Research Article

Student Misconceptions about Heat Transfer Mechanisms: An Island Ethnophysics Study

Cinta Amergebi Souisa, John Rafafy Batlolona*, and Seska Malawau

Physics Education Study Program, Faculty of Teacher Training and Education, Pattimura University

ORCID

John Rafafy Batlolona: https://orcid.org/0000-0003-3447-7432

Abstract.
Learners' conceptual frameworks vary greatly, but they develop from their everyday experiences over time and change as they mature. Their intuitive understanding of the world around them often needs to match scientific concepts as seen by experts. It is essential in culturally based teaching to recognize how these naïve conceptions differ from scientific explanations of concepts and why children construct these ideas. Heat transfer mechanisms are conceptually rich material. Particularly in the Indonesian context, little effort has been made to reduce misconceptions. This prompted us to conduct a study in this area. We present a study on students' misconceptions about heat transfer mechanisms, namely conduction, convection, and radiation. This study aimed to analyze students' misconceptions about heat transfer mechanisms through an ethnophysics study. The method used was a non-experimental quantitative case study. In addition, a survey was conducted in the form of a diagnostic test in the form of questions related to heat transfer for 100 students. The findings in the field show that students experience relatively high misconceptions. So far, teachers have not accustomed students to learning from contextual things in the form of local wisdom around them. They have given scientific questions to search for, find, and provide answers and solutions to these natural phenomena. The teacher mainly pursues cognition and physics problems in textbooks and less explores contextual matters. Future research is suggested to develop physics teaching materials based on local wisdom oriented to 21st-century life skills that can support students to live in the future.

Keywords: student misconceptions, heat transfer mechanisms, island ethnophysics

Corresponding Author: John Rafafy Batlolona; email: johanbatlolona@gmail.com

Published: 11 November 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the 8th Isedu Conference Committee.

1. Introduction

In 2024, the Nature Physics Editorial released the article "Unlock the Potential of a Physics Education." The article is only one page about the development of physics education. They said that the physics education curriculum has remained unchanged for decades, and the curriculum may be improved according to the needs and developments of the times. For example, there is a need for more at the undergraduate level of physics education. As a result, many potential talents of physics education need to be absorbed in the world of work. In addition, the purpose of teaching physics designed in universities is to train students to work in academia, thus making graduates less prepared to work in the industrial world. Physics education departments should pay more attention to constructive and humanistic teaching to help students become excellent members of the physics community. Physics teaching should be more equitable and relevant so everyone can thrive [1].

Experts recognize that attention to literacy is essential. Literacy is needed to improve the competitiveness of an economy to excel. In addition, new technologies are needed to meet needs or solve current environmental degradation problems. Therefore, the global era demands strong basic science and math knowledge. Researchers across disciplines have tried identifying what constitutes a new generation of science and math avoidance [2]. This is evidenced by the low interest of high school students who enter college to choose science, math, and engineering majors [3]. They see physics as unable to contribute to environmental or medical problems and increasingly see physics as requiring math skills [4]. A critical and interesting question is the situation of a country where students consistently perform well in science and math examinations nationally and internationally. Asian students have often been shown to score well in international science and math assessments. Their attitude towards science subjects, such as physics, intrigues many. This can be seen from Singaporean students who view physics as an advanced field of study. Studies show that Singaporean students repeatedly top the charts of international science and math assessments, such as the Trends in International Mathematics and Science Study (TIMSS). Singaporean students have been placed at the top, particularly in physics, along with students from Taipei, Korea, Hong Kong, and Japan [5].

Conditions are very different from Indonesian students who 2018 scored 379 out of 500 mathematics sections of the PISA Program. A score of 379 ranked 7th, the lowest score among nearly 80 countries or states taking this test (OECD, 2019) [6]. In Indonesia, the proportion of grade 4 and grade 12 students with basic mathematics skills was only 10 percentage points (32% vs 42%) [7]. In the Indian state of Andra Pradesh, only 5% of fifth-grade students could do basic arithmetic [8]. Low-income areas severely impair students' academic achievement [9]. The quality of teaching, human resources, facilities, and infrastructure are the most effective indicators of improving student learning outcomes. This is a point of concern for almost all countries in the world [6]. Higher education should provide a learning environment in specific fields such as natural sciences, social sciences, and engineering for ordinary people, as a foundation for a promising future career for them. Despite reasonable service efforts, there are still areas for improvement that lead to more and more students dropping out. In 2020, the dropout rate in Indonesia was 16.9% and 3.14%, respectively, most of which came from engineering and education, particularly science majors. The reasons identified for the high dropout rate in engineering and science education are primarily related to a sub-optimal learning environment, namely the unavailability of adequate laboratories for research and learning, financial problems, health status, and low academic progress [10]. Personal status and inadequate educational support also play an essential role in low academic progress, leading to a decline in students' desire to study. In addition, classroom atmosphere and attitudes toward subjects are also related to academic performance, which indirectly affects student dropout rates [11]. Learning attitudes in science and mathematics subjects are essential as they influence academic success [12].

