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Audiovisual Media Based on Tapai Singkong Local Wisdom in Project-Based Learning for Science Concept Understanding, Environmental Care Attitudes, and SDGs

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Abstract: Science instruction in many schools remains verbalistic and disconnected from students' everyday experiences, limiting conceptual understanding and environmental care attitudes. This study examined the effectiveness of audiovisual-based learning grounded in local wisdom for improving science concept understanding and environmental care attitudes among ninth-grade students at SMP Negeri 3 Singkohor, Aceh Singkil, using a sequential explanatory mixed-methods design. A one-group pretest-posttest design was applied to ten students using a validated 20-item multiple-choice instrument, followed by a qualitative phase with six purposively selected students representing high, medium, and low conceptual gain, examined through participatory observation, interviews, and documentation. The average score rose from 61.00 to 91.50, yielding an N-Gain of 0.79 (high category), though the small sample limits statistical generalization. Qualitative findings showed local wisdom bridged abstract concepts, and environmentally responsible behaviors emerged spontaneously at school, though this awareness did not consistently extend to plastic use at home. These results suggest that local-wisdom-based audiovisual learning can strengthen conceptual understanding and environmental awareness, while broader application warrants further testing.

Keywords: Environmental care attitudes; Local wisdom; Project-based learning; Science concept understanding; Tapai singkong fermentation

Introduction

Natural Science education plays a strategic role, as it not only conveys factual knowledge but also cultivates critical thinking, conceptual understanding, and environmental awareness. At the global level, escalating environmental crises such as climate change, pollution, and deforestation (Huoponen, 2024) place growing pressure on the education sector particularly school-based science instruction to begin cultivating environmental literacy from an early age (Cajurao et al., 2024). Students equipped with strong environmental literacy are expected to better understand ecological problems and take concrete action toward sustaining the planet.

Science education in Indonesian junior high schools, however, continues to face several persistent challenges. First, instruction tends to remain verbalistic and disconnected from students' everyday realities (Ramadhani et al., 2023); topics such as biotechnology and environmental pollution are frequently taught without contextual grounding in students' surrounding environment, limiting their perceived relevance (Khoiriyah & Khoiri, 2024). Second, instructional media that engage multiple sensory channels remain underutilized, despite multisensory learning theory

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suggesting that instruction is more effective when sight, hearing, and movement are engaged together. Edgar Dale's Cone of Experience illustrates this point: learners retain only about 10% of what they read and 20% of what they hear through passive exposure, whereas retention increases substantially through direct, hands on experience. This principle indicates that audiovisual media alone engaging sight and hearing occupies a relatively passive position on the retention spectrum; its instructional value is therefore maximized not by viewing alone, but when paired with an actively experiential process in which students apply what they see and hear through direct practice. Third, science instruction has yet to meaningfully draw on local wisdom as a context close to students' lived experience, despite its potential to anchor abstract concepts in familiar cultural practice.

These problems are clearly visible at SMP Negeri 3 Singkohor, Aceh Singkil Regency a small, three classroom school situated in a border sub-district within an oil palm plantation landscape with a limited surrounding population. The area holds a rich local tradition of cassava tapai (fermented cassava) production passed down across generations, yet environmentally friendly practices once central to this tradition, such as using banana, guava, or teak leaves as natural wrappers, are increasingly giving way to plastic. At the same time, students' environmental care at school remains a concern: littering, desks cluttered with plastic and paper waste, and cleaning duties carried out only under teacher reminder. Together, these observations point to a gap between environmental knowledge and consistent pro-environmental behavior, underscoring the need for an instructional approach that meaningfully bridges local wisdom with science education.

Whereas prior studies have examined audiovisual media and local-wisdom-based instruction separately, few have combined the two within a structured Project Based Learning (PjBL) sequence built around a specific, place based fermentation practice. The novelty of this study lies in pairing two complementary audiovisual components one introducing the traditional cassava tapai-making process as an entry point into biotechnology concepts, and another addressing the environmental risks of plastic waste with a PjBL sequence in which students directly practice fermentation using natural, locally available wrapping materials, rather than relying on video viewing alone. This design draws on Vygotsky (1978) theory of social constructivism, which highlights the role of social interaction and cultural context in knowledge construction, and Mayer's cognitive theory of multimedia learning concerning the instructional value of dual channel visual auditory media. Examining this integrated approach carries particular importance in geographically and economically marginalized settings such as Aceh Singkil, where local ecological knowledge remains an underused pedagogical resource despite its potential to strengthen both conceptual understanding and environmental care attitudes among students.

