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The Impact of the Common Knowledge Construction Model (CKCM) Integrated with Ethnoscience and Podcasts on Science Process Skills in the Topic of Chemical Bonding

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ABSTRACT

Technological advances and competition in the 21st-century demand that students enhance their knowledge and skills. The Common Knowledge Construction Model (CKCM) can effectively influence students' academic skills and achievements in chemistry. This study examined the impact of CKCM integrated with ethnoscience and podcasts on improving science process skills and student learning outcomes. A quasi-experimental design with cluster random sampling was employed to select experimental and control groups from the population of specialization 11th-grade science program (five classes) in a senior high school in Boyolali Regency. Multiple-choice questions were used to measure science process skills and learning outcomes. Descriptive analysis and hypothesis testing were conducted using the Kruskal-Wallis test. The results revealed a significance value of 0.000 in both hypothesis tests for science process skills and learning outcomes. A significance value of less than 0.05 indicates that the application of CKCM positively impacts both variables. Integrating ethnoscience provides a deeper understanding by building culturally contextualized logical thinking. Supported by podcast media, it creates a dynamic and engaging learning environment that helps students actively construct their knowledge. This research contributes to developing the CKCM learning model mediated by podcasts to empower chemistry knowledge and science process skills, preparing students to meet the challenges of the 21st century.

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1. INTRODUCTION

Entering the 21st century, various aspects of human life, including social interactions, recreation, learning, careers, the economy, and organizations, have been significantly influenced by technological advancements (Haryadi & Pujiastuti, 2020; Thornhill-Miller et al., 2023). Consequently, individuals need to prepare for unpredictable, unknown, and uncontrollable challenges and the emergence of new professions like programmers, content writers, and social media content creators (Kocak et al., 2021). Integrating technology and information in daily life, especially in education, necessitates adapting to rapidly changing data and information formats, whether digital or printed. The education sector must equip the next generation with critical thinking and practical skills to navigate uncertainty and avoid confusion (Afandi et al., 2019; Lavi et al., 2021; Peña-Ayala, 2021). This preparation involves integrating 21st-century skills, known as the "4Cs" (creativity, critical thinking, communication, and collaboration), into the curriculum (Thornhill-Miller et al., 2023). These skills promote effective communication and cooperation, enhance critical thinking, and enable students to access and analyze information through technology. Additionally, fostering creativity and scientific attitudes helps students develop problem-solving abilities (Astuti et al., 2020).

Problem-solving skills can be enhanced through the development of science process skills. These skills involve thinking critically to generate knowledge, address problems, and formulate results (Kızılaslan & Zorluoğlu, 2019). Science process skills emphasize investigations that utilize the environment, technology, and society, presenting research and observation data and communicating findings through various media. This approach

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encourages students to actively observe, question, experiment, reason, and create (Afandi et al., 2019). Effective teaching strategies are essential to developing these skills (Gizaw & Sota, 2023). Traditional teacher-centered strategies, such as lectures, are no longer effective, as they fail to maintain student engagement and focus on the concept.

CKCM involves the active engagement of students with their learning environment, enabling them to discover and construct their knowledge, thereby improving academic skills and achievements (Bakırcı et al., 2017; Bayar et al., 2019; Taşdere & Kaya, 2023). Social issues such as pollution, global warming, traditions, and food additives can be learning contexts based on students' direct experiences. This approach helps students become aware of their surroundings and integrates science, technology, society, and the environment, fostering critical and scientific thinking skills (Kiryak & Çalik, 2018). Bayar et al. (2019) outlined CKCM into four phases: exploring and classifying, constructing and negotiating, translating and expanding, and reflecting and evaluating.

Several studies have demonstrated the positive influence of CKCM on academic achievement and student skills in various topics, including the nature of science (Bakırcı et al., 2017), the solar system and eclipses (Bayar et al., 2019), the density and buoyancy of liquids (Taşdere & Kaya, 2023), heat transfer (Duruk et al., 2021), solubility (Çalik & Cobern, 2017), and water pollution (Kiryak & Çalik, 2018). Despite these findings, more research is needed to highlight the effectiveness of CKCM in other scientific topics, especially in chemistry, where its application remains underexplored. This study aims to address this gap by examining the impact of CKCM on a chemistry topic.

