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ENHANCING GREEN FOOD INTENTION AND CREATIVITY THROUGH PROBLEM-BASED LEARNING INTEGRATED WITH SCAFFOLDED NUTRITION AMONG PRE-SERVICE SCIENCE TEACHERS

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ABSTRACT

This study aims to determine the effect of the implementation of Problem-Based Learning through Scaffolded Nutrition (PBL-SN) on increasing green food intention and creativity in pre-service science teachers to support SDGs, the effect of the implementation of PBL-SN in developing creativity in the context of sustainable food consumption in pre-service science teachers, and whether there is a significant relationship between green food intention and creativity of pre-service science teachers after participating in PBL-SN based learning. The novelty of the research lies in integrating PBL with Scaffolded Nutrition as a specific instrument to simultaneously increase Creativity and Green Food Intention among pre-service science teachers, thereby supporting SDGs 2, 3, and 12. This study is a quantitative, quasi-experimental, posttest-only research design. The statistical tests used are t-tests and multiple linear regression. The results of this study show that the green food intention variable has an average EC (M = 3.47) and CC (M = 3.27), with t = -1.841 and Cohen's d = 0.516, indicating a moderate effect. The creativity variable shows that the average EC (M = 87.52) is higher than the average CC (M = 82.76), with t = -4.078 and Cohen's d = 1.141; the effect size is relatively large, indicating that the treatment given to the EC has a strong impact on increasing the creativity of pre-service science teachers. There is a weak positive correlation between creativity and green food intention, suggesting no strong relationship between the two variables in the intervention group.

Keywords: green food intention; creativity; problem-based learning; scaffolded nutrition; SDGs

INTRODUCTION

The global human population is projected to reach 9.7 billion by 2050, significantly increasing the complexity of ensuring safe, nutritious, and healthy food availability. To meet these needs, global food production is projected to increase by more than 50% compared to 2012 levels (FAO, 2017). Rising incomes and improved quality of life in developing countries have driven a surge in demand for animal products and horticultural commodities. However, the pressure on natural resources resulting from this increased demand has led to environmental damage such as soil erosion, biodiversity loss, and pollution, ultimately creating new challenges in the security and sustainability of food systems (Afshin et al., 2019; El-Bilali et al., 2019; Garcia et al., 2020). This situation is driving a shift in consumer preferences toward sustainable food consumption, such as organic and environmentally friendly foods, as awareness of the importance of a healthy diet and its impact on the environment grows.

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Green food, which prioritizes health and sustainability, is seen as a potential solution to addressing the global food crisis. Long-term consumption of conventionally produced foods containing chemical residues is associated with an increased risk of chronic diseases and cancer (John & Babu, 2021), so consumers now tend to choose foods with lower chemical content (Savelli et al., 2019; Siddiqui et al., 2022). Green Food Intention is a concrete action to teach environmentally friendly and sustainable health education in science.

The transformation from conventional to sustainable consumption patterns is a crucial step in addressing future food challenges in a comprehensive, sustainability-oriented manner (Vermeir et al., 2020; Deksne et al., 2025). In this transformation process, Indonesia's role as one of the world's most populous countries with a continuously growing food market cannot be ignored. However, the current structure of the environmentally friendly food industry in Indonesia remains relatively limited, with low added value and a predominance of basic products, thereby failing to fully meet the growing domestic demand for healthy, high-quality, and diverse food (Nasution, 2022). Therefore, encouraging consumers to switch to and choose environmentally friendly food products is of significant strategic importance, not only to support healthier consumption patterns but also as a concrete step toward the sustainability of the national food system amid changing preferences and lifestyles (Davis et al., 2025).

Understanding consumer intentions to adopt green food consumption is a strategic step in encouraging the transition to a sustainable diet. Green food intention is a consumer's intention, attitude, or willingness to purchase and consume food products produced and handled in an environmentally friendly and sustainable manner (Zhu et al., 2013). Consumer intention to purchase green food refers to an individual's willingness or plan to choose food products that are environmentally friendly, sustainable, and safe for health, such as organic, local, and low-synthetic foods (Lile et al., 2023). Green food initiatives support SDGs 2, 3, and 12. This research supports SDGs 2 (Zero Hunger) by identifying factors that encourage consumers to adopt more environmentally friendly food practices, thereby promoting improved nutrition and sustainable food production systems. (Lile et al., 2023). Green food intention is also related to SDG 3 (Good Health and Well-being), as it increases consumption of healthier, safer food, thereby reducing the risk of disease and improving community welfare (Petelos et al., 2025). In addition, Green Food Intention is a sustainable practice in daily routines by reducing the environmental impact of the food system by choosing environmentally friendly foods and reducing food waste as a form of responsibility for preventing environmental pollution, which is an important element of SDGs 12 (Responsible Consumption and Production) (Jacob-John et al., 2021).

