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Improving Primary Students' Learning Outcomes through Ethnoscience-Based Virtual Field Trips and Project-Based Learning

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Abstract: Instruction on local cultural topics in primary schools often relies on teacher explanation and textbooks, and this classroom action research examined whether an ethnoscience-based virtual field trip (VFT) integrated with project-based learning (PjBL) could improve fourth-grade learning outcomes in Natural and Social Sciences. Following the Kemmis spiral across two cycles, the study involved all 11 fourth-grade students of a public elementary school in Klaten, Central Java, used *jamu kunir asem* (a traditional turmeric-tamarind drink) as the cultural context, collected data through an observation checklist and a ten-item test, and analyzed class mean scores and the percentage of students reaching the learning objective attainment criterion of 75 descriptively. The class mean rose from 44.55 in the pre-cycle to 54.55 in Cycle I and 90.00 in Cycle II, and mastery increased from 9.09% to 18.18% and then to 100%, which met the success criteria of a class mean of at least 75 and mastery of at least 85%. These findings indicate that combining ethnoscience content, a VFT, and project work was associated with improved cognitive learning outcomes in a local heritage topic, and the single-class design without a comparison group calls for cautious generalization and further testing with larger and comparative samples.

Keywords: Learning Outcomes; Virtual Field Trip; Ethnoscience; Project-Based Learning; *Jamu Kunir Asem.*

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INTRODUCTION

Primary science education increasingly expects students to explain phenomena in their immediate surroundings using scientific concepts. In Indonesia, the Natural and Social Sciences subject (*Ilmu Pengetahuan Alam dan Sosial*, IPAS) brings science and social studies together so that students can examine natural and cultural environments within one learning experience. Hikmah et al. (2025) reviewed research published between 2014 and 2024 and reported that ethnoscience contributes to scientific, environmental, and cultural literacy by contextualizing science learning and fostering engagement, critical thinking, and cultural awareness. The same review indicated that ethnoscience has been applied widely at the high school level, which suggests that primary school classrooms deserve further empirical attention.

Observations in the participating fourth-grade classroom indicated that lessons on local culture were delivered mainly through teacher narration and textbooks, with minimal use of instructional technology. The pre-cycle assessment showed a class mean score of 44.55, and only one of 11 students (9.09%) reached the learning objective attainment criterion (*Kriteria Ketercapaian Tujuan Pembelajaran*, KKTP) of 75. These figures suggest that students had few opportunities to examine concrete cultural objects and practices that illustrate the concepts taught in class. Instructional approaches that bring local cultural phenomena into the classroom in a visual and experiential form therefore represent a relevant direction for improvement.

Ogawa (1995) described science education from a multiscience perspective in which indigenous knowledge and Western modern science are both recognized as ways of understanding nature. This perspective supports ethnoscience-based instruction, in which students examine cultural practices as sources of ideas that can be connected to school science concepts. Vygotsky (1978) proposed that higher psychological processes develop through social interaction and cultural tools, which provides a rationale for group discussion and collaborative projects in the classroom. Mayer (2024) explained that meaningful learning from words and graphics involves selecting relevant material, organizing it into coherent representations, and integrating it with prior knowledge, and this explanation informs the design of a virtual field trip (VFT) that presents visual and verbal information together.

Zulirfan et al. (2023) surveyed 480 high school students living around the Kuantan River and found that their ethnoscientific literacy regarding the *Pacu Jalur* tradition was unsatisfactory, which indicates that proximity to a cultural practice does not automatically yield the ability to explain it scientifically. Dewi et al. (2021) examined contextual collaborative learning based on ethnoscience and reported effects on students' scientific literacy in the dimensions of content, process, and attitude. At the primary level, Uslan et al. (2024) involved 78 elementary school students in Kupang, Indonesia, and found that a local knowledge-based module enhanced students' scientific literacy and thinking skills. Yuliana et al. (2021) examined the effect of ethnoscience-themed picture books

embedded within context-based learning on students' scientific literacy, which illustrates the variety of culturally themed media used in this line of work.

Traditional medicine preparation offers a culturally familiar context for science learning because it involves identifiable plants, preparation procedures, and community knowledge. Sumarni et al. (2022) investigated indigenous knowledge of medicinal plants and their preparation among traditional medicine sellers and makers in Semarang Regency, Central Java, and concluded that the scientific concepts in these preparations carry implications for indigenizing the science curriculum through an ethno-STEM approach. Lestari et al. (2024) introduced an inquiry ethnobotany model that draws on medicinal plants used in the community, and their pretest-posttest control group study showed a substantial difference in students' environmental literacy for this model compared with inquiry and discovery learning models. *Jamu kunir asem*, a Javanese drink prepared from turmeric and tamarind, fits this context and can serve as a concrete cultural artifact through which fourth-grade students observe materials, preparation steps, and community practices.

