



Integrating Next Generation Science Standards Dimensions in Preparing Prospective Biology Teachers Oriented to Traditional Food Culture

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Abstract: This study examines the declining interest among prospective biology teachers in traditional food culture, which is essential to supporting sustainable development goals, particularly food security and environmental sustainability. The research aims to develop a learning model integrating the Next Generation Science Standards (NGSS) dimensions with traditional food culture, known as the Traditional Food Culture Learning (TFCL) model. A research and development (R&D) method based on the Dick and Carey instructional design was employed, involving prospective biology teachers at Universitas Tidar. The model was developed through stages of needs analysis, design, validation by multidisciplinary experts, and revision. The results indicate that the TFCL model is feasible and effective, with validation scores indicating very strong performance. The model's implementation shows significant positive relationships among exploration of local knowledge, nutritional analysis skills, and student engagement. The study concludes that the TFCL model enhances teaching competencies and fosters awareness of traditional food culture. This research contributes to science education by providing an innovative, culturally contextualized learning model that integrates global standards with local wisdom to promote sustainability-oriented learning.

Keywords: local wisdom; NGSS; prospective biology teachers; traditional food culture

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INTRODUCTION

Traditional food consumption is closely linked to sustainability values, particularly among younger generations influenced by modern lifestyles (Kristia et al., 2024). Environmental education also plays a crucial role in fostering pro-environmental behavior and supporting long-term sustainability goals (Ardoin et al., 2020). Traditional Indonesian food, a product of local wisdom, is increasingly losing popularity among the younger generation (Anggadhanita et al., 2023; Rahayu et al., 2024; Kristia et al., 2024). Traditional food not only meets nutritional needs but also has a proven heritage of local wisdom, making it in harmony with nature. Indonesian society possesses various local wisdoms for cultivating land for farming that emphasize the value of balancing with the environment (Kuipers & de Jong, 2023; Sumarwati, 2024; Purwanto et al., 2024). Traditional foods, which embody local wisdom, are threatened with extinction due to younger generations' lack of interest (Haq et al., 2024; Gora, 2025). The younger generation's growing abandonment of traditional food means they are increasingly forgetting the diversity of native Indonesian local wisdom. Indigenous customs are threatened with oblivion, as traditional food culture is increasingly abandoned. At the same time, imported instant foods are increasingly popular among the younger generation in Indonesia.

Preserving traditional food culture is crucial to becoming a national movement, in line with the government's Asta Cita program on food self-sufficiency and maintaining harmony between the environment and culture. The younger generation is rarely consuming traditional foods or is experiencing a crisis in traditional food culture. Traditional foods are passed down from generation to generation, becoming traditions (Hegde et al., 2018; Putra et al., 2023; Sharma, 2024). Making traditional foods a subject of study significantly fosters a love for them (Mardatillah et al., 2019; Kassaye, 2024; Tabassum et al., 2025). Learning biology to preserve Indonesia's traditional food culture is expected to have a broad impact and reach the younger generation in secondary schools. The habits of prospective biology teachers affect their ability to practically design and implement learning (Suryawati & Osman, 2017; Parmin et al., 2024; Schmidt et al., 2024). Bridging indigenous and scientific knowledge systems in science education can enhance students' understanding by connecting cultural context with scientific concepts (Aikenhead & Michell, 2016). Moreover, understanding the nature of science and scientific inquiry is essential for developing students' scientific literacy and their ability to apply scientific knowledge in real-world contexts (Lederman & Lederman, 2019).

A preliminary study was conducted by surveying 50 prospective biology teachers from diverse ethnic backgrounds to collect data on traditional food culture. The ethnic backgrounds of the prospective biology teachers included Javanese, Sundanese, Betawi, Madurese, Dayak, Bugis, Batak, Papuan, and Minang. The

survey revealed that 46 prospective biology teachers (96%) preferred instant noodles to cassava, sweet potatoes, and potatoes when rice was unavailable. At the same time, 39 prospective biology teachers (78%) had experience growing cassava, sweet potatoes, and potatoes. The results of this preliminary study confirm the assertion that the issue of traditional food culture is a major concern for the younger generation, including prospective biology teachers. Prospective teachers are prepared not only to be skilled in teaching biology concepts but also to adapt the material to everyday life (Haviz et al., 2020; Funke et al., 2024; Dorji et al., 2025; Kang et al., 2019).

