



Optimizing Tofu Production with Contextual Learning and Linear Programming

Dwi Yulianto

Fakultas Pendidikan Matematika, Universitas La Tansa Mashiro, dwiyulianto554@gmail.com

Egi Adha Juniawan

Fakultas Pendidikan Matematika, Universitas La Tansa Mashiro, egiadha93@gmail.com

ABSTRACT

The study of contextual learning implementation introduces mathematical concepts by linking the material with real-life situations or contexts in Rancamulya Village, West Java, commonly known as Tofu Village, where tofu is a staple food and an affordable source of nutrition favored by the wider community. Through research using linear programming simplex method, an optimal solution was found to maximize tofu production, achieving a maximum profit of Rp 1,480,000 with the production of 364 white and 182 yellow tofu boards. Seventy-two mathematics education students at La Tansa Mashir University, Rangkasbitung, conducted this project-based ethnomathematics study. The research employed an ethnographic approach with data collection techniques through observation, documentation, and interviews. Data analysis was performed using a mixed-method approach combining qualitative and quantitative methods. The quantitative data revealed a significant difference in mathematical critical thinking skills between the Problem-Based Learning (PBL) and Numbered Heads Together with Student-Constructed Criteria for Success (NHT-SCCS) learning models. Students taught with the PBL model demonstrated higher critical thinking skills compared to those using the NHT-SCCS model.

Keywords: Contextual Learning, Simplex Method, NHT-SCCS, Problem Based Learning, Tofu Production, Linear Programming.

ABSTRAK

Studi penerapan kontekstual learning memperkenalkan konsep matematika dengan mengaitkan materi tersebut dengan situasi atau konteks kehidupan nyata. Di Desa Rancamulya, Jawa Barat, biasa dijuluki dengan Kampung Tahu, di mana tahu menjadi makanan pokok dan sumber gizi yang terjangkau yang disukai oleh masyarakat luas. Melalui penelitian dengan model linear programming metode simpleks, ditemukan solusi optimal untuk memaksimalkan produksi tahu, mencapai keuntungan maksimum sebesar Rp 1.480.000 dengan produksi 364 papan tahu putih dan 182 papan tahu kuning. Penerapan studi etnomatematika berbasis proyek ini, dilakukan oleh 72 mahasiswa pendidikan matematika di Universitas La Tansa Mashir, Rangkasbitung. Penelitian ini menggunakan pendekatan etnografi dengan teknik pengumpulan data melalui observasi, dokumentasi, dan wawancara. Hasil analisis data menggunakan metode mix method dengan pendekatan gabungan kualitatif dan kuantitatif. Hasil data kuantitatif menunjukkan perbedaan signifikan dalam keterampilan berpikir kritis matematis antara model pembelajaran PBL dan NHT-SCCS. Mahasiswa yang diajarkan dengan model PBL menunjukkan keterampilan berpikir kritis yang lebih tinggi daripada siswa yang menggunakan model NHT-SCCS.

Keywords: Pendekatan Kontekstual, Simplex Method, NHT-SCCS, Pembelajaran Berbasis Masalah, Program Linear.

INTRODUCTION

Contextual learning is an instructional approach that enables educators to connect the taught material with real-world situations, encouraging learners to relate the knowledge they possess to its application in daily life (Ridho et al., 2024). The philosophy underlying the development of this



approach is that knowledge is gradually built through experiences expanded within limited and non-sudden contexts (Astuti & Najuba, 2024). Therefore, in teaching mathematics, which has an abstract nature, efforts must be made to make it more concrete (Rombe et al., 2023). This would facilitate students in understanding the material (Trisnawati et al., 2023). Hudoyo emphasizes that instructional material can interact with learners if it aligns with their intellectual development and cognitive structure (Khoiruzzadi & Prasetya, 2021). Characteristics of contextual learning include problem-based, utilizing multiple contexts, evoking learning regularity, students becoming part of the context, learning within social contexts, and using authentic assessment (Trisnawati et al., 2023). Ahmad (2022) asserts that successful mathematics education will integrate cultural values to make learning more vibrant and relevant for students. For example, in teaching geometry, educators can leverage traditional buildings or architecture from local cultures to explain geometric concepts such as symmetry, patterns, and proportions. Referring to the research findings of Kumala (2022), which indicate that communities utilize mathematical knowledge in traditional food production, this study encourages further exploration of mathematical concepts in the context of tofu production. Literature research shows that a contextual approach to learning is highly effective in enhancing students' critical thinking skills and curiosity (Triyani, 2019). Supranoto's study (2016) indicates that students engaged in contextual-based learning tend to have better critical thinking abilities. Factors contributing to the effectiveness of contextual learning for developing critical thinking skills include instructional design relevant to real life, active and collaborative teaching methods, and an emphasis on reflection and real-world experiences (Yulianto & Juniawan, 2022). Thus, this study reinforces the positive effect of contextual learning on students' mathematical critical thinking abilities.

Critical thinking skills are essential for students, as suggested by the Committee on the Underground Program in Mathematics (Yulianto, 2020), stating that every mathematics course should support the development of students' analytical, critical reasoning, problem-solving, and communication skills. Susanti & Marhayati (2020) describe critical thinking as rational decisions or judgments about something. Students with critical thinking skills tend to continuously monitor their thinking to ensure they do not draw incorrect conclusions, which is crucial in tackling complex problems. Critical thinking skills also enhance students' understanding of mathematical concepts because they aid in interpreting, analyzing, evaluating, and presenting data logically and sequentially (Yulianto et al., 2023). This indicates that mathematical critical thinking skills deepen students' understanding of mathematical concepts by helping them in analysis and evaluation. Critical thinking skills provide tangible benefits for students in their academic and professional lives (Marlina, 2020). Academically, these skills enable students to understand materials more deeply, complete tasks more effectively, and become critical readers and writers (Rahma et al., 2024). Professionally, critical thinking makes students effective problem solvers, good leaders, and contributing team members (Baharuddin, 2016).

The lack of critical thinking skills among students, as seen from their limited involvement in solving real-world problems, can hinder the development of critical thinking skills (Asri, 2022). Fifth-semester students of the mathematics education program at La Tansa Mashiro University demonstrate low levels of mathematical critical thinking. Most students come from Islamic boarding

schools with cognitive backgrounds dominated by Arabic language or religious education. Additionally, the results of their mid-term and final exams indicate an inadequate understanding of mathematical concepts. Interviews with several lecturers who have taught them also demonstrate students' lack of critical thinking skills. Students tend to passively receive information from lecturers, resulting in suboptimal learning processes. Lack of student engagement can also be observed from the scarcity of questions students ask and their difficulties in solving problems that require argumentation. Factors such as lecturer-centered learning approaches and limitations in self-regulated learning also contribute to students' low critical thinking skills. Therefore, improvement measures to increase student engagement in the learning process and develop their critical thinking skills are crucial.

In the context of challenges faced by students who also hold roles as managers and organizers of events in Islamic boarding schools, it is essential for educational institutions to provide adequate support and facilities to assist students in developing their self-regulated learning skills through project-based assignments as challenges for mathematical critical thinking skills (Yulianto et al., 2023). This background indicates that limitations in self-regulated learning, especially for students with additional roles in Islamic boarding schools, can affect their ability to develop critical thinking skills (Zakaria & Yulianto, 2021). The reason for assigning student projects is that students often struggle to understand mathematical concepts due to the lack of practical application in daily life, resulting in a lack of interest, motivation, and critical thinking skills (Yulianto et al., 2023). Passive traditional learning approaches also pose a challenge (Yulianto, 2020). Therefore, it is essential for educators to not only consider the technical aspects in implementing the learning process but also to pay attention to the needs of students in developing critical thinking skills.