Misconceptions are one of the barriers to learners' academic success. Misconceptions arise in all fields of science and all age groups. Empirical evidence shows that children have qualitative differences within themselves [13]. Most students bring ideas from the outside world into the classroom incompatible with scientific explanations. Therefore, in order for students to understand and accept correct scientific phenomena, they must undergo a process of conceptual change [14]. Conceptual change in science learning is rooted in Piaget's constructivist ideas. He considered learning a process where new knowledge is built upon existing knowledge (pre-conceptions). It can be achieved through revision by modifying preconceptions to accommodate new knowledge. Learning activities should be incompatible with the student's existence. Ideas are developed to encourage dissatisfaction, and then students must explain the anomalies [15]. Change can be hard to make when students are firmly committed to previous conceptions [16]. A conception that the learner fully accommodates must be comprehensible (reasonable and understandable). Students who demonstrate good conceptual understanding can explain concepts in line with scientific explanations. Curricular physics education in the form of content, teaching strategies, and the role of teachers are essential factors in providing a rational basis for conceptual change in students. [17].

The results of a study on physics students in Thailand showed that about 30% of students stated that they could not solve the initial test because they needed to understand the relationship or difference between temperature and heat transfer [18]. The term misconception often refers to the cognitive entities that underlie and explain students' difficulties in generating correct explanations or problem solutions. Supporting students in developing scientific conceptions of physics to explain natural phenomena is one of the main goals of physics learning in schools. In physics education research, increasing efforts are being made to establish the effectiveness of pedagogical strategies that follow learner-centered teaching methods by facilitating the change of students' alternative conceptions into correct conceptual understandings [19]. In addition, studies in South Africa show that learners need help understanding the concept of temperature, with the prevalence of misconceptions ranging between 60% and 90% [20]. From a constructivist point of view, the benefit of students learning initial conceptions is that it provides teachers with possible misconceptions that students have. If students have high misconceptions before learning, it can prevent them from learning new subjects correctly, thus causing new misconceptions [21], [22]. Conventional teaching could be more effective at promoting significant conceptual change. This is a crucial failure because mastering basic concepts is essential for developing technical expertise [23].

Physics is one of the essential sciences because its concepts are used to explain existing phenomena. In addition, physics is one of the most studied sciences because it is widely used in developing science. Many problems are found in physics learning. Physics learning needs to be more oriented to the local culture found in the local area [24]. Physics learning only relies on cognitive aspects that reduce the nature of physics as a process, product, and attitude. In addition, teachers only give general or rarely known examples to students, so physics learning is only limited to the imaginary. Therefore, it is necessary to integrate culture, local wisdom, or local potential in physics learning. The study of culture, local wisdom, and local potential related to physics can be taken from learning resources such as books and research journals. However, econophysics research that explicitly examines culture-related phenomena in physics has yet to be widely conducted. In addition, previous research has limitations in examining physics concepts in more depth. Another problem is that information or original records of local wisdom often do not exist, so they are easily eroded by the times [25].

The study results contribute to the development of ethnophysics and become the first step for researchers who want to examine ethnophysics, especially physics, from local wisdom and the local potential of other regions in Indonesia. Students who gain knowledge through direct experience can improve their cognitive aspects. It can help improve students' ability to understand the material, investigate it, and explain the science contained in the original knowledge of the community. Students' relationships with the surrounding community can also be improved by linking local wisdom with modern knowledge. Thus, learners can become cultured individuals and agents of change who can transfer culture to the next generation. A narrow view will impact the knowledge they acquire, meaning that viewing and interpreting the culture of the community only on one side will not improve their mindset. Much of the community's indigenous knowledge has been forgotten and lost due to a lack of understanding of the importance of the noble values contained therein. In addition, exploring indigenous knowledge that is not accompanied by a logical understanding can give birth to misconceptions in science itself. Therefore, this study aimed to analyze students' misconceptions about heat transfer mechanisms through ethnophysics studies.

2. Methods

2.1. Research Design

This study used A non-experimental quantitative case study [26]. The design was suitable for this study as the data was collected using a questionnaire. In this study, the researchers investigated the prevalence of misconceptions about heat transfer mechanisms among university students. A case can be an individual, group, activity, event, or process. Survey studies use statistical generalizations, while case studies rely on analytical generalizations.

2.2. Sample and Collection

The sampling technique used in this study was random sampling. The random sampling technique is a random sampling of the population so that each member of the population has the same opportunity to be taken as a research sample. The population used in this study were students of physics education study program who were taking basic physics 1 and 2 courses and students of elementary school teacher education program who were completing basic science concepts courses. The sample used in this study consisted of 100 students, 40 physics education students and 60 elementary students of the school teacher education study program.

2.3. Instrument

The data collection instrument used in this study was a diagnostic test of misconceptions of heat transfer mechanisms on the topic of 'Nasi Bambu Pulut' (Pulut Bamboo Rice). The questions were in the form of descriptions totaling 5 questions that physics and learning physics experts have validated. This test was given with the aim that the lecturer could find out the students' knowledge after answering the questions provided. Lecturers will analyze information or answers from each student according to the questionnaire filling. Errors or incorrect answers indicate the occurrence of misconceptions in students. The misconception category of Minarni et al. (2018) [27] students can be seen in Table 1.