Early studies on green food behavior focused largely on demographic factors such as age, income, occupation, and education. Several studies have shown that individuals with higher economic backgrounds, younger age, those with young children, and those living in smaller families tend to be more open to environmentally friendly food consumption (Deng et al., 2024). Meanwhile, most research remains concentrated in developed countries such as the United States (Maniatis, 2016), which has developed more innovative research methods by integrating consumer psychology with technologies such as fMRI (Vezich et al., 2017) and eye-tracking (Ruppenthal, 2023). Even in China, food safety and environmental issues related to food cultivation, processing, and production have become a public concern (Zhu et al., 2013; Hassan et al., 2020). Tanzania and Kenya were also chosen as case studies because both are developed countries known for agricultural production, with several products seeking to enter the organic market. Both countries have promoted organic product projects, such as "Promoting Production and Trading Opportunities for Organic Agricultural Products in East Africa," initiated by the United Nations Conference on Trade and Sustainable Development. The main results indicate that personal attitudes toward health awareness are a significant factor influencing consumer purchase intentions regarding Green Food Intention. The greater the knowledge about Green Food Intention and its benefits for human well-being, the higher the intention to promote the movement (Wang et al., 2019).

On the other hand, in developing countries, including Indonesia, studies on green food consumption remain limited and do not delve deeply into local socio-cultural contexts, especially in higher education (Anyanwu et al., 2023). A bibliometric analysis of ESD integration in science education identified that PBL serves as a natural vehicle for embedding sustainability values through evidence-based reasoning in socio-ecological contexts. However, empirical studies specifically targeting green food consumption in teacher education remain scarce (Rahmawati

et al., 2025). However, university students are a strategic research segment, given their position as the younger generation in the process of forming values and social responsibilities. Students also live in a strong social environment, which strongly influences their consumption behavior. Pre-service science teachers play a role in teaching material related to sustainable diets in the junior high school curriculum. Therefore, research examining green food consumption intentions and behavior among pre-service science teachers can make an important contribution to the design of more effective and relevant educational interventions for Indonesian society. Furthermore, the findings suggest that the comprehensive integration of sustainability learning into the educational curriculum can enhance pre-service teachers' capacity to engage effectively with sustainability issues in an ethno-socio-scientific context. This approach deepens the ethnic, social, and contextual relevance of science concepts, thereby preparing future educators to address sustainability challenges (Novita et al., 2025).

In the context of green food consumption among pre-service science teachers, creativity is a crucial element that can drive changes in consumption behavior toward more sustainable ones (Merritt et al., 2018). Creativity functions not only as the ability to generate new ideas but also as an adaptive mechanism in responding to complex social, economic, and environmental challenges (Mitchell & Walinga, 2017; Souto, 2022). In higher education, students are required to think critically and provide solutions, as well as to integrate cross-disciplinary knowledge to produce consumption decisions that are not only rational but also ecologically sound (Saari et al., 2021). For example, creativity can encourage students to explore healthy food alternatives made from local ingredients (Wang et al., 2021) or even create social campaigns that educate the public about the importance of environmentally friendly food consumption (Närvänen et al., 2018). Furthermore, creativity also plays a role in shaping the identity of environmentally conscious consumers, where students not only follow trends but also become agents of change, influencing their surrounding communities through innovative actions and consumption choices (Shah & Asghar, 2023). Therefore, studies on green food intention need to consider the creativity dimension as a supporting variable, both within a cognitive and affective framework, to strengthen the effectiveness of educational interventions and the promotion of sustainable lifestyles in educational settings (Lian et al., 2025). Sustainable lifestyles support SDGs 2, 3, and 12 (Jacob-John et al., 2021; Lile et al., 2023; Petelos et al., 2025). Such an approach is not only relevant in encouraging transformations towards healthier eating patterns but also strengthens the capacity of the younger generation to create an innovative and competitive food ecosystem in the future.

To optimize the potential of creativity in shaping sustainable food consumption behavior, a learning design is needed that not only stimulates creativity but also systematically guides pre-service science teachers through scientific and reflective thinking processes (Deksne et al., 2025; Fadzilah et al., 2025). In this context, integrating Scaffolded Nutrition into the Problem-Based Learning (PBL) model is an effective strategy. Scaffolded nutrition is a step-by-step nutrition module that includes a calorie and nutrient calculator and an application that calculates calories and nutrients from consumed foods. At the end of the PBL stage, interactive media related to green food exposure support Scaffold Nutrition. Pre-service science teachers are equipped with an in-depth understanding of the basic principles of nutrition, food sustainability issues, and their impacts on health and the environment. Problem-based learning then provides a contextual framework through real-life problems relevant to everyday life, such as dietary imbalances, food waste, or access to healthy food. The scaffolding approach in Problem-Based Learning has a high impact on improving their ability to manage cognitive load and apply systematic problem-solving strategies (Hendrayana & Mutaqin, 2025). PBL learning integrated with scaffolding yields good results because students are more enthusiastic about participating, leading, on average, to increased creative and critical thinking skills (Ernawati et al., 2021). Team collaboration, exploration of information sources, and ongoing reflection in PBL facilitate the internalization of sustainability values while intrinsically strengthening green food intentions (Uzorka et al., 2024). Thus, the application of Scaffolded Nutrition in PBL not only enhances the effectiveness of nutrition learning but also serves as a strategic medium for fostering creativity and awareness of environmentally friendly food consumption among pre-service science teachers, who are potential agents of change.