Makransky and Mayer (2022) compared a VFT experienced through a head-mounted display with a two-dimensional video among 102 middle school students and found that the head-mounted display group scored higher on presence, enjoyment, interest, and retention in immediate and delayed posttests. Koçoğlu and Haidari (2025) synthesized 33 studies involving 4,296 students and reported a large positive average effect of VFTs on academic achievement ($g = 1.36$), with significant variance within and between studies. Villena-Taranilla et al. (2022) reported in a meta-analysis of studies from kindergarten to grade 6 that virtual reality had a medium to large positive effect on learning gains, and immersive systems produced larger gains than semi-immersive and non-immersive systems. In a quasi-experimental study with seventh-grade social studies students, Alazmi and Alemtairy (2024) found that an immersive virtual reality field trip was associated with higher academic achievement and lower cognitive load than the control condition.

Project-based learning (PjBL) gives students a structure for applying concepts through the production of a tangible outcome, and the meta-analysis by Zhang and Ma (2023) reported a positive overall effect of PjBL on student learning effects. Hikmah et al. (2025) noted that project-based learning, inquiry, and STEAM are among the strategies through which ethnoscience has been applied, which indicates that PjBL is a frequent companion of ethnoscience instruction. Heliawati et al. (2022) tested ethnochemistry-based Adobe Flash learning media with 68 students and concluded that the media were effective for students' scientific literacy on secondary metabolites, which illustrates that digital media can carry indigenous knowledge into science lessons. Valverde-Berrocoso et al. (2022) reviewed 100 research articles and reported evidence of improved performance in educational practices enriched with information and communication technology, with mathematics and science receiving the greatest research interest.

Coban et al. (2022) synthesized experimental studies on immersive virtual reality and reported a small overall effect on learning outcomes ($g = 0.38$), with effect sizes that

differed by educational level, field of education, and type of comparison resource. Yu and Xu (2022) found in a separate meta-analysis that virtual reality technologies facilitated learning outcomes at different educational levels except the primary school level. Han (2021) examined elementary students' perceptions of immersive virtual field trips, which illustrates that evidence on younger learners has often addressed immersive formats and student perceptions. Limited research has examined how ethnoscience content and VFTs can be combined within primary school IPAS instruction that uses accessible digital tools such as Google Maps and Google Earth, and this combination remains underexplored in small classes where action research cycles can show how instructional refinements relate to changes in learning outcomes.

This study addresses an underexplored aspect of primary school IPAS instruction by examining an ethnoscience-based VFT featuring *jamu kunir asem* that is integrated with PjBL. This study extends previous research on ethnoscience and VFTs by examining their combined use through two cycles of classroom action research in a fourth-grade class. The contribution of this study lies in documenting how a culturally grounded VFT built on accessible digital tools and a hands-on preparation project relates to cycle-by-cycle changes in class mean scores and mastery rates. This study aims to examine whether and how this integrated approach is associated with improved fourth-grade learning outcomes in IPAS.

Guided by this aim, the study addresses three research questions. 1) How is an ethnoscience-based VFT featuring *jamu kunir asem*, integrated with PjBL, implemented across two classroom action research cycles in fourth-grade IPAS? 2) How do class mean scores and the percentage of students reaching the KKTP change from the pre-cycle to Cycle I and Cycle II? 3) Which instructional refinements between Cycle I and Cycle II are associated with the changes in learning outcomes and in observed student participation?

METHODS

Research Design

This study employed classroom action research (CAR) following the spiral model described by Kemmis et al. (2014), in which each cycle consists of planning, acting, observing, and reflecting. The action research was conducted across two cycles, and the reflection from Cycle I informed the revision of the instructional plan for Cycle II. The intervention integrated an ethnoscience-based VFT featuring *jamu kunir asem* with a PjBL model in an elementary IPAS unit on local heritage and cultural diversity. This design was selected because it allows the teacher and researchers to improve instruction and observe its effects on learning outcomes within the same classroom.

