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Development and Validation of Contextualized Lessons in Science, Technology, and Society (STS): Impacts on Students' Conceptual Understanding, Science Process Skills, and Attitudes toward Science

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Abstract

Contextual teaching and learning (CTL) has been widely recognized for its effectiveness in enhancing student learning by connecting academic content to real-world contexts. This study employed a descriptive-developmental and true-experimental research design to develop and evaluate the effectiveness of contextualized lessons in Science, Technology, and Society (STS) for first-year undergraduate students. 40 students enrolled in the Bachelor of Science in Elementary Education program at a public university in Masbate, Philippines, were randomly assigned to experimental and control groups, with each group consisting of 20 participants. The experimental group received the contextualized lessons, while the control group followed traditional teaching methods. Pretest and posttest assessments measured the students' conceptual understanding, science process skills, and attitudes toward science. Results showed that the developed contextualized learning materials were excellent (4.68) as rated by the jurors. Inter-rater reliability analysis ($\kappa = 0.61$) demonstrated satisfactory agreement among evaluators. The paired t-test results revealed significant differences between pretest and posttest scores in the experimental group, with large effect sizes ($d > 1.8$) across all five lessons. Posttest scores in the experimental group were significantly higher than those in the control group, with substantial improvements in conceptual understanding ($d = 2.75$; $p < 0.001$), science process skills ($d = 2.16$; $p < 0.001$), and attitudes toward science ($d = 2.52$; $p < 0.001$). These findings indicate that the contextualized lessons were highly effective in enhancing student learning outcomes, even among non-science majors.

Keywords: Contextualization, Contextual Teaching and Learning (CTL), Science, Technology, and Society (STS), Conceptual Understanding, Higher Education.

Introduction

The effectiveness of learning hinges significantly on the alignment of instructional materials and teaching methods with the specific needs and contexts of students. Research shows that contextualized learning approaches, which incorporate students' local realities and experiences, can significantly improve learning outcomes (Rivet & Krajcik, 2008; Johnson, 2002). However, science educators often face challenges in designing tailored instructional approaches due to constraints such as large class sizes, classroom management difficulties, and limited instructional resources (Moluayonge & Park, 2017). These barriers limit the ability of teachers to fully engage students in meaningful science learning experiences (Hodson, 2003).

Contextualized instruction has emerged as a promising strategy to enhance the relevance and engagement of science education by incorporating local contexts, experiences, and cultures into the curriculum (Bello et al., 2023; Nashon & Anderson, 2013; Silseth & Erstad, 2018). It is particularly

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effective in the Philippines, where diverse cultural and geographical factors play a significant role in shaping students' learning experiences (Picardal & Sanchez, 2022). Studies suggest that when students see the connection between science concepts and their own lives, they are more likely to develop a deeper understanding of the subject (Johnson, 2002; Rathburn, 2015).

The dynamic nature of science education, influenced by social, cultural, and political changes, requires continuous curriculum adaptation (Kozulin, 2003). The Philippine Special Science Program aims to widen access to quality education in science and mathematics, emphasizing the adaptation of national standards to local contexts (Camara, 2018). Despite these efforts, traditional teaching methods remain prevalent, often characterized by rote memorization and fact-checking, which hinder the development of critical thinking and real-world application skills (Verma & Hbashi, 2005; Gagné et al., 2005).

This study explores the impact of contextualized Science, Technology, and Society (STS) lessons on students' conceptual understanding, science process skills, and attitudes toward science. Recent studies affirm that contextualized teaching materials can significantly improve students' science literacy and engagement (Bello et al., 2023; Abebe et al., 2023). For instance, Picardal and Sanchez (2022) conducted a meta-analysis that demonstrated the effectiveness of contextualization in enhancing science literacy among Filipino students. Their findings underscore the importance of adapting lessons to students' local realities to foster improved performance and science process skills.

Moreover, contextualization has been shown to enrich students' overall learning experiences by bridging the gap between theoretical concepts and real-world applications (Navalta, 2021). Research by Antonio and Prudente (2024) and Gillies (2023) suggests that inquiry-based and collaborative approaches, when integrated with contextual learning, further enhance students' critical thinking and higher-order thinking skills. These approaches support a shift toward more meaningful and engaging learning experiences in science education.

