IMPLEMENTATION OF PROJECT-BASED LEARNING IN THE FOOD CHEMISTRY COURSE THROUGH THE SOCIALIZATION OF FOOD INNOVATION AND TECHNOLOGY BY MAKING TEMPEH HEALTH SMOOTHIES

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Abstract

This study aims to assess the capability of project-based learning (PjBL) methods in introducing innovations in the field of food and technology by making healthy tempeh smoothies, as a product of food chemistry courses, in order to deepen students' understanding of local foods. This study is based on the importance of understanding food chemistry that includes aspects of formulating, processing, and storing quality food products. The PjBL model was chosen because it can increase students' learning motivation, creativity, and critical thinking skills in dealing with contextual problems. The study was conducted on 14 grade X students of Khadijah High School with a One Group Pretest-Posttest design. The research instrument was a multiple-choice test based on Bloom's taxonomy and a Likert scale response questionnaire. The results showed a significant increase from a pretest score of 92,86 to a posttest score of 99,29. The N-Gain value of 0,89 and an effectiveness level of 88,89% indicated an increase in understanding in the high category and effective learning. Students were able to recognize tempeh as a local food with high nutritional value, understand the fermentation process, health benefits, and its potential for development into a modern beverage product. The questionnaire results showed a very positive response. The hands-on activity of making tempeh health smoothies increased student engagement, confidence, and motivation, including interest in simple entrepreneurial opportunities. Overall, PjBL learning was effective in strengthening local food literacy and fostering an appreciative and innovative attitude toward the use of tempeh as a health smoothies.

Keywords: project-based learning, food chemistry, tempeh, food innovation, health smoothies

INTRODUCTION

Learning is a process that involves interconnected elements in order to achieve optimal learning outcomes [1]. Education demands active interaction between teachers and students to develop intellectual abilities, attitudes, and interests of students. Success in implementing educational strategies greatly depends on the choice of an appropriate learning model. One type of learning model that can be applied in the classroom environment is the project-based learning model. This project-oriented learning model offers an enjoyable learning experience, with the hope of changing the way students learn individually, increasing their enthusiasm for learning, encouraging students' creativity while working, generating innovative ideas, and training critical thinking skills in facing real-world challenges [2].

Food chemistry is closely related to the sciences of chemistry, biochemistry, chemical physiology, botany, zoology, and molecular biology [3]. Food chemistry includes the analysis of chemical composition and characteristics, as well as the changes that occur chemically during handling, processing, and storage. To obtain quality food products, understanding chemical properties is essential for the formulation, processing, and storage processes. Indonesia has abundant local food raw materials. Rice has traditionally been the primary source of staple food for Indonesians. However, with advances in technology and information, people's dietary patterns have also changed [4].

Tempeh is one of the fermented foods and can be prepared in various forms, such as fried, battered, made into chili sauce, chips, or mixed with side dishes. Tempeh has been recognized internationally as a food product for its high health benefits [5]. Tempeh is generally produced in a traditional way and is a source of protein from plants. The word "tempeh" is believed to have originated from Old Javanese [6]. Indonesia is the largest tempeh-producing country in the world and also the largest soybean market in Asia. About 50% of the total soybean consumption in Indonesia is used in the form of tempeh, 40% in the form of tofu, and 10% for other products (such as tauco, soy sauce, and others). It is estimated that the average annual tempeh consumption per person in Indonesia is currently around 6.45 kg [7]. As a fermented food native to Indonesia, it is important to introduce tempeh and its processed products to all levels of society.