Table 1: Misconception Category.

Misconception Interval	Category
0-30	Low
30-70	Medium
70-100	High

From the above categories, the percentage of 0-30 is included in the category of low misconceptions experienced by students, 30-70 is moderate misconceptions, and 70-100 is high misconceptions experienced by students. Data collection in this study by giving misconception test questions in description format to be filled in by students. Then, the answers from each student are collected and analyzed according to the researcher's needs.

2.4. Data Analysis Technique

The participants' responses were analyzed to identify the concept of heat transfer mechanisms. The qualitative analysis involved comparing the responses to heat transfer. The data analysis of this study mainly included two main phases. In the first phase, students' alternative conceptions regarding heat transfer were examined by open coding according to the related questions. In the second phase, the data of students' answers were tabulated in frequencies related to the magnitude of students' misconceptions from low, medium, and high levels.

3. Results

Although students have been involved in various physics-related activities to gain basic knowledge about heat transfer mechanisms from previous learning experiences, it is surprising that many students still need clarification. The percentage of students who have misconceptions about heat transfer mechanisms is shown in Figure 1.

Based on Figure 1, students experience high misconceptions from the first to the fifth question, namely 75, 75, 72, 77, and 85. This data indicates that students still need to understand the concepts that lecturers have taught. Misconceptions experienced by teachers will have an impact on students' mastery of concepts because teachers are

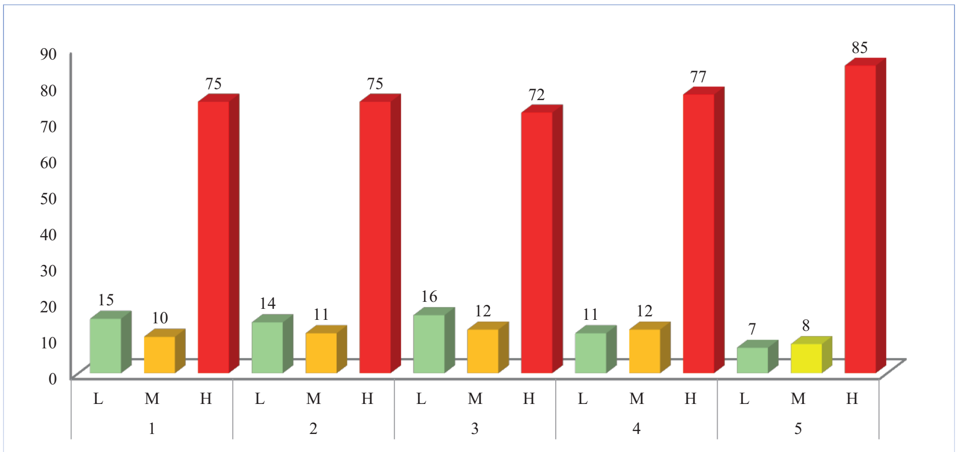

Figure 1: Student Misconceptions From 5 Questions On Heat Transfer Mechanisms.

the primary source of learning for students. Based on the research findings, students or prospective teachers who need clarification about heat transfer mechanisms will struggle to build further concepts.

Figure 2: Nasi Bambu Pulut Process.

4. Discussion

The data in Figure 1 shows that students still need to be aware of the heat transfer mechanism. This study's results align with previous findings, which explained that 30% of senior engineering students were unable to explain the concept of heat transfer.

In addition, another study also provided information that 41% of students had misconceptions about the concepts of temperature and heat [28]. This implies that the correct answer needs to be higher. Thus, learners need to understand heat transfer between the two systems better. Most learners need clarification about basic thermal concepts such as heat and temperature concepts, heat transfer and energy change, and thermal properties of materials. This shows that the strong misconceptions about thermal systems formed early in students' lives continue into higher education. Students can identify the correct formulas for various concepts but cannot solve theoretical or mathematical problems because they need to understand the underlying basic concepts [29]. Students believe bubbles are boiling water containing 'air,' 'oxygen,' 'heat,' 'hydrogen,' 'steam,' or 'nothing' [30]. The results of a study in Greece explain that female students are superior to male students in science concepts. It can be seen from socio-demographic factors, family economics, and genes owned by parents, namely mothers [31].

One of the physics concepts still recognized by students as difficult to understand is the mechanism of heat transfer [32]. Various reasons have been put forward to rationalize the low achievement rate among students. This information comes from a study in Ghana that rote learning and inadequate understanding of concepts cause difficulties in problem solving among students. Heat transfer is the process of heat energy transfer due to temperature differences in a medium or media [33]. Heat transfer occurs whenever there is a temperature difference in a medium or between media [34]. The various methods of heat transfer are conduction, radiation, and convection [35]. The teaching of heat transfer is associated with several things that must be clarified. These misconceptions create conceptual difficulties among students. Neither students nor physics teachers can accurately assess their understanding of heat transfer [36]. Their research also revealed no significant relationship between students' self-understanding and conceptual understanding of heat transfer. Conceptual understanding requires clarification of misconceptions and can potentially engage students in learning [37], [38]. Therefore, learners require effort to connect new knowledge with relevant concepts they already possess [39].