It takes courage to prepare prospective biology teachers with graduate competency orientations that align with future needs. The orientation of prospective teacher graduates needs to be revised to ensure their skills align with the needs of future teachers (Sari et al., 2021; Kinskey & Newton, 2024; Evans et al., 2025). The needs of prospective biology teachers integrate international science education standards with national standards. International standards for science education, including biology, are contained in the Next Generation Science Standards (NGSS). According to the NGSS, future teachers can integrate modern scientific knowledge and societal values to create an environmentally responsible generation (Siebert-Evenstone, 2022; Asamoah et al., 2024; Summers, 2024). Understanding the nature of science is fundamental for developing students' scientific literacy and critical thinking skills (McComas, 2017).

According to Shernoff (2024) and Drew and Thomas (2018), three dimensions of the NGSS shape future teachers' abilities: how knowledge is acquired and understood, biology knowledge content, and biology content connected to traditional knowledge. Biology as a school subject plays a strategic role in contributing to the achievement of the Sustainable Development Goals (SDGs) in Indonesia, particularly SDG 2: ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture. The integration of sustainability concepts into science education is essential for developing students' competencies in addressing real-world environmental challenges (Sjöström et al., 2017). Education for sustainable development emphasizes integrating the social, cultural, and environmental dimensions into learning processes (Leicht et al., 2018). Prospective biology teachers are prepared to design effective learning experiences by developing locally relevant content that promotes environmental sustainability (Subiantoro & Treagust, 2021; Parmin & Trisnowati, 2024; Wiyarsi et al., 2024). Changing the habits of the younger generation to consume traditional foods instead of instant foods is a major challenge.

Prospective biology teachers need to be prepared with new learning models, as preliminary study results indicate that current models are insufficient for preserving local wisdom in traditional food culture. The learning model features a syntax of learning activities that can be tailored to meet new learning needs (Muñoz & Padilla, 2024). This new learning model must address the younger generation's increasingly frequent abandonment of traditional food culture. The learning model was developed to meet new learning needs with broad applicability, thus having a real impact on achieving learning targets (Usmaldi et al., 2017; Anif et al., 2019).

The following are the problems in this research: 1) How to develop a traditional food culture learning model that integrates the dimensions of Next-Generation Science Standards with traditional food culture? 2) How feasible is a traditional food culture learning model that integrates the dimensions of Next-Generation Science Standards with traditional food culture? 3) What is the impact of using a traditional food culture learning model on the teaching skills of prospective biology teachers who are oriented towards traditional food culture? Researchers addressed these problems by adopting a new approach that integrated three NGSS dimensions into prospective biology teachers' teaching skills. The development of the new model involved multidisciplinary experts from biology, education, cultural science, and nutrition. Experts in the development of the learning model were not limited to validating and providing input; they were also directly involved in implementing the model to observe and reflect on its applicability. The direct involvement of experts in observing and reflecting on learning activities during the model-trial stage enhances the adoption of new problem-solving approaches while addressing the limitations of similar model-development research. The success of developing a new learning model can be determined by the level of applicability that has a real impact (Hafina et al., 2022).

The preparation of prospective biology teachers is challenged by the lifestyle habits of prospective teachers in the millennial generation (Sukmawati et al., 2018; Prajoko et al., 2023). Prospective biology teachers come from various ethnic groups with a rich heritage of local wisdom that is interesting to use as learning material (Sukmawati & Permadani, 2020; 2022). Prospective biology teachers' teaching skills are more easily developed when traditional knowledge is used as a learning tool (Sukmawati et al., 2024; Parmin et al., 2024). Researchers utilize various research findings to develop a research roadmap.