Based on the research results of [8], it was found that the most respondents in this study were aged 20-35 years with a percentage of 58,20%. Respondent' perspectives in terms of tempeh consumption, as many as 51,85% of respondents consumed tempeh 2-3 times per week, as many as 62,43% of respondents more often consumed leaf-wrapped soybean tempeh and 37,04% more often consumed plastic-wrapped soybean tempeh. As many as 50,79% of respondents consumed 2 medium pieces (50 grams) of tempeh per meal, and fried tempeh/mendoan was the most frequently consumed tempeh culinary from 52,38%. Regarding the ingredients that can be used to make tempeh, as many as 96,30% of respondents chose soybeans and yeast as ingredients for making tempeh. Several elements that can affect the purchase of tempeh include the cost of the tempeh itself, the cost of tofu, the cost of chicken eggs, and the cost of cooking oil. This is due to the fact that the prices of substitute or complementary goods affect how much of a product can be consumed [9].

The rise of modern foods has eroded the popularity of local foods such as tempeh. Innovation is an activity involving the introduction of new methods or new combinations of existing methods or a combination of both in changing inputs into outputs with technology to produce major changes in the comparison between the perceived utility value of a product, service, and the price determined by the producer [10]. The lack of diversification of tempeh-based food innovations is due to a lack of knowledge, mastery of technology, and skills related to tempeh processing. This is due to a lack of technological information and limited public knowledge about tempeh diversification efforts [7].

Innovative tempeh-based products should be packaged in a modern way to appeal to children in particular. Tempe provides a number of health benefits, including helping to overcome diarrhea, strengthening the immune system, maintaining cardiovascular health, slowing aging, supporting weight loss programs, meeting vitamin B12 intake, reducing bloating symptoms, lowering the risk of Parkinson's disease, improving brain performance, suppressing LDL cholesterol levels, and preventing various diseases such as coronary heart disease, osteoporosis, digestive disorders, cancer, anemia, diabetes, and asthma [11]. Tempeh consumption in children is associated with the prevention of stunting in toddlers and anemia in adolescents [12].

Health is a key aspect of human well-being and is heavily influenced by lifestyle and diet [13]. A balanced nutritional diet, which includes choices of complex carbohydrates, protein, as well as appropriate vitamins and minerals, is very crucial to support the body's metabolic processes and prevent the occurrence of diseases [14]. Dietary variety, including a combination of plant and animal proteins, plays a crucial role in supporting optimal child growth and development [15]. Smoothies are thick, semi-liquid beverages rich in vitamins, fiber, and antioxidants, and are convenient and popular with a wide range of consumers [16][17].

The Tempeh Health Smoothies innovation, made from steamed tempeh and fresh fruit, offers a healthy food alternative containing protein, fiber, and vitamins, with an appealing taste and appearance. This product has the potential to increase tempeh consumption and support health by increasing energy, endurance, and digestive health. Based on the description, this research was conducted with the title "Implementation of

Project-Based Learning in The Food Chemistry Course through The Socialization of Food Innovation and Technology by Making Tempeh Health Smoothies." This socialization aims to increase students' understanding of food innovation and technology, introduce the potential of tempeh as an alternative food ingredient, raise awareness of the importance of utilizing local food ingredients, and gain knowledge about the benefits of tempeh and tempeh innovation as a processed product for tempeh health smoothies.

The implementation of the PjBL learning model in this socialization is through the development of local food product innovations and technology using tempeh as a local food product that is nutritious, safe, and accepted by the community, especially the younger generation in the form of health smoothies, to restore the image of tempeh as a traditional fermented product with high nutritional value which is now less attractive to the younger generation.

METHOD

This research began with a preparatory phase, which involved coordinating with the school regarding the socialization plan, developing socialization materials, and developing instruments. The next step is to conduct socialization and activity assessment using a One-Group Pretest-Posttest Design, which is an experiment applied to a single group without a control group. This experimental design includes a pretest conducted before and a posttest conducted after the implementation of project-based learning in the socialization of innovation in the field of food and technology. This allowed for more accurate results, as it allowed for comparisons between the conditions before and after the treatment. This design can be described as follows:

$$O_1 \ X \ O_2$$

[18]

Description:

O_1 = Pretest score before treatment.

O_2 = Posttest score after treatment.

X = Treatment using project-based learning for the socialization of food and technology innovation.