Figure 1 presents the two-cycle structure of the study so that readers can follow how each phase led to the next. The figure shows the pre-cycle diagnostic assessment, the planning, acting, observing, and reflecting phases of Cycle I, and the revised phases of Cycle II. It also shows the decision point at which the class mean and mastery rate were

compared with the predefined success criteria. This visual summary supports the transparency of the procedure and helps readers judge the replicability of the design.

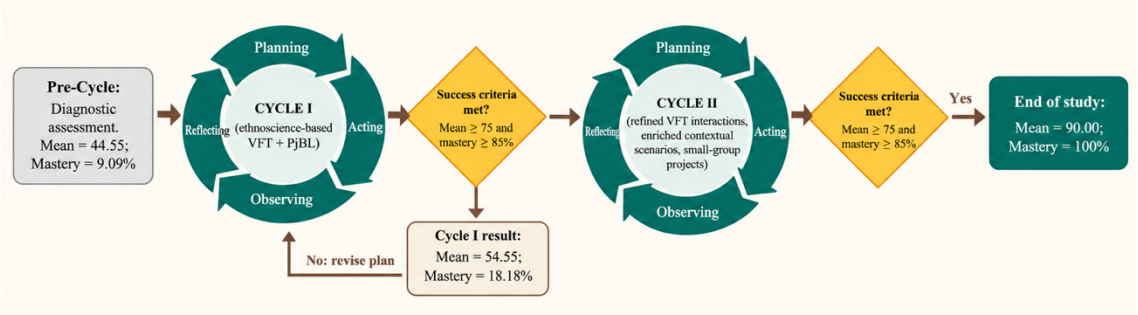


Figure 1. Two-Cycle Classroom Action Research Procedure of the Ethnoscience-Based VFT and PjBL Intervention

Figure 1 indicates that the study moved from a baseline assessment to a first cycle and then to a refined second cycle based on reflection. This sequence shows that the adjustments in Cycle II were derived from the reflection on Cycle I results.

Setting and Participants

The study was conducted at SDN 2 Sanggrahan (*Sekolah Dasar Negeri* 2 Sanggrahan, Sanggrahan 2 Public Elementary School), a public elementary school in Prambanan, Klaten, Central Java, Indonesia, during the second semester of the 2025/2026 academic year. The participants were all 11 fourth-grade students enrolled in the class, and no sampling procedure was applied because the entire class was involved. The action research was initiated to address low baseline performance in a local culture topic, with a focus on cognitive learning outcomes. The intervention was embedded in the IPAS module on local heritage and cultural diversity, which provided the curricular context for all activities.

Table 1 summarizes the research setting, participants, and instructional context. The study involved all 11 fourth-grade students at SDN 2 Sanggrahan, with jamu kunir asem as the cultural context for IPAS learning. The intervention combined an ethnoscience-based VFT using Google Maps and Google Earth with PjBL. The pre-cycle mean was 44.55, and one student (9.09%) reached the KKTP of 75.

Table 1. Research Setting, Participants, and Instructional Context

Aspect	Description
Research design	Classroom action research, Kemmis spiral, two cycles
Setting	SDN 2 Sanggrahan, Prambanan, Klaten, Central Java
Time	Second semester, 2025/2026 academic year
Participants	All 11 fourth-grade students (whole class)
Subject and unit	IPAS, unit on local heritage and cultural diversity
Cultural context	*Jamu kunir asem* (traditional turmeric-tamarind drink)
Digital tools	VFT with visual graphics, audio, text, and instructional video clips; Google Maps and Google Earth
Instructional model	PjBL combined with an ethnoscience-based VFT

Baseline condition	Class mean 44.55; 1 of 11 students (9.09%) reached KKTP of 75

Intervention Procedure

The intervention combined an ethnoscience-based VFT with PjBL so that students could explore *jamu kunir asem* digitally and then apply their understanding through a hands-on project. In the VFT component, students explored geographical locations, cultural sites, and community activities through visual and spatial representations in digital platforms such as Google Maps and Google Earth, and the multimedia materials combined graphics, audio, text, and instructional video clips. The project component involved observation tasks, group discussions, and the practical preparation of *jamu kunir asem* as an expression of cultural heritage, and small-group projects were emphasized in Cycle II. The instructional plan for Cycle II was refined by optimizing VFT interactions, enriching contextual learning scenarios that used *jamu kunir asem*, and engaging students in small-group projects to prepare the traditional drink.

Table 2 presents the planning, acting, observing, and reflecting phases in both cycles. The same data collection tools were used across cycles. Following reflection on the unmet success criteria in Cycle I, the Cycle II plan refined VFT interactions, enriched contextual scenarios, and emphasized small-group projects.