Chemistry is a science intimately connected to daily life, necessitating a scientific approach to problem-solving (Sanova et al., 2021). The subject involves abstract concepts often integrated with other disciplines, making it challenging for many students. This difficulty is reflected in the low learning outcomes among students, as evidenced by the average scores of 50–65 in mid-semester chemistry assessments in 11th grade at a high school in Boyolali. These scores fall short of the achievement criteria set by the chemistry teacher (Shidiq et al., 2019). Chemistry is typically represented at three levels: macroscopic, microscopic, and symbolic (Antrakusuma et al., 2017). Chemical bonding, a topic with inherently abstract concepts, often leads to misconceptions among students (Karim et al., 2022; Musa et al., 2023). The abstract nature of chemical bonds involving elements or atoms that cannot be directly observed contributes to these misconceptions (Fahmi & Irhasyuarna, 2017).

CKCM has been shown to minimize misconceptions and provide a deeper contextual understanding, particularly in science education (Taşdere & Kaya, 2023). Contextual understanding can be achieved through ethnoscience-based learning, which links local cultures and indigenous knowledge with scientific principles (Sudarmin et al., 2017). Integrating Socioscientific Issues (SSI) that present social issue backgrounds also enhances learning. This approach encourages discussions, reflection on cultural backgrounds, and new perspectives in decision-making, ultimately leading to better problem-solving skills (Zidny & Eilks, 2022).

In response to technological advances and the influx of information in the 21st century, it is highly recommended that these conditions be leveraged in teaching (Firoozehchian et al., 2019). Using podcasts as an educational medium is a positive step in this direction. Podcasts facilitate the easier dissemination of subject matter, thereby improving student learning outcomes (Rahmawati et al., 2023). They offer several advantages, including ease of access, direct control, and portability, allowing students to engage with the content anytime and anywhere (Firoozehchian et al., 2019). Podcasts address the challenges of technological advancement and are an effective educational tool for the 21st century (Sutarto et al., 2020).

The latest technological developments and innovative learning models open up opportunities to enhance chemistry education. The CKCM learning model, which facilitates the improvement of science process skills and academic achievement, is supported by podcasts as a flexible and engaging medium for delivering subject matter. However, further investigation is needed to integrate these approaches into the teaching of chemical bonding. This study tests the effectiveness of using CKCM and podcast media in teaching chemical bond concepts. This approach aims to address challenges in chemistry education and inspire further research on interactive and innovative learning methods. Thus, the study aims to investigate the effectiveness of applying CKCM integrated with ethnoscience and podcast media on science process skills and student learning outcomes.

2. MATERIAL AND METHOD

Research Design

This study employs a quasi-experimental method with a posttest-only control group design, as illustrated in **Table 1**. Quasi-experiments were conducted due to limitations in randomly assigning subjects to experimental

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and control groups, resulting in partial control over the studied variables (Gopalan et al., 2020). In this study, students were not randomly assigned to groups. Instead, two existing classes with similar characteristics were selected.

The objective is to determine the effectiveness of the CKCM model integrated with ethnoscience and mediated by podcasts on science process skills and learning outcomes. The experimental group utilized CKCM integrated with ethnoscience and podcast media, while the control group used a discovery learning model with PowerPoint presentations. Chemistry teachers commonly employ discovery learning at the studied high school. Following the intervention, both groups underwent a posttest, and the results were analyzed using statistical tests, including homogeneity, normality, and hypothesis tests.