Based on this rationale, this study aims to describe the improvement in science concept understanding among ninthgrade students of SMP Negeri 3 Singkohor following their participation in audiovisual based, local wisdom integrated learning, and to describe students' environmental care attitudes after taking part in the learning process.

Method

This study employed a mixed methods approach using a sequential explanatory design (Creswell & Clark, 2018), selected because the research required two complementary forms of data: quantitative data to measure improvement in science concept understanding, and qualitative data to gain deeper insight into students' environmental care attitudes within their local cultural context. The study was conducted at a junior high school in Aceh Singkil Regency, Aceh Province. All ninth grade students at the school (N = 10) participated through total/saturated sampling; as a small, three classroom institution located in a border sub district within a limited population oil palm plantation area, this school had only ten ninth grade students in total, meaning the quantitative sample represents the entire ninth grade population rather than a subset drawn from a larger pool.

The research procedure comprised two phases. The quantitative phase employed a one group pretest posttest design (Creswell & Clark, 2018) delivered across four instructional sessions (2 × 40 minutes each). The first session allocated 30 minutes to the pretest, measuring students' initial understanding of biotechnology and environmental concepts through a 20 items multiple choice instrument, followed by orientation activities within the remaining session time. The second session involved project planning and initial hands on fermentation practice; the third involved wrapping, fermentation, and observation. Across these sessions, instructional activities included screening a video on traditional cassava tapai-making (6 minutes) and a video on the dangers of plastic waste (5 minutes), followed by students directly practicing PjBL based cassava tapai fermentation using natural leaf wrappers. The fourth session involved student presentations and reflection, concluding with a 30 minutes posttest using the same instrument as the pretest.