Table 2. Operationalization of the Action Research Phases in Cycle I and Cycle II

Phase	Cycle I	Cycle II
Planning	Designing IPAS lessons that integrate an ethnoscience-based VFT on *jamu kunir asem* with PjBL; preparing the observation checklist and the ten-item test	Revising the plan based on Cycle I reflection: optimizing VFT interactions, enriching contextual scenarios with *jamu kunir asem*, and planning small-group projects
Acting	Implementing digital exploration through VFT and project-oriented tasks	Implementing the refined VFT, enriched scenarios, and small-group projects to prepare the traditional drink
Observing	Monitoring intervention fidelity and engagement with the observation checklist; administering the end-of-cycle test	Monitoring intervention fidelity and engagement with the observation checklist; administering the end-of-cycle test
Reflecting	Comparing results (mean 54.55; mastery 18.18%) with the success criteria; identifying that thresholds were unreached	Comparing results (mean 90.00; mastery 100%) with the success criteria; confirming that both thresholds were reached

Data Collection Instruments

Data were collected through direct classroom observation, learning outcome tests, and field documentation of classroom activities. Observations were carried out during learning activities to monitor intervention fidelity and student engagement. Learning outcomes were evaluated with formal tests administered at the end of each cycle, and the pre-cycle diagnostic assessment provided the baseline. The test consisted of ten items

comprising four multiple-choice items, three matching tasks, and three short-answer questions, and the instruments were validated to measure cognitive mastery.

Table 3 presents the data sources, formats, purposes, and analyses. The study combined a ten-item learning outcome test with classroom observations and field documentation. Test scores were analyzed using class means and the percentage of students reaching the KKTP, while observation and documentation records supported descriptive reflection on classroom implementation and student engagement.

Table 3. Data Sources, Formats, Purposes, and Analysis

Data source	Format	Purpose	Analysis
Observation checklist	Structured checklist used during learning activities	Monitor intervention fidelity and student engagement	Descriptive; used in reflection
Learning outcome test	10 items: 4 multiple-choice, 3 matching, 3 short-answer; given at the end of each cycle	Measure cognitive mastery	Class mean; percentage of students reaching KKTP
Pre-cycle diagnostic assessment	Baseline assessment before the intervention	Establish initial performance	Class mean; percentage of students reaching KKTP
Field documentation	Records of classroom activities	Support observation and reflection	Descriptive

Data Analysis and Success Criteria

Data were analyzed descriptively using individual test scores, class mean scores, the percentage of students reaching mastery, and simple differences between phases. The learning objective attainment criterion (KKTP) was set at a score of 75 for individual mastery. The intervention was considered successful when the class mean reached at least 75 and at least 85% of students achieved individual mastery by the end of Cycle II. The results of each cycle served as the basis for reflection and instructional refinement before the next cycle.

RESULTS

Baseline Learning Outcomes (Pre-Cycle)

The pre-cycle diagnostic assessment showed low performance in the local culture topic, with a class mean score of 44.55. Only one of the 11 students (9.09%) reached the KKTP of 75, so ten students remained below the mastery threshold. The class mean was 30.45 points below the KKTP, and the mastery rate was 75.91 percentage points below the 85% success criterion. These conditions confirmed the need for an instructional intervention and established the reference point for evaluating the cycles.

Learning Outcomes in Cycle I

Implementation of Cycle I raised the class mean score to 54.55, which is an increase of 10.00 points from the pre-cycle. Two of the 11 students (18.18%) reached the KKTP, which is one student more than in the pre-cycle. The class mean remained 20.45 points below the KKTP, and the mastery rate remained 66.82 percentage points below the 85% criterion. These results indicated initial improvement and showed that the success criteria had not been met, so the instructional plan was revised for Cycle II.

Learning Outcomes in Cycle II

The Cycle II plan refined VFT interactions, enriched contextual scenarios that used *jamu kunir asem*, and engaged students in small-group projects to prepare the traditional drink. After these refinements, the class mean score reached 90.00, which is 35.45 points higher than in Cycle I and 15.00 points above the KKTP. All 11 students (100%) reached the KKTP, which exceeded the 85% mastery criterion by 15 percentage points. Both success criteria were therefore met at the end of Cycle II, and the study ended after two cycles.