This study aims to contribute to the growing body of research on contextualized teaching by investigating its impact on science education outcomes in higher education in the Philippines. It highlights the need for a shift toward more contextual and authentic approaches in science instruction, aligning with global educational goals such as Sustainable Development Goal 4, which focuses on ensuring quality education for all (Albert et al., 2023; Onwu et al., 2011). Ultimately, this research advocates for a transformation in the way science is taught, making it more relevant, engaging, and applicable to students' lives.

Research Questions

This study aims to develop a contextualized lessons within the framework of Contextual Teaching and Learning (CTL) in Science, Technology and Society (STS) course with the desire to enhance conceptual understanding, science process skills, and attitudes of non-science major undergraduate students. Specifically, this study is guided by following questions:

1. What are the jurors' assessments of the contextualized lessons in terms of lesson objectives, contextualized activities, and assessment?
2. How effective are the contextualized lessons in enhancing students' conceptual understanding, science process skills, and attitudes toward learning science?
3. Is there a significant difference between the mean pretest score and mean posttest score of students in the control group and experimental group in terms of conceptual understanding, science process skills, and attitudes toward science?

Method

Research Design

A descriptive-developmental approach was employed in developing lessons and evaluating its effectiveness. This research design is valuable in developing learning materials and evaluating their validity and effectiveness (Creswell & Creswell, 2017). According to Richey and Klein (2005, 2014), this design emphasizes creating knowledge from instructional design and development practices, allowing researchers to generate insights that inform the design of educational materials. The design involves iterative cycles of description, analysis, and refinement, making it ideal for producing effective, user-centered learning resources. By capturing detailed information on how learning materials are used and how they impact learners over time, researchers can make data-driven decisions to improve the materials' effectiveness, ensuring they meet educational goals and adapt to learners' evolving needs (Blessing et al.,1998).

Additionally, the researchers also utilized a true-experimental pre-test/post-test control group design in the try-out of the developed lessons. In this design, participants are randomly assigned to either an experimental group that receives the intervention or a control group that does not. Both groups are tested on the outcome variable before (pre-test) and after (post-test) the intervention (Dugard & Todman, 1995). The systematic description of the research design is presented below:

Experimental Group	M_1	O_1	X	O_2
Control Group	M_2	O_1	C	O_2

Where:
M1: The subjects of the treatment group were randomized
M2: The subjects of the control group were randomized
O1: Pretest
X: With intervention (contextualized lessons)
C: Without intervention (conventional learning materials)
O_2: Posttest.

Population and Sample/ Study Group/ Participants

There were 40 first-year undergraduate students enrolled in the Bachelor of Science in Elementary Education (BEED) program at a public university in Masbate, Philippines that were recruited to participate in the study. Random assignment was employed to allocate participants into either the experimental or control group, with 20 participants in each group. It was carried out by assigning numbers to all participants and using a computerized randomization tool to assign them to either group. This approach aimed to reduce selection bias by ensuring that each participant had an equal chance of being placed in either the control or experimental group, thereby increasing the likelihood of comparable baseline characteristics across both groups.

In the control group, there were 13 (65%) female and 7 (35%) male participants, with a median age of 19 years (age range: 18-21 years). The experimental group included 16 (80%) female and 4 (20%) male participants, with a median age of 19 years (age range: 18-20 years). Prior to the intervention, both groups were assessed for comparability in terms of gender distribution, age, and achievement to ensure that they were similar at baseline. The demographic characteristics as well as the pretest revealed no significant differences between the groups, supporting the assumption of baseline comparability.

To further validate the random assignment, assignments were double-checked by a research assistant to confirm accurate placement of participants into their respective groups, thereby maintaining the integrity of the randomization process.

Data Collection Tools

This study employed various research instruments to assess the validity of the developed lessons, as well as to measure their effectiveness. The Validity and Acceptability of Lesson Scale (VALES) was used by the jurors to evaluate the validity and suitability of the learning materials before the try-out stage. VALES was adapted and slightly modified from the study of Cajurao (2019) to suit the study needs. To measure students' achievement, the Conceptual Understanding Test in Science, Technology, and Society (CUTESTS), a researcher-made test, was utilized. The achievement test comprised 50 multiple-choice items and underwent face validation and pilot testing to ensure reliability and consistency. The pilot test indicated that the test was reliable and consistent, with a Kuder-Richardson 20 coefficient of 0.72, making it suitable for the study. The Basic Science Process Skills Test (BSPST) was used to evaluate students' ability to perform fundamental science process skills, including observing, measuring, classifying, predicting, communicating, controlling variables, hypothesizing, experimenting, and interpreting data. Additionally, the Attitudes Toward Learning Science Scale (ATLESS) was employed to assess students' perceptions of science. Both the BSPST and ATLESS were adapted from the study of Zeidan and Jayosi (2015).