METHODS

This study used the research and development method (Borg & Gall, 1989). The new research findings are presented as a learning model that integrates NGSS dimensions with traditional food culture. The model developed is based on the instructional design of Dick and Carey (1990). The development stage of this study resulted in a new learning model, accompanied by a user guidebook. This study aims to develop a new model

that integrates NGSS dimensions with traditional food culture, known as Traditional Food Culture Learning (TFCL). This model offers advantages that have not existed before, particularly in the scientific stages that integrate the NGSS dimensions in preparing prospective biology teachers with a traditional food culture orientation. The integration was developed comprehensively, starting with the model's academic manuscript, supporting tools, and an analysis of its applicability and resulting impact. The advantage, still very rare, lies in the integration with international standards for preparing future generations of scientists.

The research targets prospective biology teachers in the Biology Education Study Program at Universitas Tidar. The first year's target population consisted of 80 prospective biology teacher students, all in the same learning environment. The research began with a preliminary study analyzing learning models commonly used in the education of prospective biology teachers. The preliminary study analyzed knowledge about traditional food culture in Indonesia, drawing on various research findings published in scientific journals. The results of the preliminary study were used to develop a draft plan for a new model, Traditional Food Culture Learning (TFCL), that integrates NGSS dimensions with traditional food culture. The name of this model does not explicitly mention biology because, as the main product of the research, it is intended to have broad applicability. The model syntax was developed to integrate the NGSS dimensions with traditional food culture. The next stage was to validate the TFCL model, developed by integrating the NGSS, through the review of three validators.

A preliminary study was conducted to identify the ethnic origins of prospective biology teachers enrolled in microteaching courses within the Biology Education Study Program. The preliminary study was conducted at two universities with two different clusters: Legal Entity State University (Universitas Negeri Semarang) and Public Service Agency University (Universitas Tidar). The ethnic origins of prospective biology teachers varied from Javanese, Dayak, Batak, Minang, and Papuan. Following up on the results of the ethnic origin identification, a mapping of the local wisdom of traditional foods from each ethnic group of prospective biology teachers was conducted. The first year of the research phase focused on integrating NGSS dimensions with traditional food culture to create a new learning model. The three dimensions mentioned include how knowledge is acquired and understood, the content of biological knowledge, and biology content connected to traditional knowledge.

The activity stages begin with potential and problem analysis, data collection, product design, product validation, and product revision. The urgency of the research, based on the results of the preliminary study, indicated the need for a new learning model to reintroduce prospective biology teachers to the culture of eating traditional foods. Product validation involved experts from multidisciplinary fields, including biology learning experts with a track record of research in preparing prospective teachers, environmental science experts with a track record of research on the SDGs, and cultural experts with a track record of research on the local wisdom of indigenous Indonesian communities.

The instrument used is novel because it was specifically developed to elaborate on NGSS standards and traditional food culture indicators, which were then modified into a new learning model. The instruments used consisted of a model validation sheet and a model usage tool. Product validation data were analyzed by processing the validation sheet entries using a Likert scale. The product validity percentage was calculated by dividing the validator's percentage (rounded to the nearest whole number) by the total score for each selected criterion. The achievement level qualification used three percentage ranges: very feasible or very strong (86-100), feasible or strong (70-85), and less feasible or less strong (<70). Data were analyzed descriptively by referring to the calculation results of each assessment item.

RESULT AND DISCUSSION

The syntax of Traditional Food Culture Learning consists of identification, laboratory test data collection, laboratory test results, nutritional content analysis, traditional food processing, and follow-up planning. Learning activities for each syntax are presented in [Table 1](#).