One way to minimize student misconceptions is to implement good teaching strategies through innovation to improve student understanding. Introducing an innovation is wider than equipping teachers with theoretical knowledge or a detailed explanation. What is done is continuous support by equipping students' ability to understand and solve problems related to heat transfer mechanisms that are very useful for their daily lives [40]. Therefore, physics teachers need to give great confidence to their professionals in developing and understanding students about heat transfer [41]. Teachers are considered to play a significant role in influencing the quality of teaching and the success of student learning [42]. Another area for improvement with conceptual difficulties among students is their mindset [43] Students must change their minds and take responsibility for what they learn through critical thinking [44]. In order to develop a better understanding of heat transfer, some experimental-based teaching methods are needed [45]. Educators use different teaching methods based on educational standards and the needs of students [46].

Remember that learners do not come to school like a clean sheet of paper, meaning they come to school with prior knowledge. Learners come to school with scientific knowledge of right or wrong [47]. Pre-existing knowledge can cause a gap between what learners learn and what teachers expect them to learn [48]. Learners' failure stems from factors such as inappropriate teaching or a clash between pre-existing and scientific knowledge, especially if the teacher cannot resolve the difference. In addition, learners come from different socio-cultural contexts, and their experiences affect how they understand scientific concepts. Minimizing learners' misconceptions will improve the quality of learning [49]. Physics is one of the sciences that can be learned through culture, local wisdom, or local potential. Physics studies the basic properties of matter and energy and the interaction between the two. There are many methods to prevent or correct misconceptions. The most important of these are modeling and conceptual change texts. However, incorrect modeling can also result in misconceptions. Therefore, models should be designed so that they do not lead to misconceptions. Misconceptions about heat and temperature were found to center on (1) the equivalence of heat and temperature, (2) the determination of coldness or warmth of an object based on temperature, (3) heat as a substance that moves between objects, (4) the addition of energy because heat always increases the temperature of an object, and (5) the change in temperature during a phase transition when energy is added or removed.

Much research has been conducted in physics at the student level. Most misconceptions occurred in the 1980s and primarily focused on students in the 11-16 age range, with only a much smaller number of studies involving undergraduate students. While recent studies have found that undergraduate physics students still retain old concepts or misconceptions similar to those held at the student level, the prevalence of such misconceptions among students has not been investigated in depth in physics or science teacher trainee classrooms [50]. Indeed, while there is a large body of literature on school students' misconceptions around the world, little literature addresses students' misconceptions in a local cultural context.

Imagine, now, that we heat one end of this tube. As a result, the first molecule oscillates and reaches the point of its nearest neighbor, and so on. In this case, the air molecules are restricted to moving back and forth only, and there is regularity in the collisions. Therefore, we can predict which molecule will start moving and with which molecule it will move to collide at each point. Therefore, the heat transfer is directly to the bamboo material under these conditions. The elements interact sequentially, with the first molecule colliding with the second, the second with the third, and so on. Elemental interactions are continuous, as each collision depends on the previous interaction. Heating one end of the tube increases the speed of the molecules. It increases the number of possible molecular configurations, resulting in higher entropy. Indeed, the more molecules found within the tube's cross-section, the more collisions are likely to occur at each point in time, causing the overall process to be more emergent and the rate of heat flow to increase. As the tube narrows, the entropy flowing through the tube decreases [51]. The state of Figure 2 is simulated in Figure 3.

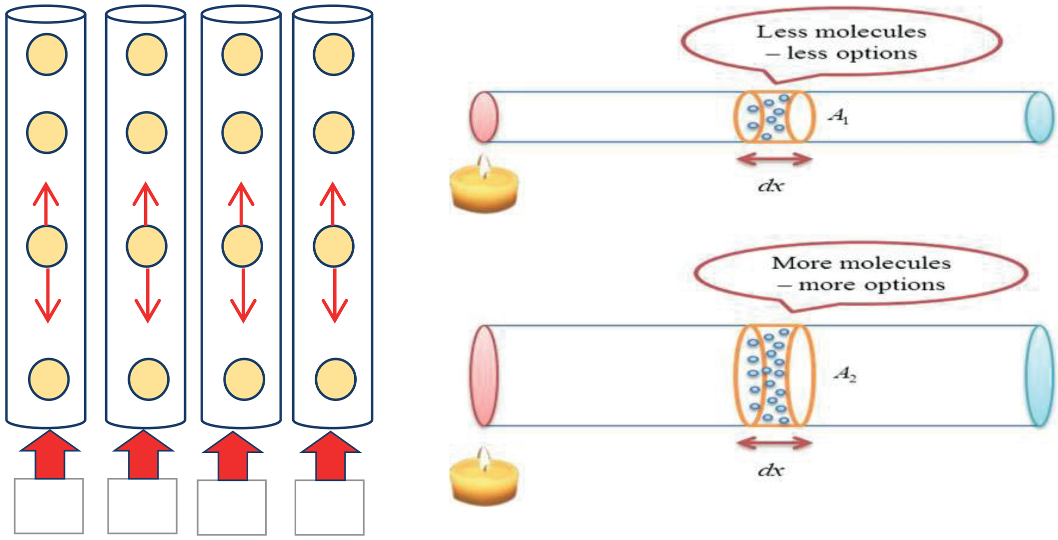

Figure 3: a) Heat Conduction (schematically) Within One Dimension of Bamboo During The Burning Process Of Nasi Bambu Pulut, B) The Hotter The Cross-Section, The More Collisions Are Likely To Occur.