This research was conducted at Khadijah High School in Surabaya, East Java. The subjects were 14 students from 10th grade. The instruments used in this study were a pretest-posttest and a student response questionnaire. The test consisted of 20 multiple-choice questions, each of which was measured using Bloom's Taxonomy of Cognitive Development. The questionnaire aimed to determine students' responses to the socialization program. The questionnaire contained 10 positive statements. The data collection method used in this study was a pretest administered to students before implementing project-based learning in the socialization of food and technology innovation, and a posttest administered after implementing project-based learning in the socialization of food and technology innovation. A questionnaire was also used, namely a response questionnaire administered to participants after the socialization program.

The data processing technique applied for the pretest and posttest in this study is based on the scores obtained by students on the pretest and posttest. The increase in pretest and posttest scores from student learning achievements can be observed through the calculation of the N-Gain score using the formula shown below:

$$-gain = \frac{posttest \ scores - pretest \ scores}{maximal \ scores - pretest \ scores} \times 100$$

The N-gain results obtained are then converted according to the N-gain score level criteria as Table 1.

Table 1. N-Gain Criteria

Score	Criteria
$g < 0,3$	Low
$0,3 \leq g \leq 0,7$	Medium
$g \geq 0,7$	High

[19]

Based on the N-Gain values obtained, knowledge about local cuisine improves if each student achieves an N-Gain score of $0.7 > g \geq 0.3$ for the medium category or $g \geq 0.7$ for the high category.

Based on the percentage of N-Gain scores obtained, they can be interpreted based on the criteria in Table 2.

Table 2. Interpretation of N-Gain Effectiveness

Percentage (%)	Category
< 40	Ineffective
$40 - 55$	Less Effective
$56 - 76$	Moderately Effective
> 76	Effective

[19]

The implementation of a project-based learning method related to the dissemination of innovations in the field of food and technology can be considered successful if the N-Gain score > 76.

The data analysis technique for the student response questionnaire used categories 1-5 on a Likert scale, as shown in the Table 3.

Table 3. Likert Scale

Score	Category
1	Strongly Disagree
2	Disagree
3	Somewhat Disagree
4	Agree
5	Strongly Agree

[20]

Based on the Likert scale above, the researcher provided 10 statements to students. These statements had to be filled in by each student. The results of the questionnaire responses obtained were described qualitatively. Based on the 5 categories of the Likert scale used, the student questionnaire response data can be classified into two responses: positive and negative. The results of the student questionnaire responses were converted into percentages using the following formula:

$$Percentage = \frac{Score\ of\ students'\ answers\ who\ chose}{Number\ of\ students\ (respondents)} \times 100$$

The percentages obtained are then interpreted in the criteria as in Table 4.

Table 4. Percentage Criteria for Student Response Questionnaire

Percentages	Criteria
$80\% < P \leq 100\%$	Very Positive
$60\% < P \leq 80\%$	Positive
$40\% < P \leq 60\%$	Moderately Positive
$20\% < P \leq 40\%$	Less Positive
$P \leq 20\%$	Very Less Positive

[21]

RESULTS AND DISCUSSION

The Food and Technology Innovation Socialization Activity with the Making of Tempeh Health Smoothies was held at Khadijah High School, Surabaya City, East Java on Friday, November 7, 2025 at 08.10-09.30 AM. This activity was divided into three main activities, namely: socialization presentation, practical session, and understanding evaluation. Before the socialization presentation regarding what food and

technology innovation is, the definition, benefits, and case studies of tempeh, health smoothies product innovation and its benefits, students took a pretest first to measure initial understanding.

Students studied case studies related to interest in tempeh while also practicing directly one of the latest interesting food innovations, namely health smoothies from tempeh, a beverage product that combines tempeh as a fermented food ingredient rich in protein, fiber, beta carotene, vitamins B1, B2 and minerals with fruits rich in antioxidants such as dragon fruit and bananas. After all the socialization series were completed, students took a posttest to evaluate their understanding and the success of the socialization activities. In addition, students also completed a questionnaire to record their responses after the socialization.