Summary of Learning Outcomes across Phases

Table 4 summarizes the assessment results across the pre-cycle, Cycle I, and Cycle II, including class mean scores, mastery rates, differences from the success criteria, and success status. The class mean increased from 44.55 to 54.55 and then to 90.00, while mastery increased from 9.09% to 18.18% and then to 100%.

Table 4. Summary of Student Assessment Results across the Pre-Cycle, Cycle I, and Cycle II

Indicator	Pre-Cycle	Cycle I	Cycle II
Class mean score	44.55	54.55	90.00
Mean gain from previous phase (points)	n/a	+10.00	+35.45
Students reaching KKTP (n of 11)	1	2	11
Students reaching KKTP (%)	9.09	18.18	100.00
Mastery gain from previous phase (percentage points)	n/a	+9.09	+81.82
Difference from KKTP of 75 (points)	-30.45	-20.45	+15.00
Difference from 85% mastery criterion (percentage points)	-75.91	-66.82	+15.00
Success criteria status	Not met	Not met	Met

The class mean increased by 10.00 points from the pre-cycle to Cycle I and by 35.45 points from Cycle I to Cycle II. The mastery rate increased by 9.09 percentage points in Cycle I and by 81.82 percentage points in Cycle II. Both success criteria, a class mean of at least 75 and a mastery rate of at least 85%, were met only in Cycle II.

Visual Progression of Scores and Mastery

Figure 2 compares the class mean scores across the pre-cycle, Cycle I, and Cycle II, with a reference line at the KKTP of 75.

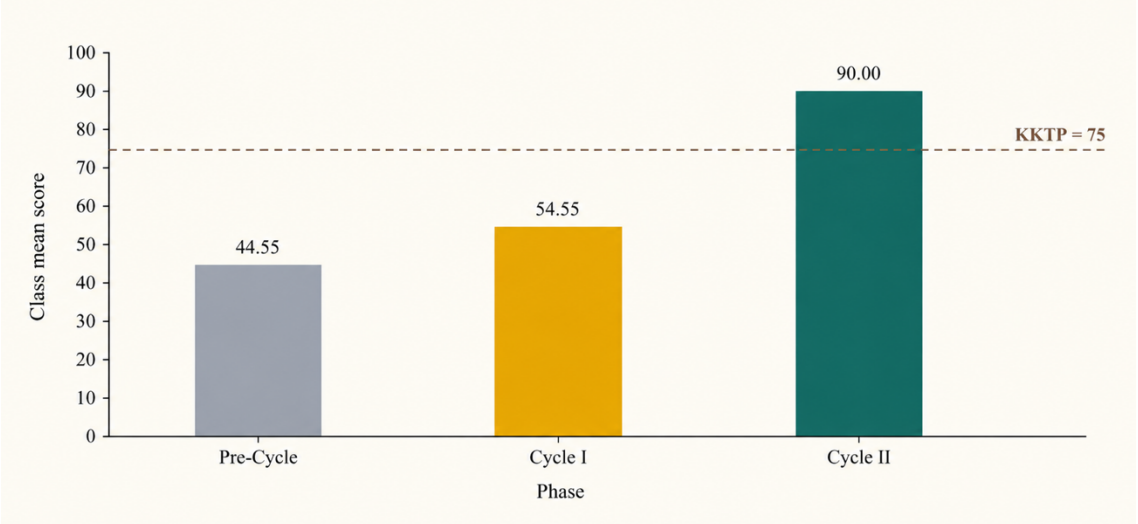


Figure 2. Class Mean Learning Outcome Scores across the Pre-Cycle, Cycle I, and Cycle II

Figure 2 shows that the class mean increased from 44.55 in the pre-cycle to 54.55 in Cycle I and 90.00 in Cycle II. The mean remained below the KKTP of 75 in the first two phases and exceeded it by 15.00 points in Cycle II. The largest increase occurred between Cycle I and Cycle II, with a gain of 35.45 points.

Figure 3 compares the percentages of students reaching the KKTP across the three phases, with the 85% mastery criterion shown as a reference line.