This study aims to investigate the effect of Problem-Based Learning through Scaffolded Nutrition (PBL-SN) on increasing green food intention and creativity in pre-service science teachers. Specifically, this study seeks to uncover how

nutrition learning designed in stages and integrated into a PBL scenario can foster awareness of environmentally friendly food consumption while facilitating the development of contextually relevant and applicable innovative ideas. The novelty of this study lies in integrating the PBL model with scaffolded nutrition, designed not only to be content-based but also to emphasize the strengthening of sustainability values and creative thinking in a local context. Furthermore, this study is the first in Indonesia to explicitly examine the interaction between green food consumption intention and creativity among pre-service science teachers within a systematic, applicable pedagogical framework. The results of this study are expected to provide theoretical contributions to the development of sustainable nutrition learning models and to offer practical recommendations for educators and policymakers on developing education-based interventions relevant to sustainable food challenges and the local needs of young people.

METHODS

This study used a quantitative design with a quasi-experimental post-test only approach to evaluate the effect of implementing the Problem-Based Learning through Scaffolded Nutrition (PBL-SN) learning model on the green food intention and creativity of pre-service science teachers. The approach used was a quasi-experimental one with two classes: an experimental class that received PBL–SN treatment, and a control class that received PBL as presented in Table 1. Data collection was carried out only after the intervention, using a post-test administered to both classes (Creswell, 2014).

Table 1. Research Design

Group	Treatment	Post-test
Experiment	Problem-Based Learning through Scaffolded Nutrition	Green Food Intention and Creativity
Control	Problem-Based Learning	Green Food Intention and Creativity

The study subjects consisted of undergraduate students in the Science Education program taking a general course on nutrition and sustainability at a university in Indonesia. The experimental class received a series of scaffolded nutrition modules integrated into a problem-based learning (PBL) scenario, focusing on real-life issues such as dietary imbalance, food waste, and access to healthy food. For example, in this study, students were asked to explore the impact of unhealthy eating habits. One of the worksheet questions encouraged students to explore further how to determine calorie and nutrient needs and determine balanced meal portions for each student. In this section, students had to fill out a table designed to guide them through the various mechanisms involved in reading a calorie and nutrient counter app. At the end of the phase, students were asked to analyze and evaluate using interactive green food media. Thus, PBL-SN functions as a learning tool consisting of a series of questions and information systematically arranged to help students understand complex concepts. This module serves as additional support (scaffolding) in addition to problem triggers and can be completed independently or through class discussions. Meanwhile, the comparison class received learning with PBL without integrating scaffolded nutrition.

This study was conducted at a leading university in Surakarta, Central Java, Indonesia, using a purposive sampling technique to select participants. The purposive sampling criteria were fourth-semester science education students currently taking a nutrition and sustainability course. A total of 51 students participated as respondents in this study. Prior to the intervention, the researchers provided a thorough explanation of the study's objectives, procedures, and potential risks and benefits.

Next, participants were randomly assigned to two classes: an experimental class and a control class. Twenty-six students were assigned to the experimental class (EC), and 25 to the control class (CC). Both classes received the same material in the nutrition and sustainability course, but with different learning approaches.

The theoretical framework presented in Figure 1 served as the basis for designing the learning experiment. Problem-Based Learning (PBL) steps were integrated with scaffolded nutrition to help students in the experimental class identify and address real-world issues such as dietary imbalances, food waste, and access to healthy food (He & Sui, 2024).

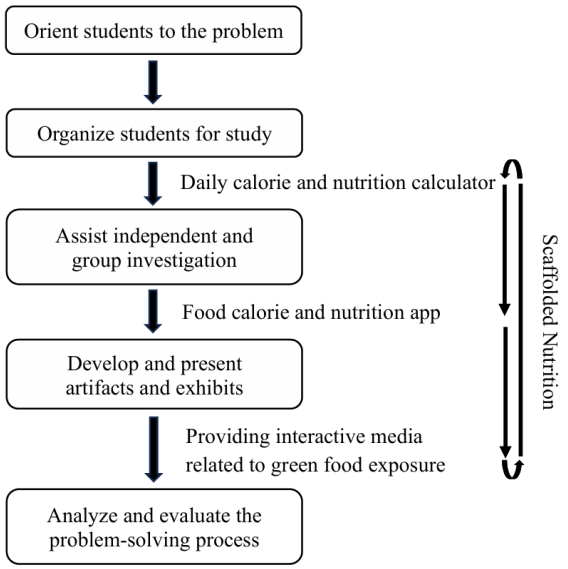

Figure 1. Theoretical Framework of PBL-SN

The PBL model consists of five main stages: (1) orienting students to the problem, (2) organizing students for study, (3) assisting independent and class investigations, (4) developing and presenting artifacts and exhibits, and (5) analyzing and evaluating the problem-solving process (Arends, 2012). PBL incorporates problem-solving, creating a structured, systematic learning flow that guides students from initial problem identification to the design and implementation of applicable solutions (Chen & Chan, 2021). The advantage of this model lies in its scaffolded, hierarchical structure, providing a comprehensive framework for developing creative thinking and problem-solving skills.