Student learning outcomes were higher after the socialization than before. This may be due to the new knowledge gained during the socialization. The improvement in how well students are learning is shown by the difference in average scores between the test before the lesson and the test after the lesson. Student learning outcomes are shown in Figure 1.
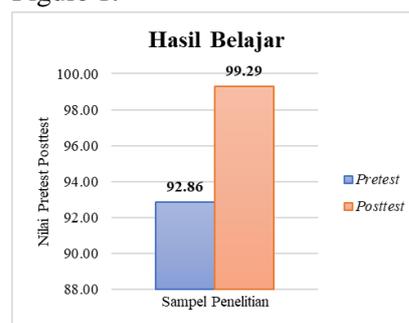

Figure 1. Pretest and Posttest Score Graph

Looking at the graph of learning outcomes from the pretest and posttest results, it's clear that there was an improvement in the average scores. The average pretest score was 92.86, and the average posttest score was 99.29, showing an increase of 6.46.

A comparative test was conducted using the Wilcoxon signed ranks test because the data were interval-based and does not follow a normal distribution. Which:

H_0 = There is no difference in pretest and posttest scores.

H_1 = There is a difference in pretest and posttest scores.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Posttest - Pretest	Negative Ranks	1ᵃ	2.00	2.00
	Positive Ranks	8ᵇ	5.38	43.00
	Ties	5ᶜ		
	Total	14		

a. Posttest < Pretest
b. Posttest > Pretest
c. Posttest = Pretest

Test Statisticsᵃ

	Posttest-Pretest
Z	-2.459ᵇ
Asymp. Sig. (2-tailed)	.014

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Figure 2. Wilcoxon Signed Ranks Test Result

The obtained significance value was 0,014, which is less than 0.05, so H_0 was rejected and H_1 was accepted. This shows that there was a difference between the scores before and after the test.

Based on the N-Gain score obtained, the scores are as in Table 5.

Table 5. Average Components and N-Gain Scores

Component	Score
Pretest Average	92,86
Posttest Average	99,26
Pretest-Posttest Average	6,43
Pretest-Maximum Score Average	7,41
N-Gain Score Percentage	0,89
Pretest Average	88,89

Based on Table 5, it can be seen that the average value of the N-Gain score is 0,89 and the percentage of the N-Gain score obtained is 88,89% so it can be concluded that the use of socialization that has been carried out has been effective because the value is more than 76 with the interpretation of the N-Gain effectiveness value is effective. The N-Gain score value of 0,89 can be interpreted as being included in the high N-Gain category because it is more than 0,7.

A response questionnaire was given to students to determine their positive and negative responses to the implementation of project-based learning in the socialization of food and technology innovation. The questionnaire consisted of 10 statements. The scale used to assess the questionnaire responses was a Likert scale on a 1-5 scale.

The results of the student response questionnaire can be identified based on each student's answer to each statement. The summary of the student response questionnaire can be seen in Table 6.

Table 6. Student Response Questionnaire Recapitulation Results

Questions	Student Response					Percentage (%)	
	SD	D	SoD	A	SA	Positive	Negative
1	10	4	0	0	0	100	0
2	9	3	0	1	1	85,7	14,3
3	11	3	0	0	0	100	0
4	7	6	0	1	0	92,8	7,1
5	9	5	0	0	0	100	0
6	6	7	0	0	1	92,8	7,1
7	4	5	3	1	1	64,3	35,7
8	7	7	0	0	0	100	0
9	7	7	0	0	0	100	0
10	9	4	1	0	0	92,8	7,1
Average						92,84	7,13

Statement:
1. I enjoyed participating in the "Health Smoothies from Tempeh" socialization activity.
2. The socialization activity helped me better understand tempeh as a local food ingredient.
3. I learned that tempeh can be processed into healthy beverages.
4. This socialization activity enhanced my creativity in processing food ingredients.
5. Making tempeh smoothies was easy and fun.
6. I'm interested in trying to make similar products at home or at school.
7. This socialization activity encouraged me to pursue entrepreneurship in food processing.
8. The media and explanations during the socialization were easy to understand.
9. The activities during the socialization activity encouraged me to actively participate in discussions with my group members.
10. I found this socialization activity to be beneficial and interesting.