Student project assignments that apply lecture materials in daily life effectively link academic concepts with real-world contexts (Kumala, 2022). This study focuses on evaluating the tofu production process at Tofu Industry Mang Emen in Rancamulya, Sumedang, West Java Province. Culturally, tofu production often becomes part of a wealthy local heritage with traditional values. The tofu-making process usually involves using traditional knowledge and skills passed down through generations to become a symbol of local wisdom and cultural identity (Kumala, 2022). In addition, variations in tofu-making techniques, flavors, and textures also reflect cultural diversity in various regions (Kumala, 2022). This industry is a home-based business with good market potential. However, tofu producers face challenges in achieving optimal income due to factors affecting the production process and increases in raw material prices, such as soybeans (Setyawan & Huda, 2022). As a result, some tofu producers experience a decrease in revenue of up to 50% (Arief, 2020). The difficulties faced by tofu producers have significant economic and social impacts. The reduction in their income can affect family economic welfare, lead to unemployment or underemployment, and disrupt the overall local economic ecosystem. Suppose the quality of tofu products declines due to production difficulties. In that case, it can impact the nutritional sources of the community as tofu is usually a significant source of protein in daily meals (Kumala, 2022). Therefore, further research on solutions to improve tofu producers' economic and social conditions is crucial to strengthen community welfare.

Although established in 1996 and remains active in the tofu industry, Mang Emen Tofu Factory faces challenges in maximizing production efficiency with limited human resources. Currently, the factory produces two types of tofu, white and yellow, but decision-making regarding production is still suboptimal. The factory aims to achieve a daily production target of 150 to 200 tofu boards with profits ranging from Rp. 1,000,000 to Rp. 1,200,000, but it struggles to combine the production of both tofu types efficiently. To improve efficiency, the factory is considering using linear programming to optimize the blend of raw materials to minimize production costs while maintaining high tofu quality. By articulating a mathematical model, the factory can determine the optimal amount of each raw material for production while considering various constraints such as nutritional requirements, raw material availability, and production capacity. Using linear programming-based simulations, tofu producers can visually understand the implications of changes in raw material blends on production costs and tofu quality, thereby assisting them in making wiser and more efficient decisions in managing their production operations.

The assignment of this linear programming project as an analytical tool aims to develop students' critical thinking skills, which is in line with previous research (Falani, 2018). Linear programming is a mathematical modeling material used to optimize production arrangements and is a crucial step in finding solutions to administrative problems (Oladejo et al., 2019). Increasing efficiency in asset distribution is a priority, primarily through the Simplex method (Vonda et al., 2019), a helpful strategy in linear programming for finding the best solutions (Firmansyah, 2018). One approach to achieve this goal is by formulating the objective function in a specific mathematical equation: $Z_{\max} = c_1x_1 + c_2x_2 + c_3x_3 + \dots + c_nx_n$; Where: Z_{\max} is the maximum profit to be achieved; c_1, c_2, \dots, c_n are coefficients affecting the variables; x_1, x_2, \dots, x_n are the variables used in the calculation.

This study investigates using the simplex method to achieve optimal results in the context of tofu making in Rancamulya (Valinov, 2018). The tofu production process involves careful processing steps with the precise use of tools and ingredients at each stage (Widaningrum, 2015). This research aims to identify the mathematical concepts underlying tofu making, particularly in determining product pricing through producer interviews. Through a contextual approach in education, this research explores the potential use of mathematical concepts in tofu making as a contextual, innovative, and realistic mathematical approach. The observation results indicate that the primary raw materials used by Mang Emen in the tofu-making process include soybeans, water, and vinegar. Nowadays, there is a tendency for the local community to use a mixture of local and imported soybeans in tofu production, which is different from previous practices that only used local soybeans. Although tofu made from local soybeans tastes better, using a mixture of local and imported soybeans increases the sustainability of tofu production. Additionally, the vinegar used in the tofu processing process is produced from previous processes, while the standard fuels used are corn husks and firewood. Kumala's study (2022) indicates that the community utilizes mathematical knowledge to produce traditional foods such as tofu, prompting further exploration of mathematical concepts in the context of tofu making.

Optimizing learning through contextual approaches supports the learning process. Therefore, the author attempts to combine contextual approaches with PBL and NHT-SCCS. These learning models emphasize student participation in developing mathematical critical thinking skills (Khoiruzzadi & Prasetya, 2021). PBL encourages real-world problem-solving (Yulianto et al., 2023), while NHT-SCCS uses case studies created by students for collaborative learning (Lestari et al, 2020). Implementing both increases student engagement in discussions, develops critical thinking skills, and improves learning outcomes (Yulianto, 2020). Literature studies indicate that both models effectively improve students' critical thinking skills. Sapitri's research (2016) suggests that learning models such as group investigation and guided inquiry can improve students' critical thinking skills.

Further research is needed to compare learning models in a contextual approach, as Yustina (2015) suggested. Another Ayuningrum (2015) study indicates that learning models such as PBL and NHT-SCCS enhance students' critical thinking abilities. Therefore, these learning models can potentially improve student's critical thinking skills in mathematics learning with a contextual approach. This study aims to analyze prospective mathematics teacher students' mathematical critical thinking abilities at La Tansa Mashiro University. The research focuses on understanding the management of Mang Emen's tofu production house in Rancamulya, Sumedang, West Java, emphasizing developing strategies to increase tofu production and optimize daily profits, considering students' self-regulated learning.

METHOD

This study employs a one-group post-test design involving two classes of fifth-semester mathematics education program students at Universitas La Tansa Mashiro Rangkasbitung. Experimental Class I (regular A) is exposed to a contextual approach with the PBL model, while Experimental Class II (regular B) is subjected to a contextual approach with the NHT-SCCS model. The selection of Experimental Class I using Class A and Experimental Class II using Class B aims to compare the two teaching approaches' effectiveness directly. Experimental Class I is chosen to implement the contextual approach with the PBL model to enhance active student engagement, so Experimental Class II utilizes the contextual approach with the NHT-SCCS model, focusing on student collaboration in task completion and instructions tailored to student abilities. By employing different classes for the two teaching approaches, this study aims to provide deeper insights into their impacts on students' academic outcomes and learning experiences.

Table 1. Research Design

The class	Treatment	Posttest
Experiment 1 (PBL)	X ₁	O ₁
Experiment 2 (NHT-SCCS)	X ₂	O ₁

Description: X₁: PBL Model; X₂: NHT-SCCS Model; O₁: Posttest of Critical Thinking Ability.

At the end of the semester, students are assigned an ethnomathematics-based project task to optimize learning related to course materials. The project assignment takes place over three weeks before the Final Exam. Post-test assessment (Final Exam) is conducted after implementing both

approaches. The sample consists of 36 students per class selected through purposive sampling, aiming to ensure adequate representation of the research population for higher validity and utility of research outcomes. The research design is detailed in Table 1.

The research on tofu production processes was conducted in Kampung Tahu Rancapurut Village, located in North Sumedang District, Sumedang Regency, West Java, Indonesia. This village was chosen as the study location because it serves as a significant tofu production center and provides a relevant context for the research objectives. The direct involvement of households in the tofu industry makes this village an ideal environment in which to observe tofu-making practices firsthand and explore the role of mathematics in its production process. By focusing on the understanding of mathematical concepts in tofu production, the research in this village aims to provide valuable insights into how mathematical concepts are applied in the actual context of the tofu industry. Furthermore, the research in Kampung Tahu Rancapurut Village also allows for a deeper understanding of the economic and social roles of the tofu industry in the local community, including the economic impacts of challenges faced by tofu producers and the contribution of mathematical knowledge in maintaining the sustainability of the industry. Thus, the study in this village is expected to significantly contribute to understanding the role of mathematics in traditional industries such as tofu production, as well as its broader implications in the local and beyond.

The data collection method involves interviewing Tofu factory owners and documenting observations to observe activities in tofu making. Technical triangulation is used to validate data by comparing interview results, observations, and documentation. Data analysis adopts a mixed method approach with a combination of qualitative and quantitative. The analysis stage begins with a qualitative approach to understanding the context and phenomena observed before conducting experiments. This approach allows the identification of relevant variables to be experimentally tested. Qualitative data may yield findings about manufacturing techniques, local customs, or cultural factors influencing tofu-making processes.