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Table 1. Post-test only control group design

Class	N	Treatment	Post-test
Control	36	X_1	O_1
Experiment	36	X_2	O_1

Description: X_1 = Learning using media package books and PowerPoint;
X_2 = Learning using podcast media; O_1 = Value post-test; N = Number of samples

Participant

This research was conducted in a Boyolali Regency, Central Java, Indonesia high school. The study population comprised five 11th-grade science programs (11th A) during the 2023/2024 academic year. Two classes were selected from this population using the cluster random sampling technique: the experimental and the control groups. Cluster random sampling was employed due to the large population size, with each class comprising 36 students, making it impractical to identify each individual (Stratton, 2019). Before group assignment, normality tests using the Kolmogorov-Smirnov method and Levene's homogeneity tests were conducted on all five classes' mid-semester chemistry assessment scores. Data is considered normal if the significance value is greater than 0.05. Similarly, data is considered homogeneous if the significance value exceeds 0.05. These criteria also apply when conducting prerequisite tests on the post-test results.

Only class D did not meet the normality criteria of the five classes tested for normality. The remaining classes with normal data were tested for homogeneity to ensure a homogeneous state before treatment. Based on the homogeneity test results, the classes were deemed homogeneous, allowing for selecting an experimental and a control group. 11th - A (N=36) was designated the experimental group, and class 11th - E (N=36) as the control group. A baseline equivalence test was then conducted using an independent sample t-test to assess the initial abilities of both groups. The results indicated no significant difference between the two classes, with a significance value of 0.056, greater than 0.05. This suggests that both groups had equivalent initial abilities in science process skills and learning outcomes.

Research Stage

Based on **Figure 1**, the preparation stage began with observing the schools and students by attending classroom sessions to understand the teaching and learning activities. This stage also involved determining the experimental and control groups and testing the validity and reliability of the instruments used. Instrument validity was assessed to ensure they met the requirements, involving two panelists. The reliability test measured the consistency of students' responses to questions within a group that had previously studied chemical bonding.

The implementation stage involved applying the podcast-mediated CKCM learning model to the experimental group, while the control group used the PPT-mediated discovery learning model. Both groups underwent post-tests following the interventions. The learning sessions for both classes spanned five meetings, each lasting 90 minutes. The podcast used was developed by Widarti et al. (2024) and had previously undergone preliminary studies in chemical bonding learning. The findings showed a high interest among students in entertainment-based audio-visual technology, indicating a positive influence on learning. The podcast can be accessed on YouTube at https://youtube.com/@etno-chemofficial?si=yjFcZy1Fx8NDKZQ-. It comprises a series of four episodes, each covering different themes: (a) Episode 1: Chemistry Is Close, (b) Episode 2: Elemental Stability, (c) Episode 3: Ionic Bonds, (d) Episode 4: Covalent Bonds Part 1, and (e) Episode 5: Covalent Bonds Part 2. Each episode ranges from 5 to 20 minutes in duration. The final stage involved data analysis and hypothesis

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testing. Data analysis included normality and homogeneity tests as prerequisites for hypothesis testing. Hypothesis testing was conducted to determine the effect of the podcast-mediated CKCM model on learning outcomes and science process skills. The data were the post-test results of science process skills and learning outcomes.