Development of Contextualized Lessons in Science, Technology, and Society

The selection and development of lessons for the Science, Technology, and Society (STS) course were guided by a robust instructional design framework that incorporated key factors: (1) the course description, (2) students' geographic and cultural contexts, and (3) the availability of resources within their communities. The chosen lessons were designed to be resource-efficient, minimizing the reliance on extensive materials such as internet access and advanced technological devices, thereby ensuring accessibility and feasibility for students regardless of their location or socioeconomic status.

The contextualization of these lessons was grounded in the principles of Contextual Teaching and Learning (CTL) (Johnson, 2002) and implemented using the REACT Strategy (Crawford, 2001), which emphasizes Relating, Experiencing, Applying, Cooperating, and Transferring. By connecting learning content to real-world situations relevant to students' lives, the lessons aimed to enhance engagement, motivation, and comprehension. For example, the "**Relating**" component ensured that lessons connected directly to students' prior knowledge and personal experiences, making the content more relatable. "**Experiencing**" involved hands-on, inquiry-based activities that allowed students to explore concepts actively. Through "**Applying**," students used what they learned in practical, real-world contexts. "**Cooperating**" facilitated collaborative learning experiences, while "**Transferring**" encouraged students to apply their knowledge and skills to new situations beyond the classroom.

The ADDIE Model (Gagné et al., 2005) was used to systematically design and refine the contextualized lessons, ensuring they met both educational goals and the needs of the learners. During the **Analysis** phase, the specific needs of the STS course and contextualized activities to be integrated were carefully identified, including an understanding of the students' contexts and available resources. The **Design** phase involved planning the instructional strategies using the REACT components, creating detailed blueprints that aligned learning objectives with contextualized activities. In the **Development** phase, the actual lessons and materials were created, incorporating culturally relevant examples and community-based resources to enhance the lessons' applicability and relatability. The **Implementation** phase, which is also the try-out stage, involved delivering the lessons for a period of 1 month, which were structured to ensure they could be effectively executed in varied learning environments, including those with limited access to technology. Finally, the **Evaluation** phase included the conduct of pretest and posttest to determine the effectiveness of lessons in enhancing students' conceptual understanding, science process skills and attitudes toward science.

Table 1 summarizes the five contextualized lessons developed for the STS course. These lessons were selected for their flexibility and relevance, aligning with the mandate from the Higher Education sector to ensure that General Education (GE) Courses are responsive to contemporary global and local events. By embedding contextualized activities and materials into the lessons, the content was tailored to reflect the realities of students' daily lives, making the lessons more relatable and meaningful (Bello et al., 2023; Nashon & Anderson, 2013). The developed lessons underwent rigorous face and content validation by three experts, consisting of experienced higher education science teachers with specialized knowledge in teaching STS. The jurors, selected based on criteria including advanced academic qualifications and extensive teaching experience, provided critical feedback that ensured the lessons met high standards of academic rigor and pedagogical soundness.

Data Collection Method

Phase 1 (Development Stage). The researchers prepared and developed the contextualized learning materials following the ADDIE Model of instructional development within the framework of CTL and the REACT strategy. These materials were subjected to validation by five science experts, and based on their comments and suggestions, revisions were made accordingly. Subsequently, a test was developed to measure students' conceptual understanding, which underwent pilot testing with 35 Grade 12 Senior High School students in a public secondary school in Mandaon, Masbate.

Phase 2 (Try-out Stage). After obtaining permission from the dean of the College of Education, the revised lessons were implemented using a true experimental setup. Pretests and posttests were administered to assess students' conceptual understanding, science process skills, and attitudes toward learning science for both groups.

The collected data were tabulated using MS Excel and analyzed with Jamovi, a free statistical software. After analysis, the collected data concerning participants' personal sensitive

Table 1: Summary of the learning objectives, STS topics covered, contextualized instructional activities and assessment techniques integrated in the developed lessons.