Table 1. Traditional Food Culture Learning Activities

Syntax	Learning Activity
Traditional Food Identification	Each ethnic group has traditional foods identified through direct observation. The identification results are reported in writing, mapping which traditional foods are consumed and which are not. A literature review is conducted regarding the benefits, properties, and advantages of traditional foods identified from community beliefs.
laboratory test data collection	Data on the nutritional content of traditional foods commonly consumed by the community is collected through research from various sources. Traditional foods for which the nutritional content has not yet been tested are independently tested in laboratories or in collaboration with other institutions. Independent testing begins with compiling an experimental worksheet to test the nutritional content of the identified traditional foods. The laboratory test design is developed using a scientific approach to advance scientific research.

Syntax	Learning Activity
laboratory test results	Data from the nutritional content tests of traditional foods are presented in tables or graphs. The unique and superior nutritional content of the traditional foods is explained in detail.
nutritional content analysis	The nutritional content test data is confirmed by community beliefs about the traditional foods being tested. The nutritional content is used to verify the validity of community beliefs.
traditional food processing	Processing methods for the tested traditional foods are formulated to maintain their nutritional content. Appealing processing and presentation methods are developed to appeal to the younger generation.
follow-up planning	The tested traditional foods are preserved through a sustainable preservation plan. The actual preservation is prepared using local land.

The TFCL model begins with identifying the habits of ethnic communities in consuming traditional foods. The model requires exploring habits according to the target students' ethnic origins. The activity of identifying community traditions requires the ability to establish both personal and interpersonal relationships within the community. By searching for information from ethnic communities, various types of traditional foods are identified. Learning activities continue to address the problem of declining interest in consuming traditional foods among the younger generation. Determining solutions requires independent initiative. Problems are resolved through the stages of the TFCL model, which constitute an appropriate response to the identified real-world problems.

Implementing the model syntax requires supporting devices, such as appropriate teaching materials for the study of traditional food, interesting and contextually relevant learning media, practical worksheets, and a classroom environment that supports the implementation of learning stages. The instructional impact of applying the TFCL model is seen in the knowledge, skills, and attitudes achieved through independent learning. The accompanying impact can address the problem of low traditional food consumption among the younger generation by fostering independent learning habits and providing contextual learning resources. The research revealed that prospective biology teachers who firmly maintain their traditions come from the following ethnic groups in order: Papua, Dayak, Minang, Batak, and Java. The results of the Spearman Rank correlation test are presented in [Table 2](#).

Table 2. Traditions of Prospective Biology Teachers

Ethnic Origin	Score	Category
Papua	86	Very strong
Dayak	74	Strong
Minang	72	Strong
Batak	54	Less Strong
Java	50	Less Strong

The well-preserved lifestyles of traditional ethnic communities have a profound impact on younger generations, who often retain their customs. Papuans are known for their strong adherence to traditional practices, which is why prospective biology teachers from Papua remain firmly committed to preserving traditional foods. Indigenous people continue to observe these customs because their livelihoods are closely tied to nature. Javanese communities are undergoing modernization, so younger generations are less likely to consume traditional foods. An analysis was conducted to determine the relationship between elements oriented towards traditional food culture. The test results are presented in [Table 3](#).

Table 3. Results of Spearman Rank Correlation Test

Element Relationship		P	P-Value	Direction	Category
Element A	Element B	(Spearman)			
Researching local information	Collecting nutrition data	0.737	< .001	+	Strong
Collecting nutrition data	Enjoying TFCL learning	0.720	< .001	+	Strong
Enjoying TFCL learning	Social interaction increased after TFCL	0.621	< .001	+	Moderate
Serving traditional food	Preservation plan	0.688	< .001	+	Moderate
Interested in researching local information	Enjoying TFCL learning	0.604	< .001	+	Moderate

Element Relationship		P (Spearman)	P-Value	Direction	Category
Element A	Element B				
Preservation plan	Enjoying TFCL learning	0.607	< .001	+	Moderate
Interested in researching local information	Preservation plan	0.582	< .001	+	Moderate
Enjoying consumption	Preservation plan	0.490	< .001	+	Moderate
Enjoying consumption	Researching local information	0.482	< .001	+	Moderate
Collecting nutritional data	Having nutritional analysis skills	0.400	< .001	+	Moderate

A strong relationship exists between exploring local information about traditional foods and collecting nutritional data. Prospective biology teachers exhibit a keen interest in the nutritional content of traditional foods. This curiosity is fueled by collecting data from various sources on the nutritional content of traditional foods. This strong relationship is achieved by collecting nutritional data through learning that implements the TFCL model.