Bamboo is the collective name for giant grass species. An estimated 60-90 genera of Bamboo, comprising around 1100-1500 species. These species come in a variety of sizes and shapes. Bamboo mainly grows in the tropical regions of Asia, Latin America, and Africa. In recent years, Bamboo has grown in popularity in the built environment, mainly due to its low cost, high mechanical strength, appealing aesthetics, flexibility, and very low, or even positive, environmental impact [52]. Bamboo has

DOI 10.18502/kss.v9i31.17567

one of the highest renewable energy rates compared to other natural construction materials. Bamboo is a grass (not a tree) that undergoes only vertical growth without radial growth. The stem is hollow, tapered, and branched. The parts of the stem are usually labeled as books and internodes. Nodes are diaphragms consisting of fibers that change direction. Internodes are essentially hollow tubes with oriented cell axes. Typically, the wall of a bamboo culm consists of parenchyma cells (50%), fiber bundles (40%), and conducting tissue (10%). Its mechanical properties are superior to many softwood species. Traditionally, Bamboo has been used as the primary load-bearing material for low-rise construction in rural or remote areas, wherever it is easy to find and exploit [53]. In this regard, Bamboo has raised concerns due to its flammability and mechanical performance when exposed to high temperatures. Findings from this study showed that at 200°C, bamboo retained 20%, 42%, and 70% of its compressive strength, tensile strength, and elastic modulus, respectively [54]

4.1. What is Ethnophysics

Indigenous science is sometimes called ethnoscience, the knowledge system a particular culture develops to classify objects, activities, and events in nature. Interpreting local life works when viewed through the periscope of a particular culture. The knowledge indigenous to a particular culture and related to natural objects and events thus has the potential to have the same branches as Western science. It means that the branches of ethnoscience include ethnochemistry, ethnophysics, and ethno-agriculture. In summary, ethnoscience is knowledge derived from the norms and beliefs of a particular indigenous community that influences its members' interpretation and understanding of the natural world [55]. Ethnophysics is associated with physics learning through local wisdom. Local culture can be brought into learning physics contextually so that students directly learn from environmental phenomena and conditions. The characteristics of ethnophysics link the culture of a region in physics learning processes, both as teaching materials and as learning processes. This, of course, impacts student learning outcomes so that students can easily understand physics concepts contained in regional culture. Ethnophysics deals with knowledge derived from culture, which can be the basis for building a reality emphasizing the relationship between culture and physics knowledge. Learning physics is also near ethnophysics, which is related to learning physics with the culture in the area and is a heritage passed down from generation to generation [56].

Ethnophysics is found mainly in African/non-European literature because it is African literature. Ethnophysics refers to an indigenous knowledge system incorporating elements of what Western societies call mathematics, engineering, astronomy, and calendars [57]. Introducing ethno-physics into the school curriculum will develop the practice of indigenous and cosmopolitan knowledge models that will bring a balanced process of development and change. Integrating ethnophysics into the school curriculum will develop students' skills in music, traditional food or drink-making skills, and manufacturing of items of high economic value from local materials [58]. Culture has a strong influence on learners' background knowledge. The formation of a meaningful learning environment is determined by the cultural background that teachers bring into the classroom. Various studies claim that learners with cultural backgrounds find science too abstract because it is mainly taught with Western influences [59]. Ethnophysics is one of the new fields of study in Indonesia. This can be evidenced by the many local wisdoms of indigenous people that have yet to be explored in research or learning regarding students' academic development and their love of culture. Therefore, in the future, it can be explored more in research and cultural festivals or developed in the school curriculum related to the ethnophysics of the islands in Indonesia or Maluku so that they are not endangered due to globalization.

4.2. Ethnophysics of Islands: Nasi Bambu Pulut Dusun Kusu-Kusu Sereh

In the hidden delights of Kusu-Kusuh Sereh Hamlet, there is a food that is so tempting, namely Nasi Bambu Pulut. This meal, a specialty with the fragrant aroma of red bean rice wrapped in banana leaves, promises a delicacy that captivates diners' hearts. An alluring touch of tradition, Nasi Bambu Pulut brings authentic flavors and incomparable pleasure. Richly spiced red beans are combined with the abundant fragrance of bananas, creating a perfect blend of chewy texture and delicious flavor. The cultural heritage and warmth of Kusu-Kusu Sereh Hamlet have a unique sensation that will make everyone who enjoys it long for it again and again. The field study results show that the production center of Nasi Bambu Pulut in Kusu-Kusu Sereh Hamlet is centered on Wapang, Malamang, and Laweru. Martavina Totnear is one of the great women who has been in this profession for approximately 25 years. She also pursued the making of Nasi Bambu Pulut from the upbringing of her mother-in-law (Mother of husband), one of the women famous for making nasi bambu pulut. Martavina Totnear, usually called Mama Ata, is a woman from

Southwest Maluku, more precisely Moa Island, Klis Village. She migrated to Ambon in the 90s at 15 and initially worked in a coffee house. Over time, she met a man who is now her husband. Her husband comes from Kusu-Kusu Sereh Hamlet. Nasi Bambu Pulut is produced every day except Sundays; usually, 25-30 bamboos measuring 80-100 cm are burned and, when cut, can produce 250-300 pieces of Nasi Bambu Pulut. The burning process takes place at night, and it is sliced in the morning around 4 o'clock. Then, they leave the house to go to the Mardika market to sell Nasi Bambu Pulut at around 5:30. Selling Nasi Bambu Pulut starts from 6:00-12:00.