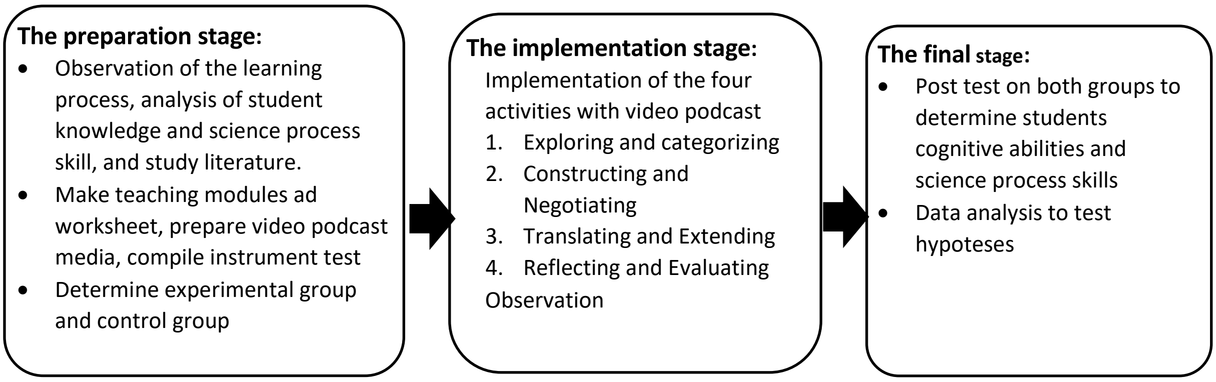

Figure 1. The Research Stage

Data Collection

Data were collected using a multiple-choice test method: 20 questions for the science process skills post-test and 15 questions for the learning outcomes post-test. The learning outcomes instrument focused on chemical bonding, while the science process skills instrument aligned with indicators such as formulating hypotheses, predicting, planning experiments, inferring, classifying, applying concepts, observing, measuring, using tools and content, and communicating. Scores were calculated using the following formula:

$$\text{Score} = \frac{Number\ of\ correct\ questions}{Number\ of\ questions} \times 100$$

The test instruments were validated by two validators and confirmed as valid using Gregory's formula for Content Validity. Additionally, reliability tests conducted using ITEMAN determined that the instruments were reliable if Cronbach's alpha value exceeded 0.6. In this study, the learning outcomes instrument achieved an alpha value of 0.791, and the science process skills instrument achieved an alpha value of 0.735, indicating that both instruments are reliable and suitable for use.

Data Analysis

Collected data, in the form of post-test results for science process skills and learning outcomes, were analyzed using normality and homogeneity tests via IBM SPSS 25 software as prerequisite tests. If the test results were found to be normal and homogeneous, a parametric test (Independent Sample T-Test) was conducted. In cases where data were not normal, a non-parametric test using the Kruskal-Wallis Test was applied.

Table 2. Research Hypothesis

H_0	H_1
The mean variable values are the same between the control and experimental classes (the CKCM model integrated with ethnoscience and podcast media is not influential).	There was a difference in the mean of variable values between the control class and the experimental class (the CKCM model of ethnoscience integrated with podcast media is influential)

The normality test employed the Kolmogorov-Smirnov test, while the homogeneity test used Levene's. Data were considered normal and homogeneous if the significance value exceeded 0.05. A parametric test (MANOVA) was performed for normally distributed and homogeneous data. Conversely, for data that were not normal or homogeneous, a non-parametric test (Kruskal-Wallis) was conducted. This approach determined the difference in the average value of science process skills between the experimental and control groups, assessing

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the influence of the CKCM model integrated with ethnoscience and podcast media. The hypotheses are outlined in **Table 2**.

3. FINDINGS

The post-test scores for science process skills and learning outcomes were analyzed to determine the effect of using the CKCM learning model mediated by podcasts. Before hypothesis testing, normality and homogeneity tests were conducted using IBM SPSS 25 on the post-test data from both the experimental and control groups. **Table 3** displays the post-test results for science process skills and learning outcomes. The experimental group achieved higher average scores compared to the control group.

Table 3. Results of Post-test Process Science Skills and Learning Outcomes

Group	N	Post-test Process Science Skills			Post-test Learning Outcomes		
		Score maximum	Score minimum	Mean	Score maximum	Score minimum	Mean
Experiment	36	93	60	79.81	90	45	75.28
Control	36	80	53	68.94	70	30	55

Table 4 summarizes the significance values for both post-tests in the experimental and control groups. All significance values are below 0.05, indicating that the data are not normally distributed.

Table 4. The result of the Normality Test

Group	Variable	N	Sig.	Decision	Conclusion
Experiment	Learning outcome	36	0.004	H_0 rejected	Not normal
	Science process skills	36	0.006	H_0 rejected	Not normal
Control	Learning outcome	36	0.002	H_0 rejected	Not normal
	Science process skills	36	0.001	H_0 rejected	Not normal

Table 5 shows the homogeneity test results for post-test science process skills and learning outcomes for both groups. The significance values exceed 0.05, indicating that the data are homogeneous.