The integration of the Next Generation Science Standards (NGSS) dimensions in the preparation of prospective biology teachers is achieved through the dimension of integrating modern scientific knowledge with community lifestyles. This dimension makes community lifestyles a necessary competency for prospective teachers to develop an environmentally responsible generation. Contextual learning resources foster a love of the environment by creating a sense of meaningfulness (Kutz, 2025; Shi & Liu, 2025). Prospective teachers live in a modern environment where food is available. Modern lifestyles can potentially lead prospective teachers to abandon various traditional foods. The characteristics of the TFCL Model, along with learning activities, have been developed to foster a desire for consuming traditional foods.

The TFCL model features a learning syntax that aligns with the learning styles of traditional communities. Identifying traditional foods through direct exploration activities in the community offers a new way to discover various types of traditional foods. Exploration requires students to possess effective communication skills to gather comprehensive information. Information retrieval is strengthened by a literature review of traditional foods, which the community believes have various benefits. Traditional communities possess a wealth of indigenous knowledge that is preserved as a testament to a life in harmony with nature (Chao et al., 2025). Information is easily accessible to obtain nutritional data on traditional foods. The learning experience of searching for information on nutritional content test results aligns with the competencies required of prospective biology teachers. Test results are easily found and corroborated with the data obtained, allowing prospective teachers to practice analytical skills to obtain reliable data.

Research has found a strong relationship between traditional food exploration and the collection of nutritional information on traditional foods. Learning activities have a unique appeal because community beliefs confirm the test data on nutritional content. Research findings suggest that some traditional communities view traditional foods not only as food but also as possessing specific religious significance. Traditional knowledge persists in the community because it embodies these values (Böttger, 2025). After analyzing existing societal beliefs, some relate to the nutritional value of food. The uniqueness of the findings makes the TFCL model even more appealing, as it explores not only traditional foods but also the various values underlying these beliefs.

Preparing prospective biology teachers with a focus on traditional food culture requires the use of various innovative strategies. The TFCL model is one option for preparing prospective teachers for learning. It will have a broad impact because every prospective teacher will become a teacher at the school. The TFCL model can be developed at all levels of education through modifications, particularly in independent learning. Analysis of student development can serve as a reference for modifying the model's use at different levels of education. A return to enjoying traditional food culture is part of active participation in environmental conservation.

CONCLUSION

The study concludes that the Traditional Food Culture Learning (TFCL) model effectively integrates NGSS dimensions with traditional food culture and significantly enhances the teaching competencies of prospective biology teachers, particularly in linking scientific concepts with local wisdom. The key findings demonstrate strong relationships among local knowledge exploration, nutritional data analysis, and student engagement, indicating that the model supports meaningful, contextual learning. The application of the TFCL model has a broader impact by increasing awareness and appreciation of traditional food culture among future educators, which can be transferred to school learning environments. This, in turn, contributes to promoting sustainable food practices, strengthening cultural preservation, and supporting environmental sustainability through education.