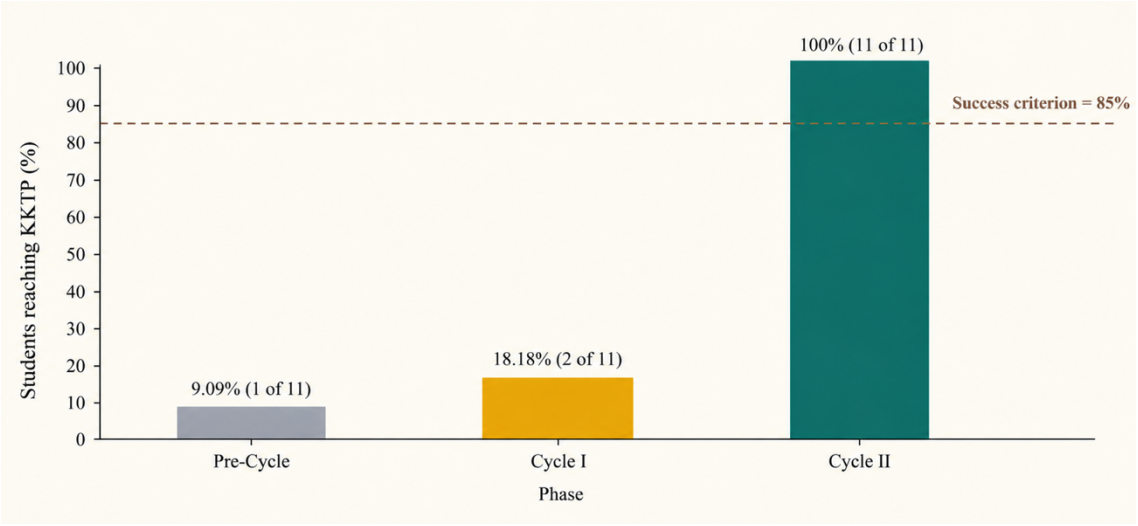


Figure 3. Percentage of Students Achieving the Learning Objective Attainment Criterion (KKTP)

Figure 3 shows that the mastery rate increased from 9.09% in the pre-cycle to 18.18% in Cycle I and 100% in Cycle II. These percentages correspond to one, two, and all 11 students, respectively. The mastery rate remained below the 85% criterion in Cycle I and exceeded it by 15 percentage points in Cycle II.

Instructional Refinements and Student Participation

Table 5 summarizes the instructional refinements introduced in Cycle II and the corresponding classroom observations. The refinements involved VFT interactions, contextual learning scenarios, and small-group projects.

Table 5. Instructional Refinements in Cycle II and Observed Implications

Component	Refinement in Cycle II	Observed implication
VFT interaction	Optimized interactions during the digital exploration of *jamu kunir asem*	Active student participation during learning sessions
Contextual scenarios	Enriched learning scenarios using *jamu kunir asem* as the local cultural context	Learning content connected to students' daily environment
Project work	Small-group projects to prepare the traditional drink	Collaboration through observation tasks, group discussions, and practical preparation as an expression of cultural heritage
Learning outcomes	End-of-cycle test after the refinements	Class mean 90.00; mastery 100%

Three components were refined simultaneously in Cycle II: VFT interactions, contextual learning scenarios, and small-group projects. Learning outcomes improved after these refinements were implemented. Because the components were introduced together, their individual contributions cannot be isolated. The observations indicate participation, contextual relevance, and collaboration as processes associated with the improvement.

Overall, the results show a consistent upward trend in cognitive learning outcomes across the implementation phases. The activities also encouraged collaborative participation through observation tasks, group discussions, and the practical preparation of *jamu kunir asem* as an expression of cultural heritage. These observations were recorded descriptively and were not quantified, so they are interpreted as supporting context for the test results. Together, the findings answer the three research questions by describing the implementation, the magnitude of change, and the refinements associated with the improvement.

DISCUSSION

Improvement in Learning Outcomes across Cycles

The class mean increased from 44.55 in the pre-cycle to 90.00 in Cycle II, and the mastery rate increased from 9.09% to 100%, with the largest change occurring after the Cycle II refinements. This pattern may be associated with the combination of visual exploration, a culturally familiar context, and small-group project work, which together gave students repeated opportunities to engage with the same concepts in different forms. Koçoğlu and Haidari (2025) reported a large positive average effect of VFTs on academic achievement (g = 1.36) across 33 studies, and the direction of change in the present class is consistent

with that evidence. Villena-Taranilla et al. (2022) reported a medium to large positive effect of virtual reality on learning gains in kindergarten to grade 6, which offers a further reference for interpreting the magnitude observed here.