Nasi Bambu Pulut is made from sticky rice, a local food in Southeast Asian countries. It has been adapted into various dishes, including Nasi Bambu. Nasi Bambu is named in different countries: Paung Din in Myanmar, Kralan in Cambodia, Khao Lam in Thailand and Laos, Com Lam in Vietnam, and Lemang in Malaysia, Singapore, and Indonesia. Therefore, they shared Nasi Bambu as cultural food. Today, local food is a cultural value, a marker of identity, and a central relation of family, community, ethnic group, or nationality, changing with time and place. The government developed Nasi Bambu into a commercial local product, and the tourism sector supports it well in Vietnam and Thailand (Afrilla et al., 2020). In the Jambi area, Nasi Bambu Pulut is known as lemang bambu. Lemang Bambu is a traditional food typical of the Malay tribe in Sumatra made from glutinous rice cooked in Bamboo. The culture of melemang (making lemang bambu) is one of the traditions of the Jambi people that has been passed down from generation to generation. Lemang bambu is usually served at traditional events, wedding parties, holidays, and as a break-fasting meal during the holy month of Ramadan [61]. It has become a challenge for traditional traders with the emergence of an eating-out culture in modern society, with McDonald's, KFC, and Burger King restaurants lining high-traffic streets and shopping malls [62]. Therefore, we are all responsible for maintaining traditional specialties with high health values and local wisdom. Therefore, it continues to be introduced to the current generation to remain sustainable. Moreover, the current generation prefers fast food that looks cooler when eaten in luxurious places. However, the health value of the meal cannot be adequately guaranteed compared to traditional meals.

5. Conclusions

Based on the findings, analysis, and discussion, students experienced misconceptions in the high percentage category. This finding has important practical implications.

Educators should be aware of possible misconceptions about heat transfer mechanisms that must be addressed. Otherwise, misconceptions will continue throughout the students' studies and beyond during their professional lives. This emphasizes the importance of prevention against prospective teachers entering their professional lives with misconceptions of the concept. Future findings should also investigate the long-term impact of this teaching intervention, such as concept retention and the ability to apply concepts in the workplace. The ethnophysics curriculum is part of the experiential learning that students are expected to achieve; teachers should, therefore, provide opportunities for students to understand the critical reciprocal relationships among science, technology, society, and the cultural environment.

References

[1] Nature. "Unlock the potential of a physics education". Nat Phys. 2024;20(3):335.

[2] Guimarães MH, Pohl C, Bina O, Varanda M. Who is doing inter- and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours. Futures. 2019;112:1–15.

[3] Brakhage H, Gröschner A, Gläser-Zikuda M, Hagenauer G. Fostering students' situational interest in physics: Results from a classroom-based intervention study. Res Sci Educ. 2023;53(5):993–1008.

[4] Dominguez A, De la Garza J, Quezada-Espinoza M, Zavala G. Integration of physics and mathematics in STEM education: Use of modeling. Educ Sci (Basel). 2024;14(1):1–26.

[5] Oon PT, Subramaniam R. On the declining interest in physics among students-from the perspective of teachers. Int J Sci Educ. 2011;33(5):727–46.

[6] Senden B, Teig N, Nilsen T. Studying the comparability of student perceptions of teaching quality across 38 countries. Int J Educ Res Open. 2023;5:1–10.

[7] Beatty A, Berkhout E, Bima L, Pradhan M, Suryadarma D. Schooling progress, learning reversal: Indonesia's learning profiles between 2000 and 2014. Int J Educ Dev. 2021 Sep;85:102436.

[8] Pritchett L, Beatty A. "The negative consequences of overambitious curricula in developing countries." SSRN Electron J. 2013;10:1–48.

[9] Igarashi T, Suryadarma D. Foundational mathematics and reading skills of Filipino students over a generation. Int J Educ Dev. 2023;96:1–11.

[10] Ameen AO, Alarape MA, Adewole KS. Students' academic performance and predictions: A review. Malaysian J Comput. 2019;4(2):278–303.

[11] Govindarajoo MV, Selvarajoo ND, Ali MS. Factors contributing to poor academic achievement among low performing pupils: A case study. Asian J Univ Educ. 2022;18(4):981–97.

[12] Wicaksono AG, Korom E. Attitudes towards science in higher education: Validation of questionnaire among science teacher candidates and engineering students in Indonesia. Heliyon. 2023 Sep;9(9):e20023.

[13] Wartono W, Batlolona JR, Putirulan A. Cognitive conflict strategy and simulation practicum to overcome student misconception on light topics. J Educ Learn. 2018;12(4):747–56.