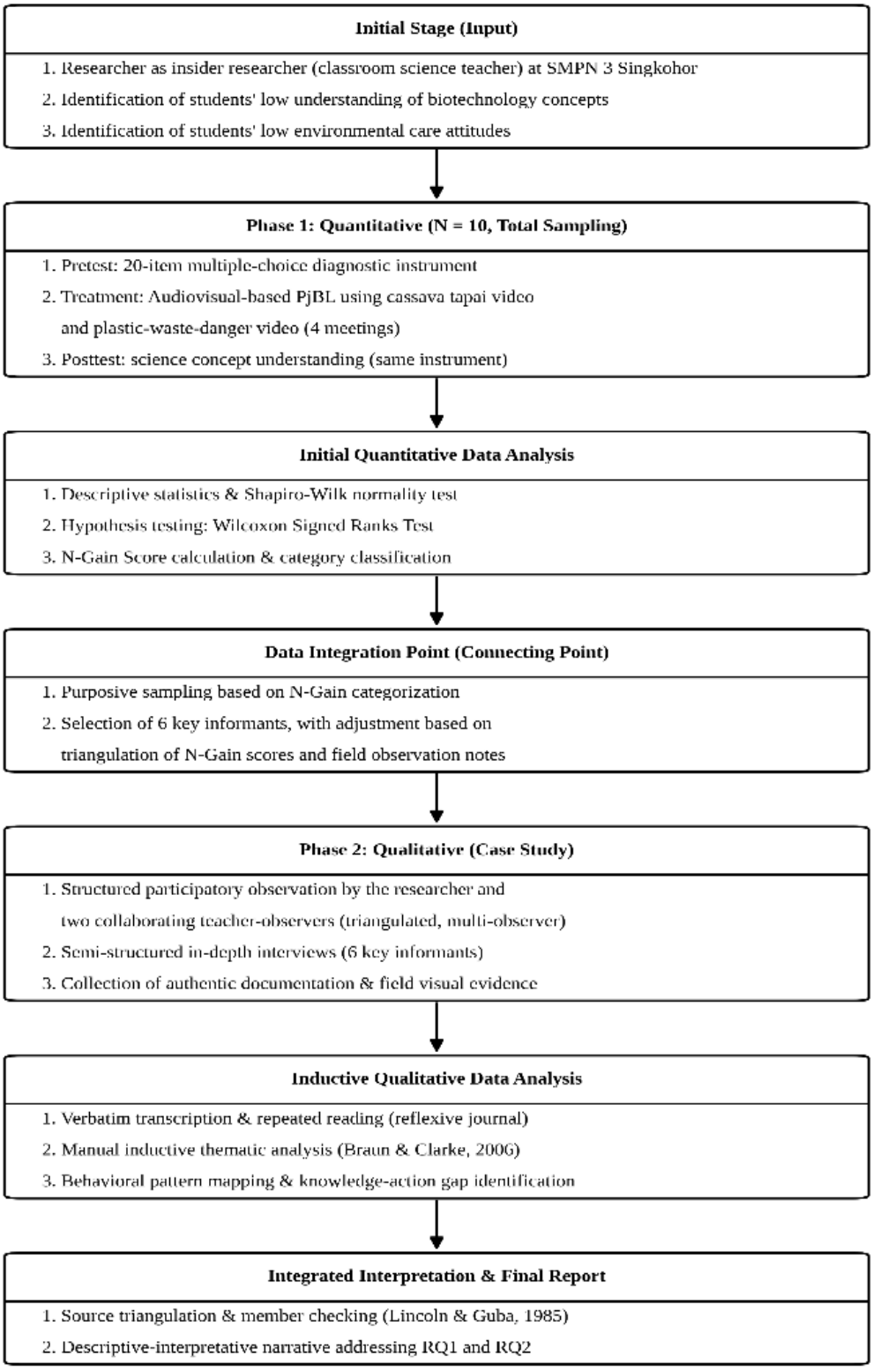

Figure 1. Research stage

The qualitative phase employed a case study approach. Participatory observation was conducted across all four PjBL sessions, with field notes recorded independently by the researcher and two collaborating teachers who served as classroom observers; this triangulated, multi observer arrangement was intended to reduce potential subjectivity arising from the researcher's dual role as the students' classroom science teacher. Following completion of the posttest, semi structured in depth interviews (25-40 minutes each)

were conducted with six purposively selected informants, supplemented by documentation of activity photographs, student work artifacts, and field notes. As the primary qualitative data gathered after the quantitative phase concluded, these interviews served to explain and elaborate the quantitative findings, consistent with the sequential explanatory design, while the concurrent observational notes from the researcher and the two collaborating teachers provided supporting contextual and triangulating evidence of the learning process itself. Informant selection followed a purposive rather than random logic, based on posttest score categorization: two students were selected from the high category, two from the moderate category, and two from the low category, in order to capture a broad range of learning experiences. One adjustment was made for participant DAH, whose posttest categorization placed him in the moderate group, but whose field observations independently corroborated by both collaborating teachers indicated notably low engagement and limited participation during group-based practical work. Because this discrepancy between quantitative performance and observed classroom engagement was considered analytically significant, DAH was reassigned to the low-engagement interview group alongside WIN, warranting deeper qualitative exploration of this anomaly.

Quantitative data were analyzed using descriptive statistics (mean, median, standard deviation, minimum maximum scores), the Shapiro Wilk normality test (appropriate for n < 50, with results interpreted cautiously given the limited statistical power of this small sample), and the N-Gain Score (Hake, 1998), calculated as g = (posttest score,pretest score) / (maximum score − pretest score), interpreted as high ($g > 0.70$), moderate ($0.30 \leq g \leq 0.70$), or low ($g < 0.30$).

Qualitative data were analyzed through manual inductive thematic analysis (Braun & Clarke, 2006), involving data familiarization, initial coding, theme searching, theme review, theme definition and naming, and report writing. Data credibility was established through source triangulation comparing observational, interview, and documentation data across all three observers along with member checking and peer debriefing.

Result and Discussion

Instrument Validity and Characteristics

Content validation by two experts indicated that 20 of the original 25 test items were declared valid (100%) and suitable for use, confirming that the instrument effectively measured students' understanding of science concepts related to biotechnology and environmental issues. Five items were eliminated due to excessively complex stimulus readability and overlapping material indicators, ensuring that each remaining item assessed a distinct learning objective. Diagnostic distractors were also strengthened; for example, item 6 was revised from "Group A discards banana leaves" to "If Group A discards the used banana leaf wrappers," providing clearer, more realistic context and reducing ambiguity in student interpretation.