Cromley et al. (2023) reported benefits across the board in a meta-analysis of STEM learning using virtual reality, and other syntheses have reported different patterns that are relevant to interpreting the present gains. Coban et al. (2022) reported a small overall effect of immersive virtual reality ($g = 0.38$), and Yu and Xu (2022) found that virtual reality facilitated learning outcomes at several educational levels except the primary school level. Hamilton et al. (2021) added that most studies on immersive virtual reality found an advantage over less immersive methods while a smaller number found no significant difference, and that the methods used to evaluate learning outcomes were often inadequate. The findings of the present study should therefore be interpreted in relation to differences in media type, educational level, and evaluation design, and the gains observed in one class without a comparison group support further testing before any general effect is claimed.

Role of the Ethnoscience Context

The use of *jamu kunir asem* as a cultural context appears to have given students a familiar object through which abstract IPAS concepts could be discussed, and this explanation is consistent with the improvement observed after the contextual scenarios were enriched in Cycle II. Sumarni et al. (2022) showed that traditional medicine preparations contain scientific concepts that can be incorporated into science teaching through an ethno-STEM approach, which supports the choice of this drink as a learning context. Lestari et al. (2024) found that an inquiry ethnobotany model centered on community medicinal plants was associated with a substantial difference in students' environmental literacy, which indicates that medicinal plant practices can function as learning contexts for different outcomes. Dewi et al. (2021) reported effects of ethnoscience-based contextual collaborative learning on scientific literacy, so the present results align with a broader set of findings on the value of local cultural contexts.

Zulirfan et al. (2023) reported unsatisfactory ethnoscientific literacy among 480 high school students living around the Kuantan River, which suggests that cultural familiarity needs to be supported by structured instruction to be translated into scientific explanation. This observation helps interpret the present findings because the VFT and project tasks provided structured opportunities to connect the drink with IPAS concepts. At the primary level, Uslan et al. (2024) reported enhanced scientific literacy and thinking skills among 78 elementary students who used a local knowledge-based module, which supports the relevance of local contexts for young learners. The implication is that teachers can select a locally familiar product, link it to specific learning objectives, and design guided activities that make the scientific ideas explicit.

Project-Based Learning and Collaboration

The Cycle II refinements included small-group projects to prepare *jamu kunir asem*, and observations recorded collaboration through observation tasks, group discussions, and

practical preparation. Zhang and Ma (2023) reported a positive overall effect of PjBL on student learning effects in a meta-analysis, which is consistent with the improvement observed after project work was emphasized. Hikmah et al. (2025) noted that project-based learning is among the main strategies through which ethnoscience has been applied, which supports the logic of combining PjBL with a cultural product. Vygotsky (1978) emphasized the role of social interaction in the development of higher psychological processes, which offers a theoretical explanation for why group discussion and shared preparation tasks may have supported conceptual understanding.

Evidence on differences among learners suggests that gains from project-based and ethnoscience-based instruction may vary within a class. Izzah et al. (2023) reported that, after Ethno-STEM learning, science concept mastery was in the moderate category for the upper and middle achievement groups and in a low category for the lower achievement group. In the present study all 11 students reached the KKTP in Cycle II, and individual scores were not analyzed by achievement level, so the distribution of gains within the class cannot be described. These patterns imply that teachers can form small groups with mixed achievement levels and monitor individual progress during projects, and future studies can test these options directly.

Digital Media and Cognitive Processing

The VFT used accessible digital platforms such as Google Maps and Google Earth together with graphics, audio, text, and video, and this combination may have helped students form coherent verbal and visual representations of the drink and its cultural setting. Mayer (2024) described dual channels, limited capacity, and active processing as core ideas of learning from words and graphics, which provide a theoretical account for this interpretation. Makransky and Petersen (2021) proposed that interest, motivation, self-efficacy, embodiment, cognitive load, and self-regulation influence learning in immersive environments, and the observed participation in the present class is compatible with the roles of interest and motivation although these constructs were not measured. Makransky and Mayer (2022) found that enjoyment mediated the pathway from instructional media to immediate posttest scores and interest mediated the pathway to delayed posttest scores in a VFT, which offers a comparison for the affective processes that may have operated in this class although the present VFT used non-immersive tools.

Studies on immersive media report related patterns: Alazmi and Alemtairy (2024) reported higher achievement and lower cognitive load for seventh-grade students after an immersive virtual reality field trip, and Chen and Chu (2024) reported improved science learning achievements and sense of presence with a VR-assisted inquiry-based approach compared with an e-book-assisted approach. Valverde-Berrocoso et al. (2022) indicated that the effects of digital technologies depend on the fit between the approach to learning and the technology, which supports the interpretation that the pedagogical design of the VFT and project tasks was central to the observed results. Heliawati et al. (2022) reported that ethnochemistry-based multimedia was effective for scientific literacy, which shows that digital media can carry indigenous knowledge into science lessons in different learning contexts. The practical implication is that schools with limited resources can use

freely available mapping platforms and short multimedia materials as a starting point for VFTs, and future studies can measure engagement and cognitive load to test the proposed mechanisms.