[14] Ugwuanyi CS, Ezema MJ, Orji EI. Evaluating the instructional efficacies of conceptual change models on students' conceptual change achievement and self-efficacy in particulate nature matter in physics. SAGE Open. 2023;13(1):1–29.

[15] Prinz A, Kollmer J, Flick L, Renkl A, Eitel A. Refuting student teachers' misconceptions about multimedia learning. Instr Sci. 2022;50(1):89–110.

[16] Kulgemeyer C, Wittwer J. Misconceptions in physics explainer videos and the illusion of understanding: An experimental study. Int J Sci Math Educ. 2023;21(2):417–37.

[17] Im SH, Jitendra AK. Analysis of proportional reasoning and misconceptions among students with mathematical learning disabilities. J Math Behav. 2020;57:1–20.

[18] Tanahoung C, Chitaree R, Soankwan C, Sharma MD, Johnston ID. Research in science & technological education the effect of interactive lecture demonstrations on students' understanding of heat and temperature: A study from Thailand. Res Sci Technol Educ. 2009;27(1):37–41.

[19] Dahn M, Lee C, Enyedy N, Danish J. Instructional improv to analyze inquiry-based science teaching: Zed's dead and the missing flower. Smart Learn. Environ. 2021;8(1):1–29.

[20] Kibirige I. Exploring the prevalence of misconceptions regarding heat and temperature among grade nine natural science learners. Unnes Sci Educ J. 2021;10(3):115–23.

[21] Biber Ç, Tuna A, Korkmaz S. The mistakes and the misconceptions of the eight grade students on the subject of angles. Eur J Sci Math Educ. 2021;1(2):50–9.

[22] Mertala P, Fagerlund J. Finnish 5th and 6th graders' misconceptions about artificial intelligence. Int J Child Comput Interact. 2024;39:1–8.

[23] Prince M, Vigeant M, Nottis K. Repairing student misconceptions in heat transfer using inquiry-based activities. Chem Eng Educ. 2016;50(1):52–61.

[24] Festiyed. "Ethnophysics studies in various Indonesian cultures: A systematic literature review." J Innov Educ Cult Res. 2024;5(1):170–80.

[25] Puchumni P, Tungpradabkul S, Magee R. Using information retrieval activities to foster analytical thinking skills in higher education in Thailand: A case study of local wisdom education. Asian J Educ Train. 2019;5(1):80–5.

[26] Reio TG Jr. Nonexperimental research: Strengths, weaknesses and issues of precision. European J Train Dev. 2016;40(8–9):676–90.

[27] Minarni M, Kurniawan Y, Muliyani R. “Identifikasi Kuantitas Siswa Yang Miskonsepsi Pada Materi Listik Dinamis Menggunakan Three Tier-Test (TTT),” JIPF (Jurnal Ilmu Pendidik. Fis. 2018;3(2):38.

[28] Twumasi EA. Diagnostic assessment of students’ misconceptions about heat and temperature through the use of two-tier test instrument. Br J Educ Learn Dev Psychol. 2021;4(1):90–104.

[29] Olakanmi EO, Doyoyo M. Using structured examples and prompting reflective questions to correct misconceptions about thermodynamic concepts. Eur J Eng Educ. 2014;39(2):157–87.

[30] Senocak E. Prospective primary school teachers’ perceptions on boiling and freezing. Aust J Teach Educ. 2009;34(4):27–38.

[31] Stylos G, Sargioti A, Mavridis D, Kotsis KT. Validation of the thermal concept evaluation test for Greek university students’ misconceptions of thermal concepts. Int J Sci Educ. 2021;43(2):247–73.

[32] Alami AH, Ramadan M, Tawalbeh M, Haridy S, Al Abdulla S, Aljaghoub H, et al. A critical insight on nanofluids for heat transfer enhancement. Sci Rep. 2023 Sep;13(1):15303.

[33] Kolsi L, Selimefendigil F, Gasmi H, Alshammari BM. Conjugate heat transfer analysis for cooling of a conductive panel by combined utilization of nanoimpinging jets and double rotating cylinders. Nanomaterials (Basel). 2023 Jan;13(3):1–17.

[34] Pagliarini L, Cattani L, Mameli M, Filippeschi S, Bozzoli F. Heat transfer delay method for the fluid velocity evaluation in a multi-turn pulsating heat pipe. Int. J. Thermofluids. 2023;17:1–15.

[35] Rashid FL, Hussein AK, Malekshah EH, Abderrahmane A, Guedri K, Younis O. Review of heat transfer analysis in different cavity geometries with and without nanofluids. nanomaterials (Basel). 2022 Jul;12(14):1–30.

[36] Brown CP, Englehardt J, Mathers H. Corrigendum to “Examining preservice teachers’ conceptual and practical understandings of adopting iPads into their teaching of young children” [Teaching and Teacher Education 60 (2016) 179–190] (Teaching and Teacher Education (2016) 60 (179–190), (S07420. Teach Teach Educ. 2021;97:103191.