Understanding of Science Concepts

Pretest and posttest results for the 10 students are summarized in Table 1.

Table 1. Descriptive statistics for the pretest and posttest scores

Statistic	Pretest	Posttest
Mean	61.00	91.50
Median	60.00	95.00
Standard Deviation	10.49	12.48
Lowest Score	50	60
Highest Score	85	100

The average score increased by 30.50 points, from 61.00 to 91.50. The standard deviation also increased slightly, from 10.49 to 12.48, indicating that score variation widened rather than converged following the intervention. While all 10 students showed improvement, gains were not uniform: several students (ALF, M, FRZ, HAS) reached the maximum score of 100, whereas WIN improved only marginally, from 50 to 60. This divergence suggests that the audiovisual-based PjBL intervention was not equally effective across all ability levels, indicating that students with lower initial understanding may require additional scaffolding or differentiated support an issue explored further in the qualitative findings below.

Item level analysis revealed that the concepts most strongly mastered after treatment were enzymatic fermentation reactions and characteristics of environmentally friendly local food, both answered correctly by all students (100%) in the posttest, consistent with Vygotsky (1978) view that contextualized, culturally grounded learning fosters deeper and more durable understanding. The item with the weakest gain concerned the socioeconomic impact of biotechnology, which declined slightly from 70% to 60% correct responses, plausibly because this dimension requires broader context and more extended engagement than a four-session intervention can provide (Anderson & Krathwohl, 2001). The largest gains occurred in items distinguishing modern and conventional biotechnology and identifying advantages of conventional local food, both rising from 30% to 80% correct responses suggesting that the audiovisual media successfully

bridged students' existing local knowledge with previously abstract scientific frameworks (Mayer, 2024).

Normality Test. The Shapiro-Wilk test showed that both the pretest ($W = 0.938$; $p = 0.55$) and posttest data ($W = 0.954$; $p = 0.65$) were normally distributed ($p > 0.05$). Despite this, given the small sample size ($N = 10$), the Wilcoxon Signed Ranks Test a more conservative non-parametric approach was selected for hypothesis testing rather than a parametric test such as the paired t-test, which would carry limited statistical power and reliability at this sample size.

Hypothesis Testing. The Wilcoxon Signed Ranks Test showed 10 positive ranks, 0 negative ranks, and 0 ties, indicating that every student's score improved from pretest to posttest. The test statistic was $Z = -2.81$ (Asymp. Sig. 2-tailed = 0.005), which is below the 0.05 threshold, leading to rejection of the null hypothesis. This confirms a statistically significant difference between pretest and posttest scores following the audiovisual-based, local-wisdom-integrated PjBL intervention.

Figure 2. Audiovisual-based local-wisdom-integrated PjBL intervention

Individual N-Gain scores are presented in Table 2. The class-average N-Gain score was 0.79 (high category). Six students (60%) reached the high category, three (30%) the moderate category, and one (10%) the low category. Although WIN's improvement was modest relative to peers, this pattern along with DAH's later reassignment for qualitative follow-up is examined further below in relation to classroom engagement.

Table 2. N-Gain score per student and category

Initials	Pretest	Posttest	N-Gain	Category
ALF	55	100	1.00	High
DAH	60	85	0.63	Medium
FAH	85	95	0.67	Medium
DAF	65	95	0.86	High
M	70	100	1.00	High
FRZ	60	100	1.00	High
HAS	50	100	1.00	High
SU	60	95	0.88	High
NVT	55	85	0.67	Medium
WIN	50	60	0.20	Low

Qualitative Findings

Following completion of the posttest, six informants were purposively selected two from the high, two from the moderate, and two from the low posttest-score category to capture a broad range of learning experiences (M, MIR, DAF, FAH, DAH, WIN). One adjustment was made for DAH: although his N-Gain score (0.63) placed him in the moderate category, field observations independently corroborated by both collaborating teachers noted consistently low engagement and limited participation during group practical work. This discrepancy between quantitative performance and observed classroom behavior was considered analytically meaningful, and DAH was accordingly grouped with WIN for low-engagement interview analysis.