Practical and Curriculum Implications

The findings suggest that a locally grounded VFT combined with project work can serve as a feasible instructional option for IPAS lessons on cultural diversity and local wisdom in small primary classes. This suggestion is consistent with Rosyidah et al. (2025), who reviewed the integration of local wisdom and STEM in science education in relation to the fourth Sustainable Development Goal on quality education, and with Khusniati et al. (2023), who examined indigenous science constructs in the local wisdom of Troso woven fabric through ethnoscience and ethnoecology. Nisa' et al. (2024) surveyed 72 students who studied through ethnoscience-integrated worksheets and reported that the worksheet component affected students' responses more strongly than science learning and ethnoscience, which points to the value of well-designed learning materials. For practice, teachers can adapt the present procedure by selecting a local cultural product, preparing a short digital exploration, and planning a small-group project with observation tasks that link the product to IPAS learning objectives.

Grosser et al. (2023) examined the potential of virtual reality for conveying hydrological engineering content through virtual field trips in field laboratories, which shows that VFT designs are being developed for diverse content and levels, and the present study adds a primary school example grounded in local culture. Lestari et al. (2024) linked community medicinal plants with environmental literacy, which suggests that the cultural context used here may also support environmental and cultural aims in addition to cognitive outcomes, although these aims were not measured in the present study. Curriculum designers and school leaders can interpret these findings as support for allocating time and digital resources to local-context lessons, provided that learning objectives and assessment criteria such as the KKTP are specified in advance. Such planning can be considered where basic internet access and a shared display device are available, and it can be strengthened through teacher training on designing guided VFT tasks.

Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. The design involved one class of 11 students without a control group, so the observed gains cannot be separated from maturation, familiarity with the test format, or the teaching experience accumulated across cycles. The data were analyzed descriptively without inferential tests, and the observation records were not quantified, so statements about participation and collaboration remain descriptive. The refinements in Cycle II were introduced together, and the contribution of each component, as well as the roles of affective and psychomotor processes, could not be isolated.

Future studies are encouraged to use larger samples from multiple classes and to include comparison groups so that effects can be estimated with inferential statistics.

Delayed posttests would help examine retention, and instruments that measure affective and psychomotor outcomes would extend the evidence beyond cognitive scores. Analyses by achievement level, as illustrated by Izzah et al. (2023), would clarify whether gains are distributed evenly within a class. Studies that vary one component at a time, such as the VFT interactions, the contextual scenarios, and the project work, would clarify the role of each component, and replications with other cultural products and grade levels would test the transferability of the approach.

CONCLUSION

This classroom action research examined an ethnoscience-based VFT featuring *jamu kunir asem* that was integrated with PjBL in fourth-grade IPAS. Across two cycles, the class mean score increased from 44.55 in the pre-cycle to 54.55 in Cycle I and 90.00 in Cycle II, and the mastery rate increased from 9.09% to 18.18% and then to 100%. The Cycle II refinements, which comprised optimized VFT interactions, enriched contextual scenarios, and small-group projects, were associated with the largest gain and with observed collaborative participation. These results indicate that the integrated approach was associated with improved cognitive learning outcomes in a local heritage topic in this class.

Teachers and schools may consider adapting this procedure by selecting a locally familiar cultural product, using accessible digital platforms for exploration, and adding guided group projects linked to explicit learning objectives. The findings should be interpreted with caution because they come from one class of 11 students without a comparison group and were analyzed descriptively. Future research with larger and comparative samples, delayed posttests, and measures of affective and psychomotor outcomes would strengthen the evidence. Such studies would also clarify which components of the integrated approach contribute most to learning outcomes in different cultural and curricular contexts.

AI Use Statement

The authors used AI tools, if applicable, solely for language editing and proofreading. All authors take full responsibility for the content of this manuscript.

Author Contributions

MMIS: contributed to conceptualization, methodology, data analysis, and manuscript drafting. K: contributed to classroom implementation, data collection, and learning activity coordination. NA; NDP; NAA; PGP; RAW; & RDA: contributed to data collection, classroom observations, analysis of learning outcomes, and manuscript review. All authors reviewed and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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