[37] Al Sultan A, Henson H Jr, Lickteig D. Assessing preservice elementary teachers' conceptual understanding of scientific literacy. Teach Teach Educ. 2021;102:1–10.

[38] Stovner RB, Klette K. Teacher feedback on procedural skills, conceptual understanding, and mathematical practices: A video study in lower secondary mathematics classrooms. Teach Teach Educ. 2022;110:1–12.

[39] Hoffman JV, Wetzel MM, Maloch B, Greeter E, Taylor L, DeJulio S, et al. What can we learn from studying the coaching interactions between cooperating teachers and preservice teachers? A literature review. Teach Teach Educ. 2015;52:99–112.

[40] Michailidi E, Stavrou D. Mentoring in-service teachers on implementing innovative teaching modules. Teach Teach Educ. 2021;105:1–15.

[41] Mena J, Hennissen P, Loughran J. Developing pre-service teachers' professional knowledge of teaching: The influence of mentoring. Teach Teach Educ. 2017;66:47–59.

[42] Meschede N, Fiebranz A, Möller K, Steffensky M. Teachers' professional vision, pedagogical content knowledge and beliefs: on its relation and differences between pre-service and in-service teachers. Teach Teach Educ. 2017;66:158–70.

[43] Kertiyani NM, Fatimah S, Dahlan JA. Critical thinking skill through problem-based learning with problem posing within-solution. J Math Sci Teach. 2022;2(2):1–5.

[44] Hokor EK. Integration of critical thinking and reasoning skills into lessons through block factor game for finding factors of a number. J Math Sci Teach. 2022;2(2):1–15.

[45] Dare EA, Ellis JA, Roehrig GH. Understanding science teachers' implementations of integrated STEM curricular units through a phenomenological multiple case study. Int J STEM Educ. 2018;5(1):4.

[46] Burballa C, et al. Factors associated with the compensation of renal function after nephrectomy of a kidney donor. Nefrologia. 2018;38(5):528–34.

[47] C. Wenning, "Dealing more effectively with alternative conceptions in science." J Phys Teach Educ Online. 2008;5(1):11–19. [Online]. Available: http://www2.phy.ilstu.edu/ptefiles/publications/dealing_alt_con.pdf

[48] Sharma S, Ahluwalia PK. Diagnosing alternative conceptions of Fermi energy among undergraduate students. Eur J Phys. 2012;33(4):883–95.

[49] Kavşut G. Investigation of science and technology textbook in terms of the factors that may lead to misconceptions. Procedia Soc Behav Sci. 2010;2(2):2088–91.

[50] Abrahams I, Homer M, Sharpe R, Zhou M. Research in science & technological education - A comparative cross-cultural study of the prevalence and nature of misconceptions in physics amongst English and Chinese undergraduate students. Res Sci Technol Educ. 2015;33(1):37–41.

[51] Volfson A, Eshach H, Ben-Abu Y. Introducing the idea of entropy to the ontological category shift theory for conceptual change: the case of heat and sound. Phys Rev Phys Educ Res. 2019;15(1):10143.

[52] van der Lugt P, van den Dobbelsteen AA, Janssen JJ. An environmental, economic and practical assessment of bamboo as a building material for supporting structures. Constr Build Mater. 2006;20(9):648–56.

[53] Salzer C, Wallbaum H, Alipon M, Lopez LF. Determining material suitability for Low-Rise housing in the philippines: Physical and mechanical properties of the bamboo species Bambusa blumeana. BioResources. 2018;13(1):346–69.

[54] Gutierrez M, Maluk C. Mechanical behaviour of bamboo at elevated temperatures – Experimental studies. Eng Struct. 2020;220:1–9.

[55] Fasasi RA. Effects of ethnoscience instruction, school location, and parental educational status on learners' attitude towards science. Int J Sci Educ. 2017;39(5):548–64.

[56] Habibi. "Development of ethnophysics-based teaching materials to improve the self-regulatory skills of prospective physics teachers." J Penelit Pendidik IPA. 2023;9(Special Issue):724–731. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6557.

[57] Chongo E. Effect of ethnophysics - based instruction on students ' academic performance and attitude towards density, forces and heat transfer in college physics: A case of Mufulira College of Education. J Educ Pract. 2019;10(20):14–25.

[58] Anthony LB. The integration of ethno physics into school curriculum for skill acquisition among secondary school students in Nigeria. Int J Innov Res Adv Stud. 2017;4(8):62–5.

[59] Idul JJ, Fajardo MT. Ethnoscience-based physical science learning and its effects on students' critical thinking skills: A meta-analysis study. J Math Sci Teach. 2023;3(2):em048.

[60] Afrilla IM. Shasa Hanggana. Int J Educ Soc Sci Res. 2020;3(06):127–43.

[61] Jufrida J, Basuki FR, Oksaputra MF, Fitaloka O. Ethnoscience analysis of 'lemang bamboo' Sumatera traditional food. J Phys Conf Ser. 2021;1731(1):1–8.

[62] Schwallier R, de Boer HJ, Visser N, van Vugt RR, Gravendeel B. Traps as treats: A traditional sticky rice snack persisting in rapidly changing Asian kitchens. J Ethnobiol Ethnomed. 2015 Mar;11(1):24.