Theme 1: Audiovisual Media as a Bridge to Abstract Concepts. Across interviews and observation notes, audiovisual content consistently emerged as effective in transforming abstract fermentation concepts into concrete, imaginable processes. One collaborating teacher observed: "Class energy rose noticeably once the videos began; students who had seemed disengaged shifted their full attention to the screen." This was echoed by informant MIR: "The video helped me understand just hearing the teacher explain it would have been hard to imagine, but seeing it made it clear." These observations align with Mayer (2024) Cognitive Theory of Multimedia Learning, which holds that synchronized visual auditory input strengthens long term retention and conceptual understanding relative to text alone, and with Khoiriyah & Khoiri (2024), who found audiovisual media effective in supporting inquiry skills and conceptual understanding of complex science material.

Theme 2: Local Wisdom as a Bridge to Environmental Resources. Many students, despite growing up in an agrarian setting, had not previously recognized the scientific basis of everyday local practices. One collaborating teacher noted: "Many students had never made tapai before one even proudly shared knowledge about the cassava grown in the school garden, as if only just realizing that what they see every day carries real scientific value." This finding is consistent with Setiawan et al. (2017), who argues that ethnoscience-based instruction strengthens both cognitive outcomes and students' conservation values, and with Karuana et al. (2023), who emphasize that science learning rooted in local wisdom carries greater meaning when the object of study is part of students' own social-ecological environment.

Theme 3: Spontaneous Pro-Environmental Behavior. Perhaps the most pedagogically significant finding was the emergence of spontaneous, unprompted environmentally responsible behavior. Across two separate sessions, two different collaborating teachers independently recorded students voluntarily cleaning desks and disposing of waste without instruction for

example: "HAS and FAH threw away trash and cleaned their desks without being told; M and SU did the same on their own initiative" (Session 2), and "M and SU took the initiative to tidy up and dispose of waste; DAH cleaned up spilled tapai water from the table" (Session 3). Under Ajzen (1991) Theory of Planned Behavior, consistent, unprompted behavior reflects an underlying shift in attitude rather than situational compliance. This finding is consistent with Ratnasari et al. (2024), who found that contextual science instruction meaningfully strengthens students' environmental character, particularly when content connects directly to familiar local contexts.

Theme 4: Knowledge-Action Gap. All six informants demonstrated accurate understanding of plastic's environmental harms, correctly explaining its non-biodegradability and impact on soil and water. However, several students acknowledged that plastic waste at home was still commonly managed by burning, reflecting what Anderson & Krathwohl (2001) term a knowledge-action (or value-action) gap a state in which awareness and concern exist without full behavioral alignment. This finding is not unexpected: transforming entrenched household waste-disposal habits requires sustained exposure and support beyond a four-session classroom intervention. Consistent with Susilawati et al. (2021), pro-environmental attitudes among Indonesian students are strongly shaped by structural factors outside the classroom such as family habits and social environment meaning genuine behavioral change requires broader ecosystem-level support beyond short term instructional intervention alone.

Theme 5: Divergence Between Conceptual Understanding and Environmental Attitude. Notably, of the six students with high conceptual understanding, only two also demonstrated strong environmental care attitudes, while three students with moderate conceptual gains showed comparatively strong pro environmental engagement. This divergence is consistent with the Responsible Environmental Behavior model (Hines et al., 1987), which holds that environmental knowledge is only one of several factors shaping pro-environmental attitudes and behavior; others include locus of control, personal responsibility, and emotional engagement. The audiovisual intervention appears to have been effective in building cognitive understanding but insufficient, within a four-session timeframe, to consistently cultivate the emotional engagement and sense of personal responsibility that underlie attitude change (Anderson & Krathwohl, 2001).

Data Triangulation

Triangulation across three data sources test scores, observation notes from two collaborating teachers, and in-depth interview narratives consistently converged for both research aims. For conceptual understanding, the significant quantitative gain (N-Gain = 0.79) was corroborated by both teachers' observations of increased student engagement throughout the sessions and by interview accounts describing the video's role in clarifying the fermentation process. For environmental care attitudes, independently recorded observations of spontaneous pro-environmental behavior across two separate sessions were corroborated by students' own interview accounts, while the qualitative data additionally surfaced the knowledge-action gap not captured by the quantitative measures alone illustrating the complementary value of the mixed-methods design in revealing a fuller, more nuanced picture of student learning than either method could provide independently.