Lessons	*Learning Objectives*	*Contextualized Activities*	*Assessment Techniques*
The Good Life	1. Define the concept of the Good Life. 2. Discuss Aristotle's concepts of Eudaimonia and arête. 3. Examine contemporary issues and propose innovative and creative solutions guided by ethical standards to achieve a Good Life.	• Identification of factors involved in having a good life. (*Identifying whether the factors presented in the activity is true to them personally or not.)* • Case study about the consumption of sugar. (Finding out how human consume food in the extent of their satisfaction or until they feel good) • Interview of the meaning of good life with different age groups. *(Understand good life in others perspective)*	• Conceptual Analysis Essay • Case Study Analysis Report • Group Discussion and Peer Interviews

Lessons	*Learning Objectives*	*Contextualized Activities*	*Assessment Techniques*
Why the Future Does Not Need Us	1. Identify William Nelson Joy's arguments regarding why the future may not need us. 2. Evaluate contemporary human experiences with science and technology.	• Picture analysis. *(Analyzing how technology is utilized in modern society)* • Identification of a convenient scenario in the present community setting. *(Choosing most preferable choices considering current situation of the community)* • Metacognitive reading report. *(Giving personal view in an article about why the future might not need us)*	• Picture Analysis Essay • Scenario Analysis Exercise Report • Metacognitive Reading Report
Biodiversity and a Healthy Society	1. Identify the importance of biodiversity as a source of various biological resources. 2. Discuss the adverse effects of resource depletion on society and the measures to mitigate these effects.	• Making a list of components of biodiversity present in the community and identifying its benefits. (Awareness of species richness in their own community) • Quiz. (Awareness on existing policies in the community that protect and preserve biodiversity) • Metacognitive reading report. (Giving insights about the significance of biodiversity richness in the community)	• List and Benefits Activity Report • Multiple-Choice Questions • Metacognitive Reading Report
Genetically Modified Organism (GMO) and Gene Therapy	1. Identify the uses and effects of GMOs and gene therapy on society, particularly in the context of health and the economy. 2. Discuss the moral and bioethical questions surrounding genetic engineering.	• Making list of familiar applications of GMO and gene therapy and the problems concerning its application. (Awareness in the existence of GMOs in the society) • Quiz. (Analyzing the possible effects of GMOs in the society)	• Application List and Problem Analysis Report • Ethical Debate/ Discussion • Multiple-Choice Questions
Climate Change and Environmental Awarenes	1. Explain climate change and its adverse effects on the environment and society.	• Picture analysis. (Giving insights on how natural disaster affects the community)	• Picture Analysis Report • Interview Results

Lessons	*Learning Objectives*	*Contextualized Activities*	*Assessment Techniques*
Climate Change and Environmental Awareness	1. Explain climate change and its adverse effects on the environment and society. 2. Promote the significance of disaster preparedness in the face of natural disasters. 3. Discuss the value of conserving and preserving the environment to mitigate the impacts of climate change on society.	• Picture analysis. *(Giving insights on how natural disaster affects the community)* • Interview someone about the changes of the Philippine season occurrence and how it impacts the society. *(Awareness on how climate change alters human activities in different aspects of the society)* • Compute their own ecological Footprint. *(Awareness about how they personally contribute to climate change)*	• Picture Analysis Report • Interview Results • Ecological Footprint Calculation Report

information, were discarded in accordance with existing laws on data privacy.

Data Analysis

Both descriptive and inferential statistics were utilized to thoroughly analyze the data collected in this study. Descriptive statistics, including the weighted mean, and mean score were employed to assess the validity of the developed lessons in Science, Technology, and Society (STS). These statistics also measured the effectiveness of the lessons in enhancing students' conceptual understanding, basic science process skills, and attitudes toward science.

The weighted means from the jurors' evaluations were interpreted using the adjectival interpretations outlined in the study of Cajurao (2019). The 5-point Likert scale used for the evaluation process and its corresponding verbal interpretations are presented in the table below:

Range	**Verbal Interpretation**	**Description**
4.50 – 5.00	Excellent	Indicates the criterion is extremely evident
3.50 – 4.49	Very Good	Indicates the criterion is very evident
2.50 – 3.49	Good	Indicates the criterion is evident
1.50 – 2.49	Fair	Indicates the criterion is slightly evident
1.00 – 1.49	Poor	Indicates the criterion is not evident

Inferential statistics, such as paired and independent samples t-tests were used to identify significant differences across groups. Additionally, the Kolmogorov-Smirnov test and Levene's test were conducted to determine the appropriate statistical parameters for data analysis, ensuring that the assumptions of the tests were met.