Table 5. The result of the Homogeneity Test

Parameter Test	N	Sig.	Decision	Conclusion
Post-test learning outcome	36	0.269	H_0 accepted	Homogenous data
Post-test science process skills	36	0.167	H_0 accepted	Homogenous data

Since both groups showed non-normal data, a non-parametric Kruskal-Wallis test was conducted using IBM SPSS 25. **Table 6** presents the results of the Kruskal-Wallis test for science process skills and learning outcomes. Both parameters obtained a significance value of less than 0.05, leading to the rejection of H0. This indicates a significant difference between the experimental and control groups, confirming that the CKCM model integrated with ethnoscience and podcast media is influential. This analysis confirms that the CKCM model integrated with ethnoscience and podcast media significantly impacts science process skills and learning outcomes.

Table 6. The result of the Kruskal-Wallis Test

Parameter Test	Sig. (2-tailed)	Decision	Conclusion
Post-test learning outcomes and science process skills	0.000	H_0 rejected	There is a difference

4. Discussion

CKCM-based learning requires students to actively engage in the learning process, emphasizing the discovery and construction of their knowledge. This approach facilitates learners in developing a deeper understanding of scientific phenomena. In the science learning process, including chemistry, biology, and physics,

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CKCM integrates aspects of natural science (NOS), such as imagination, creativity, experimentation, social and cultural values, and observation, all influencing decision-making and knowledge improvement. Science learning, particularly in chemistry, is context-based, necessitating the empowerment of scientific thinking habits to address scientific social issues. Therefore, this study integrates CKCM with ethnoscience to encourage active and creative student engagement in understanding, studying, and interacting with local culture and the surrounding environment, enhancing their argumentation and reasoning skills. Ethnoscience elements are embedded in each CKCM learning phase, which includes "Exploring and Categorizing," "Constructing and Negotiating," "Translating and Extending," and "Reflecting and Evaluating."

The "Exploring and Categorizing" phase aims to uncover students' initial knowledge and categorize their arguments through supportive activities related to the subject matter. Teachers focus on what and how students think without assuming that their responses are right or wrong. This phase allows students to freely express their initial ideas, making it crucial for teachers to create a supportive learning environment. Such an environment encourages discussions, provides access to information sources or subject readings, uses technology like podcasts, offers constructive feedback, and employs approaches based on students' learning styles. This enables students to become aware of alternative concepts within themselves and recognize others' perspectives.

The "Constructing and Negotiating" phase involves students in collaborative activities where they construct new knowledge by negotiating their understanding with peers. Teachers facilitate this process by providing structured guidance and promoting active student participation. The "Translating and Extending" phase encourages students to apply their newly acquired knowledge to different contexts, further extending their understanding. Finally, the "Reflecting and Evaluating" phase allows students to reflect on their learning experiences and evaluate their progress, fostering a deeper comprehension of the subject matter.

Integrating ethnoscience into the CKCM framework helps contextualize scientific concepts within students' cultural and social backgrounds, making learning more relevant and engaging. This approach enhances students' scientific literacy and promotes critical thinking, problem-solving, and communication skills. The study's findings indicate that combining CKCM with ethnoscience and podcast media creates a dynamic and interactive learning environment, significantly improving students' science process skills and learning outcomes. This innovative approach addresses the challenges of 21st-century education by leveraging technology and cultural context to enrich the learning experience.

CKCM-based learning requires students to actively engage in learning, encouraging them to discover and construct their knowledge. This approach facilitates a deeper understanding of scientific phenomena. In science education, including chemistry, biology, and physics, CKCM integrates aspects of natural science (NOS) such as imagination, creativity, experimentation, social and cultural values, and observation, all influencing decision-making and knowledge enhancement. Science learning, particularly in chemistry, is context-based, necessitating the empowerment of scientific thinking to address scientific social issues. This study integrates CKCM with ethnoscience to promote active and creative engagement in understanding, studying, and interacting with local culture and the surrounding environment, enhancing argumentation and reasoning skills. Ethnoscience elements are embedded in each CKCM learning phase, which includes "Exploring and Categorizing," "Constructing and Negotiating," "Translating and Extending," and "Reflecting and Evaluating."