Theoretically, the PBL-SN approach is firmly grounded in the constructivist paradigm, which emphasizes active learning, student engagement, and the development of critical thinking. The systematic and interactive structure of this model makes it highly relevant for learning about sustainability issues, particularly by facilitating increased student awareness and understanding of sustainable education management practices (Avelar et al., 2025). The learning intervention consisted of five sessions. All stages of PBL-SN were distributed proportionally within each stage to develop solutions oriented towards sustainability issues in the context of educational management. During the intervention, students in the experimental class worked collaboratively in small classes of four to five members.

In this experiment, post-test measurements were conducted to evaluate Green Food Intention and Creativity. Two main instruments were used as measurement tools in this study: Green Food Intention, developed by He and Sui (2024), and Creativity, developed by O'Quin and Besemer (1989). Both instruments have been tested for validity and reliability in measuring creative problem-solving skills and sustainable social responsibility. The measurement questions used in this study regarding green food purchase intention were largely adapted from tested scales used in previous studies, while creativity was designed to measure product creativity related to healthy foods high in nutrients and low in calories.

The Green Food Intention Questionnaire, developed by He and Sui (2024), was used in this study as a measuring tool to assess students' creative problem-solving abilities. This instrument was designed in the context of a teaching experiment and comprises 24 items across five main dimensions. The first dimension is Behavioral attitude, which includes 4 statement items with a reliability coefficient of $\alpha = 0.944$. The second dimension, subjective norms, consists of 4 statement items ($\alpha = 0.936$). The third dimension includes 4 items on consequence perception ($\alpha = 0.941$), while the fourth dimension, responsibility attribution, consists of 4 items ($\alpha = 0.931$). The fifth dimension measures individual norms, which consists of 4 items ($\alpha = 0.928$). Finally, the sixth dimension is purchase intention with 4 items ($\alpha = 0.936$). All statement items in Green food intention are measured using a four-point Likert scale, ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). The overall reliability test results showed a Cronbach's alpha of 0.925, indicating that this instrument has very high internal consistency and is suitable for research in higher education.

The creativity instrument in this study was compiled from indicators developed by Besemer (1998) within the Creative Product Analysis Matrix (CPAM) framework, specifically designed to assess aspects of creativity in pre-service science teachers' products. This instrument was developed as a product assessment rubric comprising three main dimensions: novelty, resolution, and elaboration and synthesis. Each dimension includes several assessment indicators. The novelty dimension assesses the extent to which the product demonstrates originality, unique ideas, and unconventional problem-solving approaches. The resolution dimension measures the extent to which the product solves problems effectively and in accordance with the stated objectives, while considering usability and relevance. Meanwhile, the elaboration & synthesis dimension evaluates the extent to which the product is developed in detail, presented systematically, and integrates various elements or concepts harmoniously.

This rubric uses a four-point Likert scale, ranging from 1 (very low) to 4 (very high), for each indicator in the three dimensions. Two independent assessors assess each student's product to ensure objectivity and reliability. Before use, this instrument underwent content validation by experts in creativity and education, and an inter-rater reliability test, which yielded a coefficient higher than 0.80, indicating high consistency of assessment. With a product-based approach and specific indicators, this rubric is capable of comprehensively measuring students' creativity in producing innovative solutions in the context of problem-based learning and sustainability.

Data analysis in this study was conducted quantitatively using IBM SPSS Statistics software version 25 to obtain accurate, valid, and reliable results. This study adopted a post-test-only control-class design, in which data were collected after the learning intervention was administered to the experimental class (González-Alonso et al., 2020; Jenkins & Quintana-Ascencio, 2020). To answer the research question regarding the effect of PBL-SN implementation on students' green food intentions, an independent-samples t-test was used. This test is used to identify differences in the mean between two unrelated classes: the experimental class that received the intervention and the control class that did not. Correlation analysis was used to examine the relationship between sustainability intentions and students' creativity levels.

Meanwhile, regression analysis was conducted to evaluate the extent to which the variable of environmentally friendly behavior intention predicts creativity achievement, and vice versa. The findings from the quantitative analysis are presented to provide a comprehensive overview of the impact of the learning approach on green food intentions and the development of students' creativity. All tests were conducted at the $\alpha = 0.05$ significance level to determine whether differences or relationships were statistically significant. The results of this analysis are expected to provide a strong empirical basis for the development of sustainability- and creativity-based learning models in higher education, as well as for strengthening the integration of nutrition education with environmentally friendly food consumption values.

RESULTS AND DISCUSSION

Analysis of Differences in Green Food Intention and Creativity between Experimental and Control Classes

To test differences in learning outcomes between the experimental class (EC) and control class (CC), a t-test was conducted on two main variables: creativity and green food intention. The t-test results showed a significant difference in creativity scores between the two classes ($t = -4.078$; $p < .05$), with EC ($M = 87.52$) having a higher average score than CC ($M = 82.76$). The effect size (Cohen's $d = 1.141$) was large, indicating that the EC treatment had a strong impact on students' creativity. T-Test analysis on creativity between experimental and control classes as presented in Table 2.