Results and Discussion

Jurors' Assessment of the Contextualized Lessons in STS

Table 2 provides a summary of the jurors' evaluations of the contextualized lessons in Science, Technology, and Society (STS), focusing on three key domains: Lesson Objectives, Contextualized Learning Activities, and Assessment.

The overall average weighted mean for these variables is 4.68, which is interpreted as an excellent rating, indicating a generally positive assessment of the contextualized learning

Table 2: *Summary of the Jurors' evaluation of the contextualized learning materials in STS (n=5)*

	Lessons						
Domains	**L1**	**L2**	**L3**	**L4**	**L5**	*WM*	*VI*
Lesson Objectives	4.70	4.75	4.95	4.60	4.60	4.72	Ex
Contextualized Learning Activities	4.85	4.70	4.80	4.50	4.50	4.67	Ex
Assessment	4.85	4.70	4.70	4.55	4.50	4.66	Ex
Average Weighted Mean	4.80	4.72	4.82	4.55	4.53	4.68	Ex

Legends: L1-L5=Lessons 1 to 5; WM=Weighted Mean; VI=Verbal Interpretation; Ex=Excellent

materials. The Lesson Objectives received a high average weighted mean of 4.72, also rated as excellent, suggesting that the objectives were well-defined and closely aligned with the intended learning goals. The Contextualized Learning Activities were similarly well-received, with an average weighted mean of 4.67, reflecting an excellent rating that indicates the activities were relevant, engaging, and supportive of the learning objectives. The Assessment component, while still receiving a positive evaluation, had a slightly lower average weighted mean of 4.66. This suggests that although the assessment was generally effective, there may be opportunities for refinement. Jurors provided suggestions for enhancing the assessment techniques, recommending more suitable methods that were subsequently incorporated into the revisions.

Furthermore, the inter-rater reliability coefficients (Fleiss kappa) for the five developed lessons as shown in Table 3, ranged from 0.52 to 0.72, with an average of 0.61. According to Landis and Koch (1977), kappa values between 0.61 and 0.80 indicate substantial agreement among the raters. Hence, the results suggest a moderate to substantial level of agreement among the jurors in their ratings of the lessons. While there were some variations in agreement across the different lessons, the overall level of inter-rater reliability was satisfactory.

Contextualized learning, which links abstract concepts to real-world situations, has been demonstrated to improve student engagement, motivation, and comprehension (Learn, 2000; Rathburn, 2015; Sambayon et al., 2023). This aligns with research highlighting the importance of authentic learning experiences in fostering deep understanding and critical thinking (Bester & Pretorius, 2022; Darling-Hammond & Snyder, 2000; Dolapcioglu, & Doğanay, 2022). Additionally, research supports the use of authentic assessments, such as performance tasks and projects, which can offer valuable insights into student learning and help cultivate higher-order thinking skills (Alfiani & Wijayati, 2022; Ayuningrum et al., 2024; Fraser et al., 2023).

Table 3: Inter-rater reliability of the ratings provided by jurors for the five lessons (n=5).

Lessons	*Fleiss kappa (κ)*	*Interpretation*
The good life	0.65	Substantial agreement
Why the future does not need us	0.62	Substantial agreement
Biodiversity and healthy society	0.72	Substantial agreement
Genetically modified organisms	0.52	Moderate agreement
Climate change and environmental awareness	0.55	Moderate agreement
Average	**0.61**	**Substantial agreement**

Effects of Lessons on Students' Conceptual Understanding of Science Concepts

Paired t-test results, as presented in Table 4, comparing the mean pretest and mean posttest scores of students in the experimental group (n=20) in the achievement test. The results revealed significant differences between mean pretest and posttest scores for all five lessons ($p < .001$). The effect sizes for all lessons were large ($d > 1.8$), which may indicate that the intervention had a substantial impact on student learning. The significant improvement in scores indicates that the contextualized activities were highly effective in enhancing students' conceptual understanding of science concepts, even among non-science majors.

This suggests that the contextualized lessons not only improved student performance but did so to a significant extent, consistent with findings from previous research. Contextualized and active learning strategies have been shown to significantly enhance students' understanding of complex scientific ideas by fostering engagement and practical application (Goodrum, 2020; Montero & Geducos, 2022; Rivet & Krajcik, 2008; Suryawati & Osman, 2017). For instance, Rivet and Krajcik (2008) found that when students learn through context-rich scenarios, they are more likely to engage deeply with the material, which enhances both their understanding and retention of complex concepts.