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The translating and extending phase provides more opportunities for students to associate their knowledge with daily life and other disciplines. This helps students expand and facilitate their understanding of the concept, improving their learning outcomes by fostering logical thinking and knowledge construction. Students were given problem-solving activities related to scientific social issues (SSI) involving elemental stability, ionic bonds, and covalent bonds. Discourse on social issues, such as the dangers of inhaling batik wax or the impact of methane gas emissions from the Lapindo mud, trained students in transferring knowledge to similar real-life problems, especially concerning chemical bonding.

In the reflecting and evaluating phase, students summarize the discussion results to reinforce what they have learned. This stage allows students to learn concepts based on alternative assessments and evaluations. Teachers assess students' behavior during each learning phase, providing meaningful learning experiences. Post-tests at the end of the learning process allow students to demonstrate their understanding. Reflecting on what they have learned, relating new concepts to existing knowledge, and applying their understanding in relevant contexts ensure that students gain meaningful learning experiences. Combining CKCM with ethnoscience and podcast media, this comprehensive approach creates a dynamic and interactive learning environment that significantly improves students' science process skills and learning outcomes. It addresses the challenges of 21st-century education by leveraging technology and cultural context to enrich the learning experience.

The Effect of the Podcast-Mediated CKCM Learning Model on Learning Outcomes

The results of this study indicate that the CKCM learning model, when integrated with podcast-mediated ethnoscience, significantly improves student learning outcomes. The Kruskal-Wallis test results showed a significance value of 0.000, less than the 0.05 threshold, leading to the acceptance of H1 and the rejection of H0. Furthermore, the average scores demonstrate that the experimental group outperformed the control group, with mean scores of 75.28 and 55, respectively. These findings suggest substantial differences in learning outcomes between the two groups. The CKCM model effectively supports students in interpreting scientific ideas and rules that encompass general knowledge, enhancing their cognitive, affective, and psychomotor abilities.

The superiority of the CKCM model over the discovery learning model in this study aligns with findings from other research. Munawarah et al. (2024) also reported that the CKCM model is more effective than discovery learning in improving student learning outcomes. While discovery learning encourages students to enhance their thinking skills by discovering concepts and learning theories, CKCM offers additional benefits. Through discovery learning, students can develop their viewpoints and begin resolving conflicts (Paramitha et al., 2023). Discovery learning fosters active, creative, and innovative thinking, enhancing students' cognitive and psychomotor skills (Atika et al., 2018; Rahmawati et al., 2023). The results presented in Table 2 reveal that the control group, which used the discovery learning model, had lower average scores on chemical bonding than the experimental group using the CKCM model. The mean score difference of 20.28 points between the two groups underscores the CKCM model's effectiveness. These results are consistent with Özden & Yenice (2020) and Ozdemir & Hamzagoulu (2016), which also reported significant differences in academic achievement between control and experimental groups using the CKCM learning model.

The Effect of the Podcast-Mediated CKCM Learning Model on Science Process Skills

As part of 21st-century competencies, science process skills are crucial for scientifically literate individuals who can build quality personalities (Özden & Yenice, 2020). These skills involve cognitive processes that enable individuals to create knowledge, analyze problems, and formulate solutions. As fundamental components of science education, they encourage students to engage actively, assume responsibility, and boost their learning motivation. With these skills, students are better equipped to explore questions, conduct research, and acquire necessary information (Kızılaslan & Zorluoğlu, 2019). The CKCM enhances science process skills by integrating students' comprehension of relational concepts into practical activities, guided discussions, collaborative projects, independent research, and reflective evaluation. This approach connects scientific theories to real-world applications, stimulating critical thinking, developing communication abilities, facilitating research, enabling data analysis, and improving the grasp of scientific concepts (Uke et al., 2024).