Table 2. T-Test Analysis on Creativity Between Experimental and Control Classes

Variables	Class	N	Mean	SD	t	Cohen's D
Creativity	CC	25	82.76	4.122	-4.078*	1.141
	EC	26	87.52	4.220		
Original	CC	25	4.28	0.678	-2.271	0.63
	EC	26	4.65	0.485		
Surprise	CC	25	4.36	0.490	-3.175*	0.891
	EC	26	4.77	0.430		

Variables	Class	N	Mean	SD	t	Cohen's D
Valuable	CC	25	4.12	0.332	-1.339	0.377
	EC	26	4.27	0.452		
Logical	CC	25	4.28	0.458	-3.935*	1.104
	EC	26	4.77	0.430		
Useful	CC	25	4.64	0.490	0.453	-0.121
	EC	26	4.58	0.504		
Understanable	CC	25	4.16	0.374	2.181	-0.611
	EC	26	4.00	0.000		
Organic	CC	25	3.84	0.374	-2.181*	0.611
	EC	26	4.00	0.000		
Elegance	CC	25	3.64	0.700	-4.397*	1.224
	EC	26	4.38	0.496		
Well Crafted	CC	25	3.92	0.812	-0.217	0.059
	EC	26	3.96	0.528		

Note. SD=Standard Deviation
*p < .05

In more detail, several aspects of creativity, such as surprise, logicality, organicity, and elegance, showed significant differences between classes. For example, in the surprise aspect, the EC (M = 4.77) had a higher score than the CC (M = 4.36), with t = -3.175 and Cohen's d = 0.891, indicating a large effect. Similarly, the logical (t = -3.935; d = 1.104), organic (t = -2.181; d = 0.611), and elegance (t = -4.397; d = 1.224) aspects also showed significant differences and large effect sizes. However, aspects such as originality, value, usefulness, understandability, and craftsmanship did not show significant differences (p > .05), indicating that not all dimensions of creativity were affected equally. For further clarification, the differences in scores across the creativity aspects between EC and CC are shown in Figure 2.

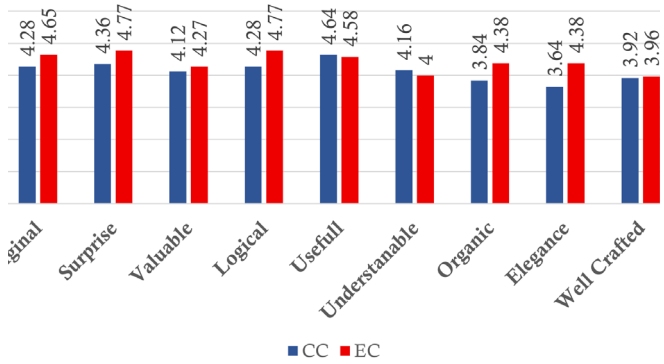

Figure 2. Scores for Each Aspect of Creativity

Based on Figure 2, all aspects indicate that class EC has higher values than class CC, except for the useful and understandable aspects. Overall, these results reinforce the finding that the learning approach provided to the EC, which integrates PBL-SN, is effective in enhancing students' creativity and encouraging their awareness and intentions toward sustainable food consumption (Ernawati et al., 2022). The results of the analysis on Green Food Intention are presented in Table 3.

Table 3. T-Test Analysis on Green Food Intention Between Experimental and Control Classes

Variables	Class	N	Mean	SD	t	Cohen's D
Green food intention	CC	25	3.2772	0.43676	-1.841	0.516
	EC	26	3.4712	0.30659		
Behavioral attitude	CC	25	3.4367	0.36742	-1.443	0.404
	EC	26	3.5865	0.37378		
Subjective norms	CC	25	3.1133	0.41380	-1.743	0.488
	EC	26	3.3173	0.42165		
Consequence perception	CC	25	3.2233	0.57470	-2.701	0.757
	EC	26	3.5865	0.36703		
Responsibility attribution	CC	25	3.2200	0.53677	-1.575	0.441
	EC	26	3.4231	0.37262		
Individual norms	CC	25	3.2400	0.50765	-1.943	0.544
	EC	26	3.4904	0.40915		
Purchase intention	CC	25	3.4300	0.55678	-1.716	0.481
	EC	26	3.6731	0.45149		

Note. SD=Standard Deviation
*p < .05

In the green food intention variable, there was a near-significant difference between the EC (M = 3.47) and CC (M = 3.27) with t = -1.841 and Cohen's d = 0.516, reflecting a moderate effect. The results of the presentation showed that the learning model, integrated PBL-SN, did not have a significant effect on green food intentions among pre-service science teachers. Several sub-variables showed significant differences, particularly in consequence perception (t = -2.701; p < .05; d = 0.757), indicating that students in the EC were more aware of the consequences of unsustainable food consumption. Furthermore, individual norms, subjective norms, and purchase intention also showed a tendency for significant differences with moderate effect sizes (d = 0.544, d = 0.488, and d = 0.481, respectively), indicating that training in the EC was able to encourage the formation of more environmentally friendly personal norms, subjective norms, and purchasing intentions. However, several other aspects, such as behavioral attitude and responsibility attribution, did not show significant differences between the classes. This indicates that changes in environmentally friendly consumption intentions and behaviors are more influenced by understanding consequences, the formation of personal and subjective norms, and greener purchasing intentions than by behavioral attitudes or attributions of responsibility alone. For further clarification, the differences in scores per aspect of green food intention between EC and CC are presented in Figure 3.

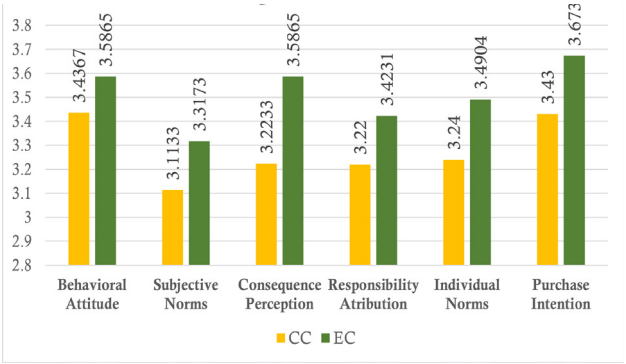

Figure 3. Scores for Each Aspect of Green Food Intention

Based on Figure 3, all aspects show that class EC has a higher value than class CC. Overall, these results reinforce the finding that the learning approach provided to the EC, which integrates PBL-SN, is effective in enhancing students' green food intention (Wang & Teng, 2019).

Effects of Creativity on Green Food Intention

Table 4 shows a non-significant positive correlation between creativity (M = 87.52) and green food intention (M = 3.4712) in the experimental class (r = 0.146, p > .05), indicating no strong relationship between the two variables in the intervention class. This means that the increase in students' creativity in the experimental class is not directly related to their increased intention to consume environmentally friendly food.

Table 4. Analysis of the Correlation between Creativity and Green Food Intention in Experimental and Control Classes

Items	Mean	Creativity	Green food intention
		Experimental Class	
Creativity	87.52	1	
Green food intention	3.4712	0.146	1
		Control Class	
Creativity	82.76	1	
Green food intention	3.2772	.458*	1

*p < .05

In contrast, in the control class, a significant positive correlation was found between creativity (M = 82.76) and green food intention (M = 3.2772), with a correlation coefficient of r = 0.458 and p < .05. These results indicate that under traditional learning conditions, there is a moderate relationship between creativity levels and green food intention. In other words, students with higher levels of creativity in the control class tended to show a stronger intention to consume sustainable food.

This finding is quite interesting because it indicates that in the uninterrupted class, creativity can be an indicator of green food intention. However, in the experimental class, the intervention (e.g., a project-based learning model, or PBL) likely shifted this direct relationship, so that green food intention was formed more by other factors (e.g., ethical values or an understanding of sustainability) than by creativity alone. As a follow-up, a regression analysis can be conducted to evaluate the contribution of each variable to green food intention, particularly to compare the direct influence of creativity across the two classes.

Effects of Green Food Intention Indicators on Creativity

Multiple linear regression analysis was conducted to determine the contribution of six predictor variables to students' creativity in the context of sustainable food consumption: Behavioral Attitude (BA), Subjective Norms (SN), Consequence Perception (CP), Responsibility Attribution (RA), Individual Norms (IN), and Purchase Intention (PI). Creativity in this study is treated as a dependent variable reflecting students' ability to generate original ideas, think critically, and design innovative solutions to environmentally friendly food issues. The analysis was conducted separately in the experimental class (EC) and the control class (CC), each consisting of 25 students. The results are more clearly presented in Table 5.

Table 5. Analysis of the Regression Between Green Food Intention Indicators and Creativity in Experimental And Control Classes

Variables	Green food intention					
	EC			CC		
	Beta	t	VIF	Beta	t	VIF
BA	-0.541	-1.565	3.025	0.124	0.374	2.764
SN	-0.036	-0.138	1.735	-0.279	-0.858	2.637

Variables	Green food intention					
	EC			CC		
	Beta	t	VIF	Beta	t	VIF
CP	0.012	0.038	2.378	0.161	0.433	3.428
RA	0.158	0.509	2.442	-0.007	-0.014	6.321
IN	0.347	0.851	4.214	0.227	0.566	4.014
PI	0.073	0.196	3.498	0.276	0.684	4.062
F		1.057			1.147	
R2		0.25			0.277	
Adjust R		0.014			0.035	

The analysis in the EC showed that the regression model had a coefficient of determination (R^2) of 0.25, an adjusted R^2 of 0.014, and an F value of 1.057. This indicates that 25% of the variation in students' creativity falls into the moderate category. There is a negative correlation in the BA variable with a coefficient of $\beta = -0.541$ with a t value of –1.565, indicating a negative relationship with the moderate category. Likewise, the SN variable ($\beta = -0.036$; $t = -0.138$) shows a negative relationship with the negligible category, indicating a very small or insignificant relationship. Among the predictor variables, 4 show positive relationships: the CP variable ($\beta = 0.012$; $t = 0.038$) and the PI variable ($\beta = 0.073$; $t = 0.196$) with the negligible category, indicating a very small or insignificant relationship. This contrasts with the RA ($\beta = 0.158$; $t = 0.509$) and IN ($\beta = 0.347$; $t = 0.851$) variables, which showed a positive trend with a weak contribution category, meaning there is a contribution to students' creativity, but it is not statistically strong enough (Schober et al., 2021). None of the Green Food Intention variables in the EC model showed a statistically significant effect. All variables had VIF values below 5, except IN, which approached the threshold (VIF = 4.214) but remained within the tolerance limit, indicating no serious multicollinearity.