In contrast, experimental data focus on quantitative measurements such as temperature, fermentation time, or additives used and their relationship to tofu production outcomes. Although different in approach, both data types complement each other to provide a more comprehensive understanding of the tofu-making process. Qualitative analysis involves data reduction, data presentation, and conclusion drawing. Data is reduced to identify parts related to mathematical concepts in the tofu-making process. Data presentation is done to obtain a comprehensive overview of the mathematical concepts in the tofu-making process. The researchers then discuss the contribution of contextual approaches and mathematical learning in the tofu production process. The quantitative data collection technique uses both test and non-test data. Two expert lecturers have validated instruments and learning observation sheets to measure mathematical critical thinking. Exams are conducted to assess students' critical thinking abilities at the end of the learning process in essays tested for validity and reliability with 6 items. This instrument is tested as a post-test for students as the final exam grade. The validity and reliability results of the instrument in this research are based on items ($n=6$) and measured with a Cronbach's alpha of 0.79, indicating a high level of internal consistency.

Furthermore, for the validity test of the 6 essay questions, the reliability of this research is based on items (n=6) and measured to be valid and suitable for use. Data processing and analysis use statistical tests (independent t-tests). Before the t-test, the prerequisite analysis uses normality and homogeneity tests to obtain normally distributed and homogeneous data. The results of the normality and homogeneity tests presented in Table 2.

Table 2. The Results of The Normality And Homogeneity Tests

Prerequisite Test	Contextual Approach		Criteria
Normality	PBL	0,952	H ₀ Accepted Normality
	NHT-SCCS	0,794	
Homogeneity	PBL	0,599	H ₀ Accepted
	NHT-SCCS	0,612	Homogeneous

Based on Table 2 above, it can be concluded that the data is normally distributed and homogeneous. Therefore, the next step is statistical testing (independent t-test), which will be discussed in the research results. Furthermore, the aspect of critical thinking abilities in this study is adopted from Facione, as presented in Table 3.

Table 3. Aspects of Critical Thinking

Aspects of Critical Thinking	Description
Interpretation	Can formulate the problem from the question indicated by writing what is known and what is asked in the issue.
Analysis	Identifying the relationship between the statements, questions, and concepts provided in the problem by constructing an accurate mathematical model.
Inference	Capable of drawing logical conclusions and answering questions accurately.
Evaluation	Using the appropriate strategy to solve the problem, complete and accurate in performing calculations.
Explanation	Presenting results, validating procedures, and Presenting arguments.
Self Regulation	Self-Assessment and Self-Correction of Arguments

The results of the data calculation for the post-test in both experimental classes were then analyzed based on indicators to observe the differences in students' critical thinking skills between the PBL and NHT-SCCS models. The categories of critical thinking skills are presented in Table 4.

Table 4. Categories of Critical Thinking Skills

Percentage	Category
80 – 100	Excellent
66 – 79	Good
56 – 65	Fair
40 – 55	Poor
0 – 39	Very Poor

RESULT AND DISCUSSION

Optimization of Tofu Production Process

Practically, this research offers a new approach to enhancing tofu production efficiency by applying contextual mathematics learning methods and linear programming. By employing this

approach, tofu producers can optimize their production processes by considering various factors such as raw materials, production costs, machine capacity, and market demand. For instance, by implementing linear programming models, producers can determine the optimal combination of raw materials to make tofu, maximizing production output and minimizing production costs. Theoretically, this research contributes to a deeper understanding of linear programming concepts and their application in the food industry, such as tofu production. Linear programming is a mathematical optimization technique to solve problems where some constraints and objectives must be achieved by maximizing or minimizing an objective function. In the food industry, this concept can be applied to optimize production processes, supply chain management, and inventory management.

The theoretical implications of this research are that a better understanding of linear programming concepts can assist scientists and food industry practitioners in designing more efficient and sustainable production strategies. Additionally, this research provides new insights into how contextual mathematics learning approaches can teach complex mathematical concepts in relevant and meaningful contexts for students or industry practitioners. Therefore, the results of this research not only provide new insights into linear programming concepts in the context of the food industry and offer practical solutions that industry practitioners can apply to enhance production efficiency, supply chain management, and inventory management in the tofu industry. This represents a significant step towards a more efficient, sustainable, and competitive food industry.

Industri Tahu Sari Murni, established by Mang Emen in 1996, employs nine workers with the following breakdown: two cutting and finishing operators, four cooking operators, one boiler and milling operator, and two delivery operators. These employees come from various regions, including around the Rancamulya area. The tofu production process uses traditional tools, most of which are self-designed by the owner. This process is in the attached operation process map in Figure 1.

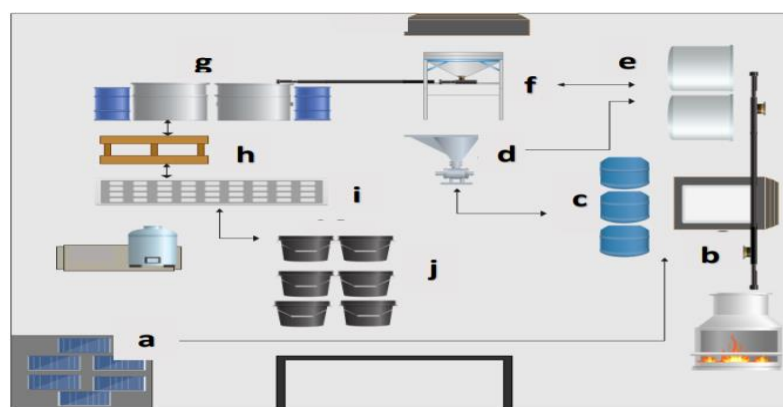


Figure 1. Flowchart of the Tofu Production Process at Sari Murni Tofu Industry

The description of the tofu-making process includes preparation of the raw material space (a), handling of the material with a water bath (b), soaking process (c), use of milling machine (d) to grind soybeans, cooking process (e) using a covered container, filtration with a filtration machine (f), coagulation process (g) using a coagulant, molding (h) tofu in a mold, cutting process (i) as desired, and finally, storage in the finished product space (j). The Tahu Mang Emen production house produces white tofu and yellow tofu. Every day, they produce white tofu three times with 200 pieces

of tofu each time and yellow tofu twice with 150 pieces of tofu each time. Interviews with researchers and students revealed several stages in the tofu production process. The following is the transcript of the initial interview results on the tofu-making process.

Researcher : What is the first step in making the typical Sumedang tofu?
Tofu Maker :

Before the washing process, the soybeans are carefully weighed, following the principle of "*Makle pas takarnah tak bilebbi*," (Do not exceed the specified measurement) which ensures that there will be no shortage in the weighing process. Subsequently, the soybeans are soaked in a bucket for one day and one night, then washed thoroughly to soften the soybeans for easier grinding. Each tub can hold 33-35 kg of soybeans. The Tofu Sari Murni Industry uses local and imported soybeans, with different soaking times for each type of soybean. Local soybeans are soaked for 2.5 hours, while imported soybeans are soaked for 2 hours, as explained in Figure 2. The soaking process ensures the beans expand more, known as "so that it blooms and expands". This process is important because soaking for more than 3 hours can result in a "Sour" taste and less expansion when fried later.



Figure 2. Soaking Process

Researcher : What is the next step?

Tofu Maker : The soybean washing process is essential in cleaning soaked soybeans from impurities such as wood debris, soil, and dry leaves. Floating impurities during soaking are removed, and the soybeans are transferred to washing baskets. Each soaking tank produces five washing baskets. The soybeans are then rinsed with water and drained for about 3 minutes. An illustration of this washing process can be seen in Figure 3. Soybean washing is done intensively to ensure the cleanliness of the soybeans, a process known as "*Berse*". This washing process typically involves three rinses to remove dirt and other particles from the soybeans.



Figure 3. Washing Process

Tofu Maker : The soybean grinding process involves grinding soybeans with a grinding machine equipped with water to facilitate it. After soaking and washing, the soybeans are put into the grinding machine and ground into a paste. The soybean paste is then boiled in a bucket placed on a tube-shaped stove without a cover, equipped with a hemispherical pan inside. One basket of soybeans can produce two bowls of soybean starch in one grinding cycle. This process takes 3 minutes for one grinding cycle. The soybean grinding process is carried out to create delicate and mashed soybean paste. "*Egilis makle kedelai bisa alos deddih bubur kedelai*" (Soy food products can also be made into soy porridge) means that soybean grinding produces smoother and softer soybean paste (Figure 4).



Figure 4. Milling Process

Researcher : Is it boiled after it turns into porridge, not when it's still whole soybeans?

Tofu maker : The process of making soy porridge begins by boiling soy porridge for one hour on a boiling stove. This is a process of cooking soybean starch with water until boiling. The ground soybean starch is put into the furnace, then water and hot steam from the kettle are added. The boiling process takes place until boiling, which takes about 5 minutes to boil two bowls of soy porridge. The boiling process can be seen in illustration 6. Soy porridge, after grinding, is cooked in a large container called a "*tahang*" on a combustion stove with the addition of water. This cooking process produces dregs and soybean starch. (Figure 5).



Figure 5. The Soybean Boiling Process

Researcher : Next?
 tofu maker : The process of filtering soybean starch extract is carried out using rectangular-shaped cheesecloth to separate the soybean extract from its pulp. This process is crucial because soybean starch extract is the main ingredient in tofu production. The first step is to place the cheesecloth on the filtering stove and hang four pieces of cheesecloth on the available hooks. Next, the boiled soybean starch extract is transferred into the cheesecloth. The filtering process is done by shaking and rotating the cheesecloth containing the soybean starch extract while adding water to increase the filtering efficiency. This step is repeated twice to ensure optimal filtering. This process produces tofu dregs that can be used as animal feed. The entire filtering process takes about 5 minutes. Subsequently, waste in the form of tofu dregs is produced. When stirring or boiling the soybean slurry, soybean "pateh" extract settles at the bottom, while soybean dregs float to the surface. Because the tofu-making process requires soybean extract, the dreg floating on the surface is filtered or separated from the soybean extract. These dregs are often utilized as animal feed (Figure 6).



Figure 6. Tofu Residue

Researcher : Is the waste discarded?
 Tofu maker : Squeeze thoroughly until all the juice is gone from the pulp.
 Researcher : What's next?
 Tofu maker :

The "Nglaru" process is a step-in tofu making where residual water from the previous process is mixed with tofu whey and stirred until evenly distributed. After this process, tofu porridge is formed by separating water from the tofu porridge. This separated water is then reused in the subsequent stage of tofu making. The following process is coagulation, where tofu vinegar water is added to the filtered soybean paste to form curds. The tofu vinegar used is a mixture of water from the previous process with regular water at a normal temperature. After mixing, the dough is stirred until curdled, and the separated water is transferred back to the vinegar water container. The coagulation process takes about 8 minutes, then wait for 15 minutes until the tofu porridge is formed. The addition of vinegar aims for two things. First, to separate water from the soybean paste. Second, the soybean paste must be thickened to be processed into tofu (Figure 7).



Figure 7. Tofu Residue

Researcher : What will be done with the formed tofu porridge next?
 Tofu maker : Making tofu porridge involves using a wooden mold measuring 40 cm x 55 cm x 8 cm to extract water from the tofu, adjusted according to the amount of soybeans used. The molding process utilizes a stainless-steel mold prepared with cheesecloth, filled with tofu starch paste, covered, and stacked with stones for about 16 minutes. Two buckets of tofu starch yield four tofu board molds (Figure 8).



Figure 8. Tofu Residue

Tofu maker : The tofu that has been formed will be cut to the desired size using a knife and a block-shaped wooden tool to ensure that the tofu pieces are straight, with a length of 70 cm, a width of 5 cm, and a height of 1 cm. After being cut, the tofu is placed on a rack to harden for at least 30 minutes before further processing, as seen in Figure 10. To reduce its moisture content, the tofu is wrapped in a square cloth measuring 18 cm x 18 cm and pressed again (Figure 9).



Figure 9. Storage Process

Researcher : What is the next step?

Tofu maker : The hardened tofu is transferred to the cutting area, where it is then cut according to the size predetermined by Industri Tahu Sari Murni. The cutting process is done using a wooden ruler and a cutting knife, taking 2 minutes. After being cut, the tofu pieces are soaked in a bucket of water and placed in a basin. Each basin can accommodate tofu pieces cut from 2 tofu blocks measuring 5 cm x 5 cm. The prepared tofu pieces are then sent to consumers. The illustration of the final storage process can be seen in Figure 10. The tofu-cutting process uses a "ladding" knife, where the tofu is cut to the desired size. Typically, the local community divides tofu into medium and large sizes.



Figure 10. Tofu Cutting Process

Table 5. Depicts Data on Raw Material Needs

Material	White Tofu	Yellow Tofu	Inventory
Soybeans	37.5 Kg	46.7 Kg	50,000 Kg
Firewood	166.67 Kg	110 Kg	83,000 Kg
Kerosene	0.3 L	0.25 L	2L
Vinegar	0.3 L	0.5 L	3L
Turmeric	-	500 g	2,000 g
Vinegar	-	250 ml	1,000 ml
Production Capacity	200 Boards	150 Boards	1,000 Boards
Boards Work Time	1.5 Hours	2.5 Hours	10 Hours
Profit	IDR 22,500/production	IDR 36,400/production	-

The research data on the raw materials for tofu production are available in Table 5. The simplex method is a decision-making technique to solve linear programming problems and find optimal values. This method can handle two or more decision variables. There are two calculation methods: manual and using applications or software. The manual steps involve determining decision variables, objective functions, and constraints. Mathematical model equations are then organized into a simplex Table 6 by identifying key columns and rows (Mayasri, 2019).

Table 6. Initial Table of Simplex Method

Basic Variables	X_1	X_2	...	X_n	S_1	S_2	...	S_n	NK
Z	$-C_1$	$-C_2$	...	$-C_n$	0	0	0	0	0
S_1	a_{11}	a_{12}	...	a_{1n}	1	0	0	0	b_1
S_2	a_{21}	a_{22}	...	a_{2n}	0	1	0	0	b_2
⋮
S_n	a_{n1}	a_{n2}	...	...	...	...	...	1	b_n

The simplex method-solving process encompasses several key steps. First, basic variables are identified, representing the values equal to the right-hand side values of the equations. In contrast, NK (key value) represents the values behind the equal sign or the values of the available resource constraints. Next, the constraint function x_1, x_2, \dots, x_n is employed to describe the constraints within the problem. To convert inequalities into equations within the mathematical model, slack variables S_1, S_2, \dots, S_n are introduced. The objective function Z , which requires optimization, is then defined. Subsequently, the intersection between the key columns and rows is determined using the cell elements, also known as key numbers. Iteration follows, involving changes to decision variables

and dividing the value in the key row by the key number. Values outside the key row are adjusted until negative values are eliminated. Without negative coefficients within Z, iteration continues until an optimal result is achieved.

This study aims to determine the daily production allocation between white and yellow tofu to achieve maximum revenue for producers using the simplex method of linear programming. The main steps of this research involve determining production variables (x_1 and x_2), the objective function to maximize revenue ($Z = 22,500 x_1 - 36,400 x_2$), and the constraint function that includes production constraints and their relation to the available raw materials: a) Soybeans: $37.5 x_1 + 46.7 x_2 \leq 50000$; b) Firewood: $166.7 x_1 + 110 x_2 \leq 83000$; c) Solar: $0.3 x_1 + 0.25 x_2 \leq 2$; d) Vinegar: $0.3 x_1 + 0.5 x_2 \leq 3$; e) Turmeric: $500 x_2 \leq 2000$; f) Vinegar: $250 x_2 \leq 1000$; g) Production Capacity: $200 x_1 + 150 x_2 \leq 1000$; h) Working Time: $1.5 x_1 + 2.5 x_2 \leq 10$.