Environmental Care Attitudes

The qualitative analysis of observations, interviews, and documentation yielded four interrelated patterns describing how students' environmental care attitudes developed during and after the audiovisual-based, local-wisdom-integrated intervention. These patterns emerged inductively from the data itself, consistent with the view that linking acquired concepts to local wisdom through project-based assignments produces more meaningful learning (Habibati et al., 2024).

Audiovisual media concretizing abstract concepts. One collaborating teacher observed that classroom engagement rose sharply once the videos began, with students who had previously seemed unfocused turning their full attention to the screen. Student MIR (high category) similarly noted that watching the video made the process far clearer than listening to a verbal explanation alone.

Local wisdom revealing the scientific value of familiar surroundings. A collaborating teacher observed that many students had never made tapai before, with one student surprising herself by realizing that cassava grown in the school garden something she saw daily held genuine scientific significance. Student DAF (high category) similarly reflected that he had previously known only that tapai tasted good, without understanding the role of yeast and fermentation, or why it needed to be tightly sealed.

Spontaneous pro-environmental behavior. Across two separate sessions, two different collaborating teachers independently recorded students voluntarily cleaning desks and disposing of waste without being asked behavior that had not been observed in earlier sessions prior to the intervention. Notably, WIN (low category), while still requiring guidance, began showing early positive changes, describing a new habit of keeping snack wrappers in his pocket until he could

dispose of them properly, rather than leaving them in his desk drawer.

Figure 3. Discussion between teacher and student

The knowledge-action gap. All six informants demonstrated accurate understanding of plastic's environmental harms; FAH (moderate category), for instance, correctly explained that plastic cannot decompose in soil and can contaminate water and harm aquatic life. Despite this understanding, plastic use remained common at home, with several students acknowledging that their families still disposed of plastic waste by burning it. DAH (moderate N-Gain category) admitted that although his mother still used plastic bags for shopping, he had begun encouraging her to use leaf-based or cloth alternatives instead. This gap suggests that behavioral change requires sustained time and support beyond the classroom alone."

This pattern is consistent with Gifford & Nilsson (2014) review of personal and social influences on pro-environmental behavior, which found that self-reported environmental concern frequently fails to translate into actual behavior due to a range of psychological barriers, helping explain why students' accurate understanding of plastic's environmental harms did not consistently carry over into household practices. A similar disjunction was reported by Abiolu (2018) among Nigerian youth, whose environmental behavior did not reflect their level of environmental knowledge, confirming that knowledge alone is not a sufficient driver of pro-environmental action. Wang & Yang (2026) further suggest that translating environmental concern into actual conservation behavior depends heavily on the mediating role of a person's sense of environmental responsibility, which is itself strengthened by adequate environmental knowledge a mechanism that may explain why students' spontaneous behaviors emerged at school, where the local wisdom-based project had cultivated both knowledge and a felt sense of responsibility, while similar reinforcement was still lacking at home.

Discussion

Improving Understanding of Science Concepts Through Audiovisual Media Based on Local Wisdom

The finding of an increase in the average score from 61.00 to 91.50 (N-Gain = 0.79, high category) indicates that audiovisual learning based on local wisdom was highly effective in this context. This figure exceeds the findings of Rizal et al. (2017), who reported an N-Gain of 0.46 for critical thinking skills using audiovisual media in a general context. The superiority of the present study lies in its contextualization with local wisdom already familiar to students' daily lives.

A similar pattern was reported by Sukmawati et al. (2022), who found that local wisdom based practicum videos improved prospective teachers' scientific literacy in an online learning context, indicating that video media grounded in familiar cultural practices supports scientific literacy development across educational levels. This is consistent with Jannah et al. (2025), who found that Canva assisted audiovisual media significantly improved elementary students' learning outcomes on climate-related topics, reinforcing that combining visual and auditory channels helps learners grasp abstract environmental science concepts. In the specific context of biotechnology, Mandalia et al. (2025) similarly reported that virtual fermentation based media improved the science process skills of ninth-grade students, paralleling the present finding that multimedia grounded in fermentation practices facilitates biotechnology concept mastery among junior high school students.