According to the summary of the student feedback questionnaire in Table 6, it can be seen that the lowest student response is on statement number 7, with a percentage of 64.3% positive and a percentage of 35,7% negative. Although it is included in the lowest student response results, the response results can be classified in the positive or good category. Meanwhile, the highest student responses were obtained in statements number 1, 3, 5, 8, 9 with a percentage of 100% positive and a percentage of 0% negative. The highest response results were obtained from the majority of respondents' choices with the categories "Strongly

Agree" and "Agree" on the statement items presented in the questionnaire. Based on these results, it can be seen that the use of project-based learning in the socialization of food and technology innovation in class X of SMA Khadijah received a very positive student response to all questionnaire statement items.

According to [22], student responses are interests that can be expressed through statements indicating a preference for a particular topic over another. Student responses can be identified through questions indicating whether students agree, disagree, or strongly disagree with the learning process. Responses are reactions students give to all stimuli in the learning process that can be observed by the five senses.

Based on Table 6, the students' responses to the highest percentage statements and statements 1, 3, 5, 8, and 9 and the lowest percentage statement in statement 7. The response with the highest percentage in statement 1 is that the majority of students chose to strongly agree and agree with the statement that they enjoy participating in socialization activities. Statement 3 says that most students chose to strongly agree and agree with the statement that they can understand that tempeh can be processed into healthy drink products. Statement 5 says that most students chose to strongly agree and agree with the statement that making smoothies from tempeh is easy to do and fun. Statement 8 says that most students chose to strongly agree and agree with the statement that the media and explanations during the socialization were easy to understand. Statement 9 says that most students chose to strongly agree and agree with the statement that the activities during the socialization made me more actively involved in discussions with group members. In general, students are happy to participate in group activities with their friends, in this activity students carry out demonstration activities making smoothies from tempeh so that students gain new knowledge and experience related to local food ingredients. The learning activities implemented use the project-based learning learning model. The project-based learning model is a group learning model that encourages students to work together and actively participate within their groups [23]. According to

[24], projects have the potential to improve student learning outcomes.

The lowest recapitulation of student responses was in statement 7, with 64,3% positive and 35,7% negative. Three students chose the negative statement, which is, they disagreed with the statement that this socialization activity encouraged me to become an entrepreneur in food management. Although some students chose to disagree, the percentage of scores for this statement was still categorized as good, meaning it received a positive response from students.

Overall, the project-based learning in the socialization of food and technology innovation received a very positive response from students to all questionnaire items with an average percentage score of 92.84% positive and 7.13% negative. These overall results can be categorized as students' responses to the socialization that has been carried out being categorized as very positive or very good. Thus, project-based learning has proven effective in improving student learning outcomes related to local food while receiving a very positive response with an average percentage score of 92,84% related to the application of the project-based learning model in the socialization of food and technology innovation.

CONCLUSION

Based on the results and discussion, it can be concluded that using a project-based learning model in the dissemination of food innovation and technology can improve student learning outcomes, with an average pretest score of 92.86 and an average posttest score of 99.29. In addition, using project-based learning models in spreading food innovation and technology is effective because the average N-Gain score is 0.89 and the percentage of N-Gain scores achieved is 88.89%. This shows that the socialization method used was effective because the value is above 76, which is considered an effective level according to the N-Gain effectiveness criteria. The use of the project-based learning approach in teaching about food and technology innovation was very well received by the students. This can be identified through the average percentage of all questionnaire statement items by obtaining a percentage value of 92,84% positive (for the choices strongly agree and disagree) and obtaining a percentage value of 7,13% negative (for the choices less agree,

disagree, and strongly agree) from the overall results of student responses.

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