Furthermore, integrating context into learning not only improves conceptual comprehension but also encourages critical thinking and active participation. Abebe et al. (2023) found that contextualized learning approaches promote critical thinking skills, allowing students to analyze and apply concepts more effectively. Similarly, Puspitasari et al. (2024) noted that contextualized instruction enhances active participation, as students are more motivated to engage in learning when they see the relevance of the content to their own lives. By integrating lessons closely aligned with students' cultural and community contexts, the intervention likely made science more accessible and relatable, fostering a positive learning environment (El Yazidi & Rijal, 2024). Glynn and Koballa (2006) support this by stating that when students perceive the relevance of content, their interest and motivation increase, which can lead to improved academic performance.

However, while the results are promising, it is important to consider that the participants were non-science majors, which might influence the generalizability of the results. Osborne et al. (2003) suggests that attitudes and prior knowledge can vary significantly between science and non-science majors, potentially affecting their responsiveness to contextualized interventions. Despite these considerations, the consistent gains across all lessons in this study suggest that contextualized teaching strategies can be broadly applicable and beneficial across diverse learner groups, regardless of their academic background (Table 5).

The analysis of the pretest scores, as shown in Table 5, revealed no significant difference between the control and experimental groups ($t_{38} = 1.80$, $p = 0.08$, $d = 0.57$). This result suggests that the two groups demonstrate comparable initial understanding of the science concepts, thereby establishing a baseline equivalence at the beginning of the study. However, a significant difference was observed in the posttest scores between the control and experimental groups ($t_{38} = 8.53$, $p < 0.001$, $d = 2.75$), with the experimental group demonstrating markedly higher mean posttest scores compared to the control group. The large effect size ($d = 2.75$) indicates the substantial impact of the intervention on the students' conceptual understanding of the introduced science concepts.

These findings indicate that the contextualized lessons significantly enhanced student performance, aligning with prior research that highlights the effectiveness of

Table 4: Paired t-test results comparing students' mean pretest and posttest scores across five lessons in the experimental group (n=20).

Lessons	*No. of items*	*Pre-test* M	SD	*Posttest* M	SD	*MD*	*t*	*p-value*	*Effect size (d)*
The good life	12	5.95	2.28	10.8	1.14	-4.90	-8.45	.000	1.89
Why the future does not need us	8	4.35	1.79	7.35	0.88	-3.00	-8.11	.000	1.81
Biodiversity and healthy society	11	5.80	2.48	10.0	1.03	-4.20	-8.30	.000	1.86
Genetically modified organisms	9	4.55	1.76	8.00	1.12	-3.45	-7.98	.000	1.79
Climate change and environmental awareness	10	4.60	2.16	9.25	0.72	-4.65	-10.1	.000	2.26

Legends: M-Mean; SD = Standard deviation; MD = Mean difference

Table 5: Independent samples t-test results comparing control and experimental groups mean pretest and posttest scores (n=40)

Group	*Mean*	*SD*	*Mean Difference*	*df*	*t*	*p-value*	*Effect size (d)*
Control Group-Pretest	21.25	5.46	-4.00	38	1.80	0.08	0.57
Experimental Group- Pretest	25.25	8.25					
Control Group-Posttest	25.65	9.90	19.80	38	8.53	.000	2.75
Experimental Group-Posttest	45.45	3.10					

contextualized and active learning strategies in deepening students' understanding of complex scientific concepts through increased engagement and hands-on application (Goodrum, 2020; Montero & Geducos, 2022; Rivet & Krajcik, 2008; Suryawati & Osman, 2017). Studies have shown that integrating contextual elements into learning not only boosts conceptual comprehension but also promotes critical thinking skills (Abebe et al., 2023) and fosters greater student participation (Puspitasari et al., 2024).