All variables, including slack variables ($S_1, S_2, S_3, S_4, S_5, S_6, S_7,$ and S_8), must be non-negative, expressed as $x_1, x_2, S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8 \geq 0$. This research utilizes the simplex method to find a solution that maximizes the tofu producer's revenue while satisfying all existing constraints. This process involves transforming the mathematical model equations into the canonical form of the simplex method. Slack variables are added to the initial simplex table according to the modified constraint and objective functions, as depicted in Table 7.

Table 7. Simplex Method

Basic Variables	Z	x_1	x_2	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	NK	Indeks
Z	1	-22.500	-36.400	0	0	0	0	0	0	0	0	0	0
S_1	0	37.5	46.7	1	0	0	0	0	0	0	0	50.000	1.070,66
S_2	0	166.67	110	0	1	0	0	0	0	0	0	83.000	754.55
S_3	0	0.3	0.25	0	0	1	0	0	0	0	0	2	8
S_4	0	0.3	0.5	0	0	0	1	0	0	0	0	3	6
S_5	0	0	500	0	0	0	0	1	0	0	0	2.000	4
S_6	0	0	250	0	0	0	0	0	1	0	0	1.000	4
S_7	0	200	150	0	0	0	0	0	0	1	0	1.000	6.67
S_8	0	1.5	2.5	0	0	0	0	0	0	0	1	10	4

To achieve the maximum objective value in the simplex method, the first step is determining the key columns and rows. Key columns refer to columns with the largest negative coefficients, while key rows are rows with the smallest indices. The steps in the Simplex method to determine the optimal combination of decision variables x_1 and x_2 that will maximize tofu production while satisfying all given constraints, as depicted in Table 8.

Table 8. Key Columns

Basic Variables	Z	x_1	x_2	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	NK
Z	1	-22.500	-36.400	0	0	0	0	0	0	0	0	0
S_1	0	37.5	46.7	1	0	0	0	0	0	0	0	50.000
S_2	0	166.67	110	0	1	0	0	0	0	0	0	83.000
S_3	0	0.3	0.25	0	0	1	0	0	0	0	0	2
S_4	0	0.3	0.5	0	0	0	1	0	0	0	0	3
S_5	0	0	500	0	0	0	0	1	0	0	0	2.000
S_6	0	0	250	0	0	0	0	0	1	0	0	1.000
S_7	0	200	150	0	0	0	0	0	0	1	0	1.000
S_8	0	1.5	2.5	0	0	0	0	0	0	0	1	10

The row index is calculated by dividing the right-hand side (RHS) value by the corresponding key column value. It is important to note that negative and 0 values in the key columns are not included in the index calculation. The resulting table may not provide an optimum solution if there are multiple smallest values involving negative or 0 values in the index calculation. In such situations, the row must be selected arbitrarily. The intersection between the key column and key row is determined by the simplex table's cell elements (key numbers). The key number in question is 500, which can be found in Table 9.

Table 9. Key Rows

Basic Variables	Z	X ₁	X ₂	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	NK	Indeks
Z	1	-22.500	-36.400	0	0	0	0	0	0	0	0	0	0
S ₁	0	37.5	46.7	1	0	0	0	0	0	0	0	50.000	1.070,66
S ₂	0	166.67	110	0	1	0	0	0	0	0	0	83.000	754,55
S ₃	0	0.3	0.25	0	0	1	0	0	0	0	0	2	8
S ₄	0	0.3	0.5	0	0	0	1	0	0	0	0	3	6
S ₅	0	0	500	0	0	0	0	1	0	0	0	2.000	4
S ₆	0	0	250	0	0	0	0	0	1	0	0	1.000	4
S ₇	0	200	150	0	0	0	0	0	0	1	0	1.000	6,67
S ₈	0	1.5	2.5	0	0	0	0	0	0	0	1	10	4

Subsequently, the iteration stage is carried out by adjusting decision variables and dividing the key row by the key number in Table 10.

Table 10. Key Rows

Basic Variables	Z	X ₁	X ₂	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	NK
Z												
S ₁												
S ₂												
S ₃												
S ₄												
X ₂	0	1	0	0	0	0	0	0	0,002	0	0	4
S ₅												
S ₆												
S ₇												
S ₈												

Then, Change the values outside the key rows until there are no negative values:

New row = old row - (key column value * new key row value) to Table 11.

Table 11. Results of New Rows in the First Iteration

Basic Variables	Z	X ₁	X ₂	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	NK	
Z	1	-22.500	-36.400	0	0	0	0	0	0	0	0	0	
-36.400	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
1	-22.500	0	0	0	0	0	0	78.2	0	0	14.560	145.600	
S ₁	0	37.5	46.7	1	0	0	0	0	0	0	0	50.000	
46,7	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
0	37,5	0	1	0	0	0	0	-0,0934	0	0	0	4.9813,2	
S ₂	0	166.67	110	0	1	0	0	0	0	0	0	83.000	
110	0	0,6	1	0	0	0	0	0	0	0	0,4	4	(-)
0	100,7	0	0	1	0	0	0	0	0	0	-44	82.560	
S ₃	0	0.3	0.25	0	0	1	0	0	0	0	0	2	
0,25	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
0	0.3	0	0	0	0	1	0	-0,248	0	0	0	1	
S ₄	0	0.3	0.5	0	0	0	1	0	0	0	0	3	
0,5	0	0	0	1	0	0	0	0,002	0	0	0	4	(-)
0	0.3	0	0	0	0	0	1	-0,001	0	0	0	1	
S ₅	0	0	250	0	0	0	0	0	1	0	0	1.000	
250	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
0	0	0	0	0	0	0	0	-0,5	0	0	0	0	
S ₇	0	200	150	0	0	0	0	0	0	1	0	1.000	
150	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
0	200	0	0	0	0	0	0	-0,3	0	1	0	400	
S ₈	0	1.5	2.5	0	0	0	0	0	0	0	1	10	
2,5	0	0	1	0	0	0	0	0,002	0	0	0	4	(-)
0	1.5	0	0	0	0	0	0	-0,005	0	0	1	0	

In this step, iteration is performed because there are still negative values in the Z score. This iteration aims to achieve a positive Z score, indicating the attainment of the optimal solution.

Table 12. The Results of the New Rows in the Third Iteration

Basic Variables	Z	X ₁	X ₂	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	NK
Z	1	0	0	0	0	0	0	0	0	6	14.200	148.000
S ₁	0	0	0	1	0	0	0	0	0	-0,09	-13,51	49.778,73
S ₂	0	0	0	0	1	0	0	0	0	-0,092	10,93	82.193,82
S ₃	0	0	0	0	0	1	0	0	0	0	-0,02	0,45
S ₄	0	0	0	0	0	0	1	0	0	0	-0,20	1
X ₂	0	0	1	0	0	0	0	1	0	-0,01	0,73	1,82
S ₆	0	0	0	0	0	0	0	0	1	1,36	-181,82	545,45
S ₇	0	0	0	0	0	0	0	1	0	2,73	-363,64	1.090,91
X ₁	0	1	0	0	0	0	0	0	0	0,01	-0,55	3,64

Based on the data from Table 12, the optimal solution has been found as there are no negative coefficients in the objective function. The optimal values are $x_1 = 364$ and $x_2 = 182$, with a maximum objective function value of $Z_{max} = 1,480,000$. This finding has significant implications for understanding and applying linear programming concepts in the tofu industry. Using linear programming methods to optimize tofu production can reduce production costs while maintaining product quality. The impact is directly felt in operational management, allowing tofu producers to plan the efficient use of raw materials and enhance their expenditure effectiveness.