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REFERENCES

- Aikenhead, G., & Michell, H. (2011). Bridging Cultures: Indigenous and Scientific Ways of Knowing Nature.
- Anggadhania, L., Setiarto, R. H. B., Yusuf, D., Anshory, L., & Royyani, M. F. (2023). Exploring Tempoyak, Fermented Durian Paste, a Traditional Indonesian Indigenous Fermented Food: Typical of Malay Tribe. *Journal of Ethnic Foods*, 10(1), 42.
- Anif, S., Utama, S., Prayitno, H., & Idrus, N. (2019). Effectiveness of Pedagogical Competence: A Development Model Through Association of Biology Teachers Forum. *Jurnal Pendidikan IPA Indonesia*, 8(1), 22–31.
- Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental Education Outcomes for Conservation: A Systematic Review. *Biological Conservation*, 241, 108224.
- Asamoah, D., Baidoo-Anu, D., Quainoo, E. A., Gyamerah, K., Amoateng, E. Y., & Sasu, E. O. (2024). Teacher Candidates' Experiences of Emergency Remote Assessment During COVID-19. *SN Social Sciences*, 4(2).
- Borg, W. R., & Gall, M. D. (1989). *Educational Research: An Introduction* (5th ed.). Longman.
- Böttger, F. (2025). CAFTA-DR, European Free Trade Agreements and the Industrial Property System in Central America: A Contribution to the TRIPS-Plus Debate. Springer Nature.
- Chao, O., Li, X., & Reyes-García, V. (2025). Exploring the Dynamic Functions of Pastoral Traditional Knowledge. *Ambio*, 54(6), 932–946.
- Dick, W. and Carey, L. (1990). *The Systematic Design of Instruction*. Harper Collins Publishers.
- Dorji, S., Zangmo, S., & Dorji, K. (2025). Exploring Bhutanese Students' Perceptions of Flipped Classroom Instruction in Biology. *Journal of Pedagogical Sociology and Psychology*, 7(4), 78–95.
- Drew, S. V., & Thomas, J. (2018). Secondary Science Teachers' Implementation of CCSS and NGSS Literacy Practices: A Survey Study. *Reading and Writing*, 31(2), 267–291.
- Evans, M., Trolli, E., Pierson, A., & Tilak, S. (2025). Designing Courses With Sustainable Virtual Learning Communities: A STEM Teacher Candidate Course That Extends Beyond Higher Education. *Journal of Computing in Higher Education*, 37(1), 225–247.
- Funke, M., Bergmann-Gering, A., Müller, K., & Zabel, J. (2025). Pre-Service Teachers' Beliefs on the Subject-Specific Use of Digital Media in Biology Classrooms. *Technology, Knowledge and Learning*, 30(2).
- Gora, L. S. (2024). "The Bitter Taste of Extinction": Writing the Environmental Crisis Through Food. In *The Literary Journalist as a Naturalist* (pp. 91–109). Springer Nature Switzerland.
- Hafina, A., Nur, L., & Malik, A. A. (2022). The Development and Validation of a Character Education Model Through Traditional Games Based on the Socratic Method in an Elementary School. *Jurnal Cakrawala Pendidikan*, 41(2), 404–415.
- Haq, S. M., Waheed, M., & Bussmann, R. W. (2024). "Traditional" Use in a Global World: Unsustainable Ethnozoological Usage Among Himalayan Ethnic Groups Drives Species to Extinction. *Biodiversity and Conservation*, 33(3), 1125–1144.
- Haviz, M., Maris, I. M., & Fudholi, A. (2020). Assessing Pre-Service Teachers' Perception on 21st Century Skills in Indonesia. *Journal of Turkish Science Education*, 17(3), 351–363.
- Hegde, S., Nair, L. P., Chandran, H., & Irshad, H. (2018). Traditional Indian Way of Eating—An Overview. *Journal of Ethnic Foods*, 5(1), 20–23.
- Kang, N. H. (2019). A Review of the Effect of Integrated STEM or STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education in South Korea. *Asia-Pacific Science Education*, 5(1), 1–22.
- Kassaye, W. (2024). Traditional/Indigenous Education. In *Education and Curriculum Development of Africa Vol. 1: Indigenization and Knowledge Production in Ethiopia* (pp. 1–44). Springer Nature Switzerland.
- Kinskey, M., & Newton, M. (2024). Teacher Candidates' Views of Future SSI Instruction: A Multiple Case Study. *Disciplinary and Interdisciplinary Science Education Research*, 6(1), 8.