According to a study conducted by Prabawani et al. (2020) on education for sustainable development as a diffusion of innovation among secondary school students, junior high school students demonstrated relatively low environmental and social knowledge, yet showed a favorable disposition toward pro-environmental attitudes and behavior. Students' knowledge significantly influenced their environmentally-friendly attitudes and behaviors, with the social environment acting as a significant moderating factor. The study accordingly recommended that schools and related parties develop programs to strengthen students' environmental orientation and collective environmental awareness, particularly their ability to analyze and synthesize their surroundings.

The research by Ratnasari et al. (2024) on strengthening environmental care character through a contextual approach in science learning similarly found that a contextual learning approach positively influenced the strengthening of students' environmental care character by enabling them to connect classroom learning with practical, everyday application. This finding also aligns with the "Merdeka Belajar" (Freedom to Learn) policy initiated by Indonesia's Ministry of

Education, supporting the broader realization of national education goals.

From the perspective of Vygotsky (1978) theory of social constructivism, this success can be explained through two mechanisms. First, the existence of the zone of proximal development (ZPD). Students who initially only knew tape (fermented cassava) as a food were then guided through video and hands on practice to understand the concepts of fermentation, the role of yeast, anaerobic conditions, and environmental impacts, with the teacher acting as a scaffolder providing appropriate support when needed. Second, knowledge was constructed collaboratively; during the PjBL process, students worked in groups, discussed, and taught one another, consistent with the principle that learning is a social process (Toma et al., 2024).

From the perspective of cognitive information processing theory (Mayer, 2024), audiovisual media works by activating two processing channels visual and auditory simultaneously, thereby balancing cognitive load and facilitating information retention in long-term memory. This is reflected in student MIR's account that the video made the fermentation process clearer compared to listening to a lecture alone.

Cultivating Environmental Care Attitudes Through Contextual Learning

The finding of spontaneous behaviors, such as disposing of trash and cleaning tables without teacher instruction, is a strong indicator that environmental care attitudes were beginning to become internalized. Within the framework of the Theory of Planned Behavior (Ajzen, 1991), this behavioral change is driven by three factors: attitude toward the behavior, which became more positive once students directly observed the impact of plastic use and the benefits of natural materials; subjective norm, formed as students observed peers also prioritizing cleanliness; and perceived behavioral control, which increased as students gained concrete knowledge of natural wrapping alternatives.

This finding aligns with the classic meta-analysis by Hines et al. (1987), who examined 128 empirical studies and identified attitudes, personal responsibility, locus of control, knowledge of issues, and knowledge of action strategies as key predictors of responsible environmental behavior, lending broader empirical support to the multi-factor explanation offered by the Theory of Planned Behavior in the present study (Hines et al., 1987).

This finding is corroborated by Rahmadani et al. (2026), who reported that integrating local potential into project-based learning on biotechnology material significantly improved students' critical thinking and scientific attitudes, supporting the view that combining local wisdom with PjBL fosters both cognitive and affective learning outcomes. Similarly, Daningsih et al. (2026) found that a PjBL model built around a traditional fermented-food project engaged students in authentic, culturally rooted science practice, consistent with the present study's use of tapai cassava fermentation as a community-based biotechnology project.

Fitriah & Ita (2022) further demonstrated that instructional media containing local wisdom content improved problem-solving ability while simultaneously promoting an environmental awareness campaign among students, suggesting that local wisdom-based media can build conceptual skill and environmental consciousness at once. Wahyuni et al. (2026) likewise found project based learning effective in developing sustainability awareness and critical thinking among high school students, aligning with the present finding that project-based approaches nurture environmentally responsible attitudes alongside cognitive gains.

At the junior high school level specifically, Irhasyuarna & Fahmi (2026) showed that local wisdom-based science learning design improved students' higher-order thinking skills, reinforcing that contextualizing science instruction in local ecological practices benefits both conceptual and higher-order cognitive outcomes among the same age group as the present study. Sudirman (2025) offers further support, reporting that PjBL collaboration in a local-coagulant cheese-making practicum enhanced students' science process skills, indicating that hands-on fermentation-based projects rooted in local food practices are effective vehicles for developing procedural science competencies.