This research also confirms that linear programming concepts, including tofu production, can be widely applied in the food industry. Concrete evidence from this study shows that linear programming can effectively improve food industry operations, both in cost reduction and in increasing efficiency and product quality. Furthermore, these findings contribute to the literature on applying linear programming in the food industry by presenting relevant and concrete case studies in the tofu industry. This enriches understanding of the application of linear programming concepts in the context of the food industry in general and provides practical guidance for producers to manage their operations effectively. Thus, this research significantly impacts the practice and development of academic knowledge about linear programming and its application in the food industry.

Comparison of Students' Mathematical Critical Thinking Abilities

The described data includes post-test results of critical thinking skills and observations during the learning process. Posttest calculations for both experimental classes were then analyzed to compare students' mathematical critical thinking skills between PBL and NHT-SCCS learning models. The analysis results indicate that students' mathematical critical thinking skills are better when using the PBL model than the NHT-SCCS model in applying linear programming with the simplex method. The distribution of post-test results of students' critical thinking skills is documented in Table 13.

Table 13. Descriptive Statistical of Posttest Mathematical Critical Thinking Skills

Descriptive statistical	Experiment 1	experiment 2
Mean	70.88	65.16
Median	71.43	65.71
Std. Deviation	10.57	7.84
Maximum	91.43	74.29

Descriptive statistical	Experiment 1	experiment 2
Minimum	40.00	34.29

This study evaluates critical thinking skills through six main aspects: interpretation, analysis, inference, evaluation, explanation, and self-regulation. The average scores of critical thinking skills from both experimental groups indicate students' level of critical thinking skills. The comparison of the percentage of students' achievement in each aspect of mathematical critical thinking skills between the PBL and NHT-SCCS models can be presented in Table 14.

Table 14. Percentage Results and Categories of Mathematical Critical Thinking

Aspect	Achievement in Percentage	
	Experiment 1	experiment 2
Interpretation	73.33 (Good)	65.85 (Fair)
Analysis	75.56 (Good)	71.11 (good)
Inference	77.22 (good)	76.11 (good)
Evaluation	46.11 (poor)	38.33 (poor)
Explanation	68.33 (Good)	71.67 (Good)
Self Regulation	76.67 (Good)	67.22 (Good)

The results of hypothesis testing on students' critical thinking skills in both experimental classes after treatment can be seen in Table 15.

Table 15. Hypothesis Testing Results Posttest

Statistic	Class Experiment 1	ClassExperiment 2
N	36	36
Average	70,08	65,16
t-value		2,243
t-table		1,994
Conclusion	There is a significant difference	

The hypothesis test results in Table 15 indicate that This approach involves calculating the t-value generated from an independent t-test and comparing it with the values listed in the t-distribution table to determine statistical significance. Thus, the computed t-value (2.243), exceeding the critical value listed in the t-table (1.994), indicates a significant difference between the two groups. Consequently, the null hypothesis (H_0) can be rejected, and the conclusion can be drawn that using the PBL and NHT-SCCS models has different impacts on students' mathematical critical thinking skills. Consequently, it can be concluded that there is a significant difference in students' mathematical critical thinking skills when taught using the Problem-Based Learning (PBL) model and the Numbered Heads Together with Student-Created Case Studies (NHT-SCCS) model. Regarding the interpretation aspect, which involves understanding, stating, and describing the meaning of data, the percentage of students achieving a satisfactory level is higher in experimental class 1 (PBL), reaching 73.33%, compared to experimental class 2 (NHT-SCCS), which achieved 65.83% in the satisfactory category. The higher achievement in experimental class 1 (PBL) could be explained by applying PBL syntax, where students are trained to identify the core problem through real-world case studies using the simplex method. Conversely, experimental class 2 (NHT-SCCS) also develops interpretation skills but focuses more on questions from the lecturer rather than just the factual information provided in the problem. The superior interpretation skills in the PBL class are consistent

with previous research findings showing the positive impact of the PBL model on students' understanding of concepts in linear programming and case studies (Yulianto, 2020).

The ability to analyze is the skill to identify the relationship between statements and concepts to generate opinions. Both the Problem-Based Learning (PBL) and Numbered Heads Together with Student-Constructed Criteria for Success (NHT-SCCS) learning models have good categories in the aspect of analysis, but the percentage results in experimental class 1 (PBL) are higher compared to experimental class 2 (NHT-SCCS) which are 75.56% compared to 71.11%. The main difference between the PBL and NHT-SCCS models lies in the early core activity and group discussions. In experimental class 1 (PBL), students are trained to analyze facts from the presented problem through videos before formulating the problem. The early group discussion involves students expressing opinions or ideas to solve problems, which are then supported by independent information searches from various literature. Students then explain the information found to group members, encouraging the presentation of opinions supported by relevant literature. Students then analyze each opinion proposed by group members to determine the most appropriate opinion, with the ability to defend opinions supported by solid reasons. In this regard, the PBL model encourages students to think critically, question, and seek the basis of arguments and supporting facts, resulting in deep understanding (Diani, 2016).

The role of the teacher in guiding students to think critically when solving problems is crucial. Students are given systematic guidance to identify, analyze, and solve problems, which aligns with Sani's theory (Dewina, 2017). The NHT-SCCS model also helps to train analytical skills in learning. Students are taught to identify and analyze problems through questions from the teacher and collaborate with classmates or teachers to overcome difficulties using Vygotsky's scaffolding concept (Baharuddin, 2015). However, participation in PBL classes shows higher results in analytical skills, consistent with Arends' view (Dewina, 2017). The PBL model helps students develop thinking and problem-solving skills and become independent learners focusing on analysis, criticism, and deep understanding. Therefore, the PBL model is supported because it encourages an increase in students' analytical skills. Aspect inference, involving the ability to draw conclusions and hypotheses based on relevant data and sources, is well evaluated in both learning models. However, the percentage of results from the inference aspect in experimental class 1 (PBL) reached 77.22%, while in experimental class 2 (NHT-SCCS) it was 76.11%. Although the difference is insignificant, both learning models can train students to draw rational conclusions based on analyzed data. In this context, students can formulate alternative hypotheses and examine laboratory data to validate appropriate decisions based on Piaget's theory (Dahar, 2011).

The evaluation aspect, which involves the ability to assess other statements or opinions, has less favorable categories in experimental class 1 (PBL) and experimental class 2 (NHT-SCCS). The percentage of results from the evaluation aspect in experimental class 1 (PBL) is 46.11%, while in experimental class 2 (NHT-SCCS), it is 38.33%. Both classes have less favorable categories in the evaluation aspect because students tend to have similar opinions and provide less criticism. The PBL model emphasizes group discussions and presentations to determine accurate statements considering sources. In contrast, the NHT-SCCS model trains students to assess opinions or

statements as answers to given questions. The explanation aspect, which includes the ability to explain or state results based on data, is well-rated in both learning models. The percentage of results in experimental class 2 (NHT-SCCS) is higher than in experimental class 1 (PBL), namely 71.67% and 68.33%, respectively. The PBL model trains students to explain to group members, while the NHT-SCCS model prioritizes student activities in searching, processing, and presenting information from various relevant literature sources. Students in the NHT-SCCS class have higher explanation aspect skills because they are accustomed to connecting their knowledge with knowledge obtained through discussion and presentation activities.

Self-regulation involves organizing oneself to face and solve problems, which is well-evaluated in both learning models. However, the percentage of self-regulation aspect results in experimental class 1 (PBL) is higher than in experimental class 2 (NHT-SCCS), namely 76.67% and 67.22%, respectively. The overview, integration, and evaluation stages in the PBL model train students to use their knowledge to analyze and evaluate their decision-making ability. On the other hand, the NHT-SCCS model teaches students to use understanding through question-and-answer activities in groups to find the correct answers. The difference in outcomes between the PBL and NHT-SCCS models is influenced by various complex factors, both cognitively and contextually. PBL emphasizes real-world problem-solving, allowing students to apply mathematical concepts in relevant and authentic contexts, while NHT-SCCS highlights teamwork and the collaborative construction of success criteria. Variations in students' learning experiences also play a significant role, with those accustomed to independent learning tending to be more successful in PBL.