- Kristia, K., Kovács, S., & Erdey, L. (2024). Generation Z's Appetite for Traditional Food: Unveiling the Interplay of Sustainability Values as Higher Order Construct and Food Influencers in Indonesia. *Discover Sustainability*, 5(1), 493.
- Kuipers, K., & de Jong, E. B. (2023). Resilient Livelihood Styles: An Enriched Perspective on Household Livelihood Resilience in the Sensitive Natural Environments of Indonesia. *Regional Environmental Change*, 23(4), 164.
- Kutz, M. R. (2025). Learning Contextual Intelligence. In *Contextual Intelligence: How Thinking in 3D Can Help Resolve Complexity, Uncertainty, and Ambiguity* (pp. 153–160). Springer Nature Switzerland.
- Lederman, N. G., & Lederman, J. S. (2019). Teaching and Learning of Nature of Scientific Knowledge and Scientific Inquiry: Building Capacity Through Systematic Research-Based Professional Development. *Journal of Science Teacher Education*, 30(7), 737–762.
- Leicht, A., & Heiss, J. (2018). Issues and Trends in Education for Sustainable Development. UNESCO Publishing.
- Mardatillah, A., Raharja, S. U. J., Hermanto, B., & Herawaty, T. (2019). Riau Malay Food Culture in Pekanbaru, Riau Indonesia: Commodification, Authenticity, and Sustainability in a Global Business Era. *Journal of Ethnic Foods*, 6(1).
- McComas, W. F. (2017). *The Nature of Science in Science Education: Rationales and Strategies*. Springer Science & Business Media.
- Muñoz-Galván, M., & Padilla, K. (2024). Pedagogical Content Knowledge About the Sustainability of High School Chemistry and Biology Teachers. *Journal of Environmental Studies and Sciences*, 14(4), 652–665.
- Parmin, P., Mohtar, L. E., Muhlisin, A., Trisnowati, E., & Sukmawati, I. (2024). Microteaching to Develop Prospective Biology Teachers' Basic Teaching Skills Following Next Generation Science Standards (NGSS). *Biosaintifika: Journal of Biology & Biology Education*, 16(3).
- Parmin, P., & Trisnowati, E. (2024). Internalization of Indigenous Knowledge in the Education Curriculum for Next Generation Science Standards (NGSS). *Jurnal Cakrawala Pendidikan*, 43(1), 19–27.
- Prajoko, S., Sukmawati, I., Maris, A. F., & Wulanjani, A. N. (2023). Project Based Learning (PjBL) Model With STEM Approach on Students' Conceptual Understanding and Creativity. *Jurnal Pendidikan IPA Indonesia*, 12(3), 401–409.
- Purwanto, Y., Munawaroh, E., Ajiningrum, P. S., & Cahyaningsih, R. (2024). Lesson From Ethnobotany for Conservation of Cassava (*Manihot esculenta* Crantz.): A Case Study in Indonesia. In *Industrial Crop Plants* (pp. 353–388). Springer Nature Singapore.
- Putra, F. K. K., Putra, M. K., & Novianti, S. (2023). Taste of ASEAN: Traditional Food Images From Southeast Asian Countries. *Journal of Ethnic Foods*, 10(1), 20.
- Rahayu, Y. Y. S., Sujarwo, W., Irsyam, A. S. D., Dwiartama, A., & Rosleine, D. (2024). Exploring Unconventional Food Plants Used by Local Communities in a Rural Area of West Java, Indonesia: Ethnobotanical Assessment, Use Trends, and Potential for Improved Nutrition. *Journal of Ethnobiology and Ethnomedicine*, 20(1), 68.
- Sari, M. S., Sunarmi, S., & Mawaddah, K. (2021). The Effect of Scaffolding of Information Literacy on the Botanical Literacy of Prospective Biology Teachers. *Jurnal Pendidikan IPA Indonesia*, 10(2), 253–259.
- Schmidt, C., Kühnel, D., Materić, D., Stubenrauch, J., Schubert, K., Luo, A., ... & Jahnke, A. (2024). A Multidisciplinary Perspective on the Role of Plastic Pollution in the Triple Planetary Crisis. *Environment International*, 193, 109059.
- Sharma, S. (2024). Sustainable Food Practices From Traditional Indian Culture. In *Sustainable Food Systems (Volume I) SFS: Framework, Sustainable Diets, Traditional Food Culture & Food Production* (pp. 381–386). Springer Nature Switzerland.
- Shi, P., & Liu, W. (2025). Adaptive Learning Oriented Higher Educational Classroom Teaching Strategies. *Scientific Reports*, 15(1), 15661.
- Shernoff, D. J. (2024). *Integrative STEM and STEAM Education for Real-Life Learning*. Springer.
- Siebert-Evenstone, A. L. (2021). A Qualitative Analysis of Connection-Making in the NGSS. In *International Conference on Quantitative Ethnography* (pp. 95–113). Springer International Publishing.