Similarly, Bøhlerengen & Wiium (2022) found that Norwegian youths' experience of the 5Cs of positive youth development particularly Character, followed by Caring and Competence was significantly associated with pro-environmental attitudes, behavior, and a sense of responsibility, whereas Connection showed no significant association in multivariate analysis. Their findings suggest that fostering positive youth development more broadly, not only increasing environmental knowledge, can strengthen young people's environmental contributions a pattern consistent with the present study's observation that internalized attitude change, rather than knowledge alone, underlies students' spontaneous pro-environmental behavior.

Qualitative data also show that local wisdom acts as a semiotic bridge between scientific knowledge and students' lived experiences. When students learn that banana leaves, which they have long seen merely as wrappers for tape (fermented cassava), contain polyphenolic compounds that function as natural antioxidants (Rini et al., 2018), what Anwar (2022) calls concept explication occurs revealing the science hidden

within traditional practices. This makes science feel less foreign and more a part of students' cultural identity. This pattern is consistent with Setiawan et al. (2017), who found that local wisdom-based science modules improved students' science literacy, and with Hikmawati et al. (2021), who reported that ethnoscience-integrated learning strengthens both critical thinking and local cultural concern among junior high school students, indicating that anchoring scientific content in familiar cultural practice is a recurring mechanism for deepening conceptual understanding across similar local-wisdom-based interventions. This aligns with Yuliana et al. (2023), who identified a clear need among junior high school students for locally grounded, ethnoscience-based instructional materials, further supporting the relevance of designing science media around students' own cultural surroundings.

However, the knowledge action gap that remains evident, particularly in the home environment, indicates that environmental education at school alone is insufficient, and that reinforcement from family and community is needed. This phenomenon has also been reported by Kühn & Bobeth (2022), who found that closing such gaps requires not only the formation of positive attitudes but also skill development and conditions that facilitate environmental action. This need for structured, place-based facilitation is echoed by Albar et al. (2025), who found that local wisdom-based environmental education management strengthens ecological awareness when it is deliberately organized around a community's own practices rather than left to incidental exposure, and by Amri et al. (2025), who showed that systematically integrating local ecological knowledge into biology instruction supports more durable pro-environmental orientations among students. The school has successfully planted the seeds of awareness; the next task is to nurture them so they grow into sustainable habits.

Integration of Quantitative and Qualitative Findings

The integration of data through triangulation shows strong consistency. The quantitative data demonstrate a significant improvement in conceptual understanding, while the qualitative data help explain why and how this improvement occurred: audiovisual media made abstract concepts concrete, local wisdom provided meaning and relevance, and project-based learning offered memorable hands-on experience. Similarly, regarding environmental care attitudes, although a knowledge-action gap remains, real behavioral change was evident within the school environment. Taken together, these findings indicate that both research objectives were substantively addressed.

Conclusion

Based on the results and discussion, two main conclusions can be drawn. First, audiovisual learning based on the local wisdom of cassava tape (fermented cassava) was effective in improving science concept understanding among the junior high school students involved in this study. The class average N-Gain score was 0.79, categorized as high, with all 10 students showing an increase in scores. This improvement is attributable to the ability of audiovisual media to concretize abstract concepts of fermentation and biotechnology, combined with a local wisdom context close to students' everyday lives. Second, audiovisual learning based on local wisdom proved capable of fostering environmental care attitudes among the students in this study, reflected in spontaneous behaviors such as cleaning tables, disposing of trash properly without teacher instruction, and initiatives to use natural materials. Although a gap between knowledge and action remained evident in the home environment, this learning successfully instilled ecological awareness that may serve as a foundation for long-term behavioral change. Given the limited sample size and single class scope of this study, further research involving larger and more diverse student populations across different school settings is recommended to confirm the generalizability of these findings and to examine strategies for narrowing the knowledge action gap beyond the classroom.

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Author Contributions

Conceptualization, methodology, N. and S.W.; validation, S.W. and A.H.; formal analysis, investigation, writing original draft preparation, visualization, N.; resources, N., S.W., and A.H.; data curation, S.W.; writing review and editing, A.H., R.R.F., and R.P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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