In contrast, those preferring instructor-oriented learning may excel in NHT-SCCS. These instructional models also influence students' critical thinking skills, with PBL promoting the development of analytical, synthesis, and evaluation skills. At the same time, NHT-SCCS helps hone critical thinking skills through group discussions. Additionally, instructional support factors are crucial, with the quality of content delivery and instructor support affecting learning outcomes. Considering these factors, educators must plan and implement learning strategies that meet students' needs and desired learning goals, ensuring that the chosen instructional model provides a practical learning experience. Research also indicates that students participating in PBL tend to have higher self-regulation skills, consistent with findings that this model is more effective in developing critical and independent thinking skills.

Meanwhile, the NHT-SCCS model focuses more on teaching concepts through group interaction. External factors also influence learning outcomes, such as students' initial understanding levels and instructor characteristics, which must be considered when interpreting research results. By considering these factors, a more comprehensive understanding of the influence of context and external conditions on learning can be obtained.

In addition to the explanation above, cognitive factors affecting student learning outcomes include interpretation, analysis, and inference skills. The PBL model demonstrates better results in interpretation and analysis by encouraging students to solve real-world problems using the simplex method and through group discussions. Meanwhile, the NHT-SCCS model focuses on analytical skills through instructor questions and student collaboration. Furthermore, contextual factors such as

instructional support also influence learning outcomes. The quality of content delivery and instructor support significantly impact learning outcomes. The PBL model provides a more independent learning experience, while the NHT-SCCS model emphasizes group interaction-based learning.

Variations in students' learning experiences also play a crucial role, where students accustomed to independent learning tend to succeed more in PBL. In contrast, those preferring instructor-oriented learning may excel in NHT-SCCS. In formulating effective learning strategies, it is essential to consider students' learning needs and goals and ensure that the chosen instructional model provides a practical learning experience. Research also indicates that students participating in PBL tend to have better self-regulation skills, consistent with findings that this model is more effective in developing critical thinking and independent skills. In conclusion, a deeper understanding of the contextual and external conditions that influence learning can help provide a more comprehensive interpretation of these research results. By considering these factors, we can better understand the influence of context and external conditions on learning.

In addition to the cognitive factors mentioned above, external factors can influence research outcomes, including students' initial level of understanding and faculty characteristics. Students' level of understanding before engaging with the learning material can significantly impact their ability to comprehend and apply concepts taught in the classroom. Moreover, instructors' characteristics, including teaching styles, experience, and interpersonal skills, are crucial in shaping students' learning experiences and outcomes. Therefore, a detailed analysis of how these external factors affect research results can provide a more comprehensive understanding of learning dynamics and their implications for the effectiveness of applied teaching methods.

From the results of this study, there are opportunities to explore several directions for further research. Firstly, additional research could investigate the factors influencing the differences in mathematical critical thinking abilities between Problem-Based Learning (PBL) and Numbered Heads Together with Student-Created Case Studies (NHT-SCCS) instructional models. For example, studies could focus on the specific role of instructor guidance, student characteristics, or environmental factors that may affect learning outcomes. Secondly, subsequent research could explore the long-term effects of each instructional model on students' mathematical critical thinking abilities. This could involve longitudinal studies to track students' progress over an extended period and understand the overall impact of the applied instructional models.

Furthermore, future research could broaden its scope to compare other instructional models in the context of students' mathematical critical thinking abilities. While comparing PBL and NHT-SCCS may be an initial step, comparing them with other models, such as project-based learning or problem-based learning, could provide broader insights into the effectiveness of various instructional approaches. Lastly, more profound research could expand parameters to include variables influencing students' learning outcomes, such as intrinsic or extrinsic motivation, learning styles, or previous experience in the studied topic. Therefore, further research could provide a deeper understanding of ways to enhance students' mathematical critical thinking abilities through various instructional approaches.

CONCLUSION

The research findings validate that through the implementation of problem modeling in linear programming and calculation methods using simplex, the "Sari Murni Mang Emen" tofu home industry can achieve a maximum profit of Rp 1,480,000 per day, with optimal production consisting of 364 blocks of white tofu and 182 blocks of yellow tofu. Optimizing contextual approaches in the mathematics learning process is also identified as a project to sharpen students' mathematical critical thinking abilities. This study indicates that students taught through project-based learning (PBL) models demonstrate higher mathematical critical thinking skills levels than those who follow the NHT-SCCS model. Furthermore, exploring hybrid models that combine elements from both learning paradigms could be a focus of further research to enhance learning effectiveness. By undertaking these steps, research efforts in this domain have the potential to make significant contributions to improving mathematics education at various levels.

ACKNOWLEDGEMENT

The researcher expresses gratitude to the Research and Community Service Institute (LPPM) of La Tansa Mashiro University for the financial support provided. Additionally, the author also thanks the Department of Mathematics Education for the support and facilities provided in researching the Implementation of ethnomathematics and linear programming strategies in maximizing tofu production profits: a study of students' mathematical critical thinking abilities in Rancamulya Village, Sumedang, West Java.

REFERENCES

- Ahmad, S. (2022). Integrasi Nilai Pendidikan Karakter Mulia Siswa melalui Pembelajaran Matematika. *Jurnal Konseling dan Pendidikan*, 10(3), 408-415. DOI: <https://doi.org/10.29210/191700>
- Arief, L. (2020). *Pemasaran Jasa dan Kualitas Pelayanan*. Malang: Bayumedia Publishing.
- Asri, N. A. (2022). Pengaruh Pembelajaran Kolaboratif Berbasis Lesson Study Terhadap Kemampuan Berpikir Kritis Siswa. *Prosiding Seminar Nasional Biologi*, 2(1), 455-462. DOI: <https://doi.org/10.24036/prosemnasbio/vol2/410>
- Astuti, R., & Najuba, N. (2024). Penggunaan Model Pembelajaran Contextual Teaching and Learning (CTL) untuk Meningkatkan Hasil Belajar dan Keaktifan Siswa. *Prima Magistra: Jurnal Ilmiah Kependidikan*, 5(1), 1-7. DOI: <https://doi.org/10.37478/jpm.v5i1.3141>
- Ayuningrum, D. (2015). Pengaruh Model *Problem Based Learning* terhadap Keterampilan Berpikir Kritis Siswa SMA pada Materi Protista. *Unnes Journal of Biology Education*, 4(2), 124-133. DOI: <https://doi.org/10.15294/jbe.v4i2.8904>
- Baharuddin, M. (2016). Efektifitas Pembelajaran di Perguruan Tinggi (Studi Kasus Metode Diskusi Sebagai Upaya Meningkatkan Berpikir Kritis). *Tarbiyah: Jurnal Pendidikan Agama Islam*, 1(2), 103-114. DOI: <https://doi.org/10.26618/jtw.v1i2.363>
- Dewina, S. (2017). Pengaruh Model Pembelajaran *Problem Based Learning* terhadap Kemampuan Menganalisis dan Keterampilan Berargumentasi Siswa pada Konsep Pencemaran Lingkungan di Kelas X. *Quangga: Jurnal Pendidikan dan Biologi*, 9(2), 46-54. DOI: <https://doi.org/10.25134/quagga.v9i02.748>
- Falani, I. (2018). Penentuan Nilai Parameter Metode Exponential Smoothing dengan Algoritma Genetik dalam Meningkatkan Akurasi Forecasting. *CESS UNIMED: Journal of Computer Engineering, System and Science*, 3(1). 14-16. DOI: <https://doi.org/10.24114/cess.v3i1.8268>