- Sjöström, J., Frerichs, N., Zuin, V. G., & Eilks, I. (2017). Use of the Concept of Bildung in the International Science Education Literature, Its Potential, and Implications for Teaching and Learning. *Studies in Science Education*, 53(2), 165–192.
- Subianto, A. W., Treagust, D., & Tang, K. S. (2021). Indonesian Biology Teachers' Perceptions about Socio-Scientific Issue-Based Biology Instruction. *Asia-Pacific Science Education*, 7(2), 452–476.
- Sukmawati, I., & Permadani, K. G. (2020). Genetic Material Upgrading: Misconception Identification Study in High School Biology Teachers. *Indonesian Journal of Biology Education*, 3(2), 1–6.
- Sukmawati, I., & Permadani, K. G. (2022). Analisis Kebutuhan Pengembangan Buku Perkuliahan Genetika Berbasis Kajian Miskonsepsi pada Program Studi Pendidikan Biologi. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 12(2), 78–86.
- Sukmawati, I., Prajoko, S., & Darmawan, E. (2018). Overview of Information Literacy Proficiency Among First Year Students of Biology Education Study Program in Universitas Tidar. *Indonesian Journal of Biology Education*, 1(1), 1–8.
- Sukmawati, I., Widiyatmoko, A., Tawang, A., & Muhlisin, A. (2024). Preserving Traditional Knowledge of Prospective Biology Teachers Through Science Integrated Learning With Next-Generation Science Standards. *Jurnal Pendidikan IPA Indonesia*, 13(4).
- Sumarwati, S. (2022). Traditional Ecological Knowledge on the Slope of Mount Lawu, Indonesia: All About Non-Rice Food Security. *Journal of Ethnic Foods*, 9(1), 9.
- Suryawati, E., & Osman, K. (2017). Contextual Learning: Innovative Approach Towards the Development of Students' Scientific Attitude and Natural Science Performance. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(1), 61–76.
- Summers, R. (2024). Appraising Instructional Materials From TeachersPayTeachers for Features of NGSS Design and Nature of Science Representations. *Research in Science Education*, 54(3), 523–546.
- Tabassum, S., Dauer, J. M., Scherer, H. H., Sintov, N. D., & Wang, H. H. (2025). Understanding the Emerging Food, Energy, and Water Nexus (FEW-Nexus) Systems in Science Education. *Journal of Environmental Studies and Sciences*, 15(1), 55–70.
- Usmeldi, U., Amini, R., & Trisna, S. (2017). The Development of Research-Based Learning Model With Science, Environment, Technology, and Society Approaches to Improve Critical Thinking of Students. *Jurnal Pendidikan IPA Indonesia*, 6(2), 318–325.
- Wiyarsi, A., Çalik, M., Priyambodo, E., & Dina, D. (2024). Indonesian Prospective Teachers' Scientific Habits of Mind: A Cross-Grade Study in the Context of Local and Global Socio-Scientific Issues. *Science & Education*, 33(5), 1257–1283.