Science process skills are categorized into basic skills (e.g., observing, inferring, measuring, communicating, grouping, forecasting) and integrated skills (e.g., controlling variables, defining variables, hypothesizing, interpreting data, experimenting, presenting data) (Dimyati & Mudjiono, 2023; Aldi & Ismail,

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2023). This research incorporates basic and integrated science process skills, such as hypothesizing, predicting, planning experiments, inferring, classifying, applying concepts, observing, measuring, utilizing tools and content, concluding, and communicating. These skills are systematically developed throughout the CKCM learning stages, as outlined in **Table 7**.

Table 7. CKCM Syntax of Science Process Skills (SPS)

Syntax CKCM	Activity	Indicator of SPS
Exploring and categorizing	Watch podcasts online.	Observing
	Take notes on the content of the podcast.	Classifying
Constructing and negotiating	Working on LKPD questions in groups.	Applying concepts
	We are conducting experiments in the laboratory.	Planning experiments, applying concepts, using tools and content, observing, measuring
	Record experiment results in tabular form.	Classifying, concluding
	Discuss outcomes within and between groups.	Communicating
Translating and extending	Reading discourse related to ethnoscience and social issues.	Applying concepts
	Answer questions based on the given discourse.	Applying concepts, conclude.
Reflexing and evaluating	Summarize learning conclusions.	Conclude, communicating
	Do practice questions/post-tests.	Applying concepts

The post-test results for science process skills indicated that the experimental group achieved a higher average score (79.81) than the control group (68.94). This finding is supported by the Kruskal-Wallis test, which showed a significance value of 0.000, demonstrating a significant difference in science process skills between the experimental group, which used podcast-mediated ethnoscience content in CKCM, and the control group, which employed PPT-mediated discovery learning. These findings are consistent with previous research indicating that experimental groups often outperform control groups regarding science process skills (Bayar et al., 2019).

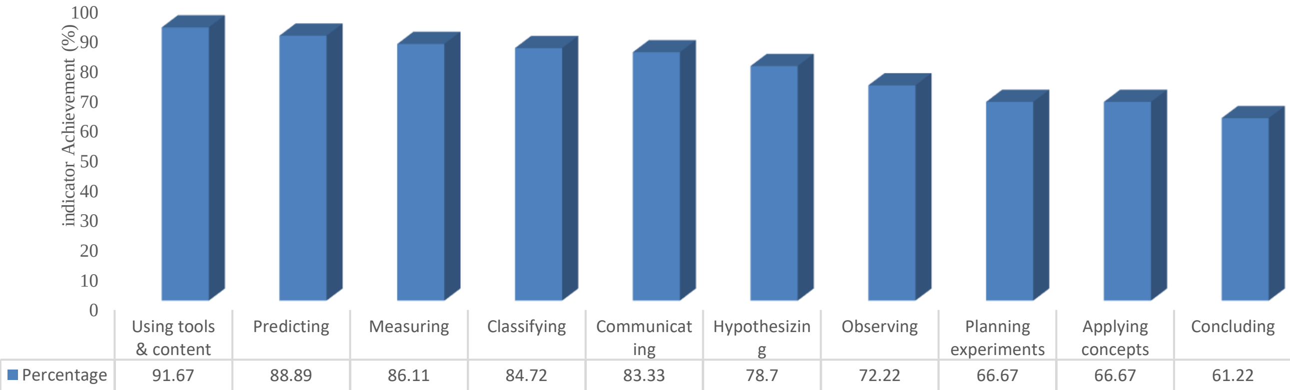

Figure 2. The average achievement of the indicators of science process skills

Based on the average achievement of science process skills indicators in the post-test results, the skills in the experimental group, ranked from highest to lowest, were using tools and content, predicting, measuring and classifying, communicating, hypothesizing, and observing, planning experiments, applying concepts, and concluding. The skill of using tools and content received the highest score, as shown in Figure 2. Using tools and content effectively involves understanding the operation and the purpose of these tools and content. This high score can be attributed to frequent encounters with these tools during practