaningful behavioral changes, including higher frequency of dragon fruit consumption, increased overall fruit intake, and reduced reliance on take-out meals. The alignment of knowledge and practice underscores the potential for targeted, well-structured interventions to facilitate sustainable dietary improvements in young adults.

The success of the module can be attributed to its multimodal, student-centered approach. Hands-on cooking workshops provided experiential learning opportunities that enhanced engagement, built self-efficacy, and encouraged practical application of nutrition concepts. Digital reinforcement through mHealth tools, quizzes, and recipe videos offered continual support, promoting self-monitoring and habit formation beyond structured sessions. Collaborative learning activities and peer engagement further reinforced motivation, social support, and knowledge sharing, highlighting the importance of an interactive and socially contextualized framework for promoting healthy eating behaviors.

Beyond immediate outcomes, the module offers a scalable and feasible model for integration into higher education curricula. By targeting nutrient-rich, locally available functional foods such as dragon fruit, institutions can enhance relevance, accessibility, and student motivation while fostering broader food literacy competencies. This approach aligns with contemporary pedagogical strategies that emphasize experiential, practical, and technology-supported learning as critical components of effective health promotion interventions.

Future research should expand participant reach to diverse university populations, incorporate longitudinal follow-up to assess long-term adherence, and explore the integration of similar modules into formal academic programs. Additionally, addressing environmental and structural factors, such as food availability, cost, and peer support, may further optimize intervention effectiveness. Overall, the Dragon Fruit Nutrition Education Module demonstrates that carefully designed, multimodal nutrition education can meaningfully enhance literacy, encourage healthier dietary behaviors, and provide a practical framework for fostering lifelong food literacy among young adults.

CONCLUSION

This study demonstrates that a structured, multimodal nutrition education module can significantly improve university students' nutrition literacy and dietary behaviors. The intervention produced substantial gains across functional, interactive, and critical literacy, showing that students not only acquired factual knowledge but

also developed skills needed to communicate, evaluate, and apply nutrition information in daily life. These cognitive improvements translated into meaningful behavioral changes, including increased fruit consumption—particularly dragon fruit—and reduced reliance on take-out meals. The findings show that even short, targeted programs can shape healthier eating patterns when they integrate experiential activities, peer engagement, and digital reinforcement.

By focusing on a locally available functional food, the module also enhanced students' understanding of nutrient-dense options within their cultural context, demonstrating the value of contextually relevant strategies in university-based interventions. The results suggest that higher education institutions can play a critical role in strengthening young adults' health literacy by embedding evidence-based nutrition education into general curricula.

Future studies should examine the long-term retention of literacy and behavioral gains, explore their potential effects on health outcomes, and test the scalability of multimodal interventions across diverse student populations. Continued refinement of nutrition education that combines cognitive, experiential, and digital components may support sustainable dietary habits and contribute to improved public health outcomes among young adults.

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