Effects of Contextualized Lessons on Students' Science Process Skills

The analysis of pretest scores, as presented in Table 6, revealed no significant difference between the control and experimental groups (t_{38} = 1.78, p = 0.084, d = 0.56), indicating that the groups were comparable in their initial science process skills. Significant differences were found in the posttest scores between the control and experimental groups (t_{38}= 6.82, p < 0.001, d = 2.16), with the experimental group achieving substantially higher mean posttest scores. The large effect size (d = 2.16) indicates a strong impact of the intervention. The substantial gain suggest that the intervention was highly effective in enhancing the science process skills of students in the experimental group compared to those in the control group. Research has consistently shown that contextualized combined with active and experiential learning approaches, such as those used in this study, significantly improve students' conceptual understanding and basic science process skills (Ernita et al., 2024; Muslim et al., 2023; Risamasu & Pieter, 2024). These methods engage students in real-world applications, fostering deeper comprehension and practical skills (Amalia et al., 2024; Jasper-Abowei & Victor-Ishikaku, 2023; Krause et al., 2016) (Table 6).

Impacts of Contextualized Lessons on Students' Attitudes toward Science

The analysis of pretest scores, as elucidated in Table 7, revealed no significant difference between the control and experimental groups (t_{38} = 0.21, p = 0.83, d = 0.07), indicating that the groups were on the same footing in terms of initial attitudes toward science. A significant difference, however, was observed in the posttest scores between the control and experimental groups (t_{38} = 7.98, p < 0.001, d = 2.52), with the experimental group demonstrating substantially higher mean posttest scores. The large effect size (d = 2.52) indicates that the intervention, which involved contextualized lessons in Science, Technology, and Society (STS), had a positive impact on improving students' attitudes toward science

Previous research has shown that contextualized learning approaches can significantly enhance student engagement, motivation, and positive attitudes toward science (Blanchard et al., 2010; Glynn & Koballa, 2006; Hajduk, 2008))Table 7).

By integrating lessons that are closely aligned with students' cultural and community contexts, the intervention likely made science more accessible and relatable, thereby fostering a more positive attitude. Studies support that when students perceive the relevance of the content to their own lives, they are more likely to develop a favorable attitude toward the subject matter (Palmer, 2009). For example, Glynn and Koballa (2006) found that students who engage

Table 6: Independent samples t-test results comparing control and experimental groups science process skills mean pretest and posttest scores (n=40)

Group	*Mean*	*SD*	*Mean Difference*	*df*	*t*	*p-value*	*Effect size (d)*
Control Group-Pretest	10.80	2.69	-1.35	38	1.78	0.084	0.56
Experimental Group- Pretest	12.15	2.08					
Control Group-Posttest	10.90	2.15	-4.40	38	6.82	.000	2.16
Experimental Group-Posttest	15.30	1.92					

Table 7: Independent samples t-test results comparing control and experimental groups mean pretest and posttest attitude scores (n=40)

Group	Arithmetic Mean	SD	Mean Difference	df	t	p-value	Effect size (d)
Control Group-Pretest	90.5	11.26	0.2	38	0.21	0.83	0.07
Experimental Group- Pretest	90.7	7.75					
Control Group-Posttest	87.30	8.14	16.35	38	7.98	.000	2.52
Experimental Group-Posttest	103.65	4.20					

in contextualized science learning are more motivated and show greater interest in the subject. Similarly, Blanchard et al. (2010) demonstrated that contextualized and inquiry-based approaches lead to improved student attitudes and engagement in STEM subjects, which aligns with the substantial impact observed in the present study.

Conclusion and Recommendations

The effectiveness of contextual teaching and learning in enhancing student outcomes has been demonstrated in numerous studies. The findings of this study provide another strong evidence that contextualized learning materials significantly improve students' conceptual understanding, science process skills, and attitudes toward science, even among non-science majors. The developed contextualized lessons in Science, Technology, and Society (STS) were rated as excellent by experts, confirming their validity and appropriateness. Inter-rater reliability analysis also indicated a satisfactory level of agreement among evaluators, ensuring consistency in the assessment of the materials. Comparison of pretest and posttest scores in the experimental group demonstrated significant improvements across all five developed lessons, indicating that the intervention had a substantial impact on students' achievement. Furthermore, students' performance in the experimental group were significantly higher than those of the control group, with substantial gains in conceptual understanding, science process skills, and attitudes toward science. These results underscore the effectiveness of the contextualized activities in enhancing the students' learning outcomes, particularly for non-science majors.

Given the success of the contextualized materials, similar interventions could be applied in other educational settings and across various subjects, particularly in disciplines where non-science majors may face challenges in studying science concepts. To sustain the benefits of contextualized learning, it is crucial that teachers receive continuing professional development on designing and implementing such materials effectively, with a focus on both content and pedagogy. Future research may explore the long-term effects of contextualized learning materials on student retention, creative thinking, and fostering behavioral change.

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