In the control class (CC), the regression analysis yielded an R^2 of 0.277, an adjusted R^2 of 0.035, and an F value of 1.147. This indicates that 27.7% of the variation in students' creativity falls into the moderate category. This means that the six predictor variables can explain variation in students' creativity, but the model's effectiveness is also relatively low. Similar to the EC, none of the variables has a significant influence on creativity. There is a negative correlation in the SN variable with a coefficient of $\beta = -0.279$ with a t value of –0.858, indicating a negative relationship with the weak category. Similarly, the RA variable ($\beta = -0.007$; $t = -0.014$) shows a negative relationship with the negligible category, indicating a very small or insignificant relationship. In the predictor variables, there are 4 positive relationships including BA ($\beta = 0.124$; $t = 0.374$), CP ($\beta = 0.161$; $t = 0.433$), IN ($\beta = 0.227$; $t = 0.566$) and PI ($\beta = 0.276$; $t = 0.684$) indicating a positive relationship direction with a weak category, meaning there is a contribution to students' creativity but it is not statistically strong enough (Schober et al., 2021). In addition, the highest VIF was observed in RA at 6.321, suggesting potential multicollinearity; further evaluation of this construct is needed.

Overall, across both the experimental and control classes, the analysis indicates that the model lacks sufficient predictive power for students' creativity. The lack of significant effects of the six variables indicates that creativity is a multidimensional construct influenced by a wider range of factors, such as self-efficacy, learning interest, or a learning environment that supports the exploration of ideas (Capron & Audrin, 2021; Fan & Cai, 2022; Ovat et al., 2024).

The implementation of Problem-Based Learning through Scaffolded Nutrition (PBL-SN) in pre-service science teachers had a strong influence on students' creative capacity and a moderate influence on the intention to consume environmentally friendly foods (green food intention). Pre-service science teachers involved in this learning model experienced significant improvements in various aspects of creativity, especially surprise, logicality, organicity, and elegance, as evidenced by a t-test that showed significant differences between classes with a large effect size (Cohen's $d = 1.141$). This indicates that integrating real problems in the context of sustainable food and scaffolded nutrition can stimulate students' creativity and reflective thinking in designing innovative solutions (Akpur, 2020; Capecchi et al., 2025). Consistent with Pratama et al.

(2025), who mapped creative thinking research trends in Indonesian science education journals, PBL-based approaches remain the most frequently used model for fostering creativity, underscoring the pedagogical relevance of the PBL-SN intervention employed in this study. These findings also align with Irwandani et al. (2025), who demonstrated that PBL integrated with social contexts significantly enhanced creative thinking skills among pre-service science teachers, suggesting that the contextual framing of real-world problems within PBL is a key driver of creativity development. However, this increase in creativity was not entirely proportional to the increase in green food intention. The t-test showed a near-significant difference between the experimental (M = 3.47) and control (M = 3.27) classes, with a medium effect size (Cohen's d = 0.516). Consequence perception was the most affected indicator in the intervention group, indicating that pre-service science teachers were beginning to recognize the impacts of environmentally unfriendly consumption. However, this improvement was not strong enough to drive comprehensive changes in behavioral intentions. This indicates that contextual problem-based learning, although effective in building conceptual and affective awareness, still requires strengthening the normative and reflective aspects to encourage concrete behavioral changes. This is in line with Sánchez-García & Reyes-de-Cózar (2025) and Nanni & Allan (2020), who emphasized that problem-based learning has the potential to foster ecological awareness but requires the internalization of values to produce more consistent changes in attitudes and intentions.

This situation becomes even more interesting when examining the relationship between creativity and green food intention in each class. In the experimental class, the correlation between the two variables was low and insignificant ($r = 0.146$; $p > .05$), despite students' creativity scores being high. Conversely, in the control class, which followed conventional learning, a significant positive correlation was found between creativity and green food intention ($r = 0.458$; $p < .05$). This indicates that in a learning environment without specific interventions, students with high levels of creativity tend to have more sustainability-oriented consumption intentions. This phenomenon can be explained through the lens of Situated Learning Theory by Brown et al. (1989), which states that personal meanings and values are formed through relevant and contextual social experiences (Hajian, 2019). In the experimental class, students may have focused more on completing tasks, developing solutions, and presenting products, without engaging in a deep process of internalizing values (Gu, 2021). Focusing on cognitive tasks can foster strong conceptual understanding, but it does not necessarily translate into behavioral commitment. In contrast, in more relaxed, conventional learning environments, students with higher creative capacities may have the space to reflect on personal values and naturally develop intentions based on experiences or internal beliefs. Ali et al. (2020) support this finding, stating that ecological behavioral intentions are influenced by intrinsic motivation and an affinity for environmental issues, which do not always align with creative thinking abilities. Therefore, to bridge creativity and sustainability intentions, learning is needed that is not only problem-solution-oriented but also reflective and transformational, encouraging students to reconstruct their values and attitudes consciously.