- Firmansyah, A., Panjaitan, D., & Salayan, S. (2018). Pengoptimalan Keuntungan Badan Usaha Karya Tani di Deli Serdang dengan Metode Simpleks. *JISTech: Journal of Islamic Science and Technology*, 3(1), 20. DOI: <http://dx.doi.org/10.30829/jistech.v3i1.1798>
- Kumala, F. Z. (2022). Etnomatematika: Eksplorasi Pembuatan Tahu Khas Kalisari Kabupaten Banyumas Sebagai Sumber Pembelajaran Matematika. *PROXIMAL: Jurnal Penelitian Matematika dan Pendidikan Matematika*, 5(1), 127–137. DOI: <https://doi.org/10.30605/proximal.v5i1.1633>
- Marlina, R. (2020). Meningkatkan Kemampuan Berpikir Kritis mahasiswa Melalui Pengalaman Belajar di Organisasi Kemahasiswaan. *Bhineka Tunggal Ika: Kajian Teori dan Praktik PKn*, 7(2), 103-108. DOI: <https://doi.org/10.36706/jbti.v7i2.12688>
- Oladejo, N. K., Abolarinwa, A. Salawu, S., dan Lukman, A. (2019). Optimization Principle and Its Application In. *International Journal of Civil Engineering and Technology (IJCIET)*, 10(2), 183-190, Available online at <http://iaeme.com/Home/issue/IJCIET?Volume=10&Issue=2>
- Rahma, S. N., Deyanti, F., & Fitriyah, M. (2024). Peran Membaca dalam Meningkatkan Kemampuan Berpikir Kritis di Kalangan Mahasiswa. *DHARMA ACARIYA NUSANTARA: Jurnal Pendidikan, Bahasa dan Budaya*, 2(1), 75-83. DOI: <https://doi.org/10.47861/jdan.v1i2.750>
- Ridho, M. N., Agus, M., & Razak, N. K. (2024). Pengaruh Model Pembelajaran Contextual Teaching Learning Berbasis Video terhadap Kemampuan Berpikir Kreatif Pembelajaran Bahasa Indonesia Siswa Kelas V SDN Gunung Sari II Makassar. *Journal on Education*, 6(2), 13282-13292. DOI: <https://doi.org/10.31004/joe.v6i2.5180>
- Rombe, A., Sinambela, M. H., Wenda, B., Yanengga, A., & Borean, S. (2023). Pelatihan Guru SD Inpres Tiom Cara Mengajarkan Hitung Dasar Matematika dengan Metode Jarimatika dan Alat Peraga. *PaKMas: Jurnal Pengabdian Kepada Masyarakat*, 3(1), 86–91. DOI: <https://doi.org/10.54259/pakmas.v3i1.1679>
- Sapitri, U. (2016). Penerapan Model *Discovery Learning* untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Kelas X pada Materi Kalor. *Jurnal Ilmu Pendidikan Fisika*, 1(2), 64-66. DOI: <http://dx.doi.org/10.26737/jipf.v1i2.66>
- Setyawan, G., & Huda, S. (2022). Analisis Pengaruh Produksi Kedelai, Konsumsi Kedelai, Pendapatan Per Kapita, dan Kurs terhadap Impor Kedelai di Indonesia. *KINERJA: Jurnal Ekonomi dan Manajemen*, 19(2), 215-225. DOI: <https://doi.org/10.30872/jkin.v19i2.10949>
- Lestari, D. A., Ariyanto, j., & Harlita. (2020). Perbandingan Keterampilan Berpikir Kritis Siswa dengan Model Problem-Based Learning dan Numbered Heads Together Berbasis Student Created Case Studies. *Edusains*, 12(1), 9-19. DOI: <https://doi.org/10.15408/es.v12i1.12291>
- Supranoto, H. (2016). Pengaruh Contextual Teaching and Learning (CTL) Teknik Praktek Jual Beli Terhadap Kemampuan Mahasiswa Memahami Akuntansi. *Jurnal PROMOSI*, 4(2), 36-42. DOI: <http://dx.doi.org/10.24127/ja.v4i2.635>
- Susanti, N. W. S., & Marhayati, T. (2020). Designing Culturally-Rich Local Games for Mathematics Learning. *BETA*, 13(1), 49–60. DOI: <https://doi.org/10.20414/Betajtm.V13i1.354>
- Trisnawati, T., Kusuma, V., & Yulianto, D. (2023). Efektivitas Metode Tutor Sebaya Berbasis Youtube dalam Meningkatkan Kemampuan Number Sense Matematis Siswa ditinjau dari Perbedaan Jenis Kelamin pada Materi Bilangan. *Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika*, 4(1), 7-22. DOI: <https://doi.org/10.46306/lb.v4i1.209>
- Trisnawati, T., Yulianto, D., & Eva Fitria Ningsih. (2023). The influence of Indonesian Realistic Mathematics Learning (PMRI) Based Ethnomathematics on the Improvement of Mathematical Communication Skills in Terms of Gender. *Cendikia: Media Jurnal Ilmiah Pendidikan*, 13(3), 552-561. DOI: <https://doi.org/10.35335/cendikia.v13i3.3320>
- Triyani. (2019). Keefektifan Pendekatan Contextual Teaching and Learning (CTL) untuk Meningkatkan Kemampuan Berpikir Kritis dan Rasa Ingin Tahu Mahasiswa. *Humanika, Kajian Ilmiah Umum*, 19(2). 70-81. DOI: <https://doi.org/10.21831/hum.v19i2.27226>
- Velinov, A., & Gicev, V. (2018). Practical Application of Simplex Method for Solving Linear Programming Problems. *Balkan Journal of Applied Mathematics and Informatics*, 1(1), 07-15. Retrieved from <https://js.ugd.edu.mk/index.php/bjami/article/view/2006>
- Vonda, Qhory Riana al., Firra Dinni., Destryan Diah Saputra., dan Ira Puspita. (2019). Implementasi Metode Simpleks dalam Penentuan Jumlah Produksi untuk Memaksimalkan Keuntungan. *STRING: Satuan Tulisan Riset dan Inovasi Teknologi*, 4(1), 53-64. DOI: <http://dx.doi.org/10.30998/string.v4i1.3713>

- Widaningrum, I. (2015). Teknologi Pembuatan Tahu yang Ramah Lingkungan (Bebas Limbah). *Jurnal Dedikasi*, 12, 14-21. DOI: <https://doi.org/10.22219/dedikasi.v12i0.2476>
- Yulianto, D. (2020). Pengaruh Strategi Pembelajaran Inkuiri dan Tutor Sebaya terhadap Self Efficacy dan Penguasaan Konsep Matematis. *Pasundan Journal of Mathematics Education: Jurnal Pendidikan Matematika*, 10(1), 25-38. DOI: <http://dx.doi.org/10.5035/pjme.v10i1.2424>
- Yulianto, D., & Juniawan, E. A. (2022). Pengembangan Media Pembelajaran Interaktif Lectora Inspire dengan Pendekatan Scientific untuk Meningkatkan Kemampuan Berpikir Kritis Matematis. *JPPM (Jurnal Penelitian dan Pembelajaran Matematika)*, 15(1), 1-16. <http://dx.doi.org/10.30870/jppm.v15i1.12395>
- Yulianto, D., Juniawan, E. A., & Kusdini, R. (2023). Pengaruh Metode Accelerated Learning For The 21st Century Terhadap Kemampuan Berpikir Kritis Siswa dalam Menyelesaikan Soal Higher Order Thinking Skill (HOTS). *Jurnal Silogisme: Kajian Ilmu Matematika dan Pembelajarannya*, 8(2), 112-127. <https://doi.org/10.24269/silogisme.v8i2.7882>
- Yustina, S. (2015). Penerapan Metode Pembelajaran *Problem Solving* terhadap Kemampuan Berpikir Kritis Siswa pada Materi Koloid. *Quantum: Jurnal Inovasi Pendidikan Sains*, 6(2), 108-117. DOI: <http://dx.doi.org/10.20527/quantum.v6i2.1165>
- Zakaria, M., & Yulianto, D. (2021). Pengaruh Model Problem Based Learning (PBL) terhadap Kemampuan Berpikir Kritis Matematis Siswa. *Geomath: Jurnal Pendidikan Matematika*, 2(2), 65-77. DOI: <http://dx.doi.org/10.55171/geomath.v2i2.868>