When six green food intention indicators were tested as predictors of creativity using multiple linear regression, the results indicated that these variables did not significantly explain creativity variance in either the experimental or control classes. In the experimental class, an R^2 value of 0.25 was obtained, indicating that although the model statistically explained 25% of the variation in creativity, its practical effectiveness was very small given the number of predictors. Similarly, in the control class ($R^2 = 0.277$), none of the six variables—Behavioral Attitude, Subjective Norms, Consequence Perception, Responsibility Attribution, Individual Norms, and Purchase Intention—had a significant contribution. However, Individual Norms and Purchase Intention showed a positive relationship in both classes, consistent with the theory of epistemic curiosity and the need for information exploration in fostering creativity (Hardy et al., 2017). However, Subjective Norms and Responsibility Attribution showed a negative relationship, especially in the control class, which may be caused by social pressure or perceived risks that limit freedom of thought (Ho et al., 2017). The VIF value for Risk Awareness, which exceeded the safe limit (6.321), also indicates potential multicollinearity and should be addressed through construct or instrument revision. This overall analysis reinforces the view that creativity cannot be explained linearly through normative or behavioral factors alone, but rather by a complex interaction between learning context, cognitive autonomy, and socio-affective dynamics. This is also in line with the Self-Determination and Componential Theory of Creativity, which emphasizes that creativity emerges from a combination of skills, intrinsic

motivation, and environmental conditions that support free exploration (Koh et al., 2019).

In the context of PBL-SN, optimal development of creativity can be achieved through the creation of challenging, flexible, and context-specific learning situations. Pre-service science teachers are not only required to solve problems but also to formulate creative approaches, synthesize ideas from various sources, and evaluate the effectiveness of their solutions (Yustina et al., 2020; Guaman-Quintanilla et al., 2023). On the other hand, the intention to behave in an environmentally friendly manner develops through a more affective and reflective process, requiring time, repetition, and the formation of values through social interaction and personal meaning-making (Varela-Candamio et al., 2018). The non-linear relationship between creativity and green food intention suggests that these two competencies, while facilitated within a single learning framework, require different pedagogical approaches (Min et al., 2023). While creativity requires space for exploration and experimentation, sustainability intention requires facilitating value discussions, social reflection, and the internalization of ecological goals. Therefore, the development of such modules must be accompanied by transformational strategies, such as value clarification, action-based learning, and interdisciplinary collaborative approaches, to comprehensively bridge the cognitive and affective domains (Miani et al., 2025). Higher education is not only responsible for producing graduates who can think critically and creatively, but also for producing individuals committed to sustainability and social justice (Howlett et al., 2016).

By considering these dynamics, the research contributes to mapping the complex relationship between creativity and green food intentions within a problem-based, contextually grounded pedagogical framework. Practical implications can be directed towards developing more holistic learning designs that target not only cognitive outcomes but also the transformation of students' values and behavioral orientations. Higher education institutions can use these findings to design curricula that explicitly integrate sustainability issues into cross-curricular learning, with approaches that enable students to experience, analyze, and interpret these issues from multiple perspectives. Issues that can be raised include supporting SDGs 2, 3, and 12. SDG 2 emphasizes the importance of sustainable food systems, which is related to increasing students' awareness of environmentally friendly food choices. SDG 3 emphasizes the relationship between healthy consumption patterns and individual well-being through creativity; students can develop nutritious, low-calorie foods (Norici et al., 2025). Meanwhile, SDG 12 calls for changes in responsible consumption and production behaviors, which can be fostered through learning approaches that encourage critical reflection and value-based decision-making (Peter et al., 2026).

Furthermore, the results of this research theoretically encourage the expansion of the interdisciplinary frameworks of science education, character education, and environmental education. This integrative effort will be an important foundation in producing a generation that not only excels in 21st-century skills but also possesses a strong ecological and social awareness. Furthermore, to strengthen the relationship between creativity and green food intention, further studies are needed that explore values-based interventions, the use of reflective technology, and community involvement in the learning process. This research demonstrates that building creativity and green food intention is not a linear or uniform process, but requires an adaptive, reflective, and transformative pedagogical framework.

CONCLUSION

Based on the discussion analysis, it was concluded that the green food intention variable showed an average of experimental class or CC (M=3.47) and control class or CC (M=3.27) with t = -1.841 and Cohen's d = 0.516, which reflects a moderate aspect. The results of the presentation indicate that the learning model, which integrates PBL-SN, has no significant effect on green food intention among pre-service science teachers. In addition, the creativity variable shows an average EC (M = 87.52) higher than CC (M = 82.76), with t = -4.078 and Cohen's d = 1.141; the effect size is classified as large, indicating that the treatment given to the EC has a strong impact on increasing the creativity of pre-service science teachers. These results strengthen the claim that the EC learning model integrating PBL-SN is effective in increasing creativity among pre-service science teachers. The insignificant positive correlation between creativity and green food intention indicates that there is no strong relationship between the two variables in the intervention group. This indicates that increased creativity among pre-service science teachers in the experimental class was not directly related to increased green food intentions. Conversely, a significant, moderate, positive correlation was found between creativity and green food intentions in the control class.

In other words, pre-service science teachers with higher levels of creativity in the control class tended to demonstrate greater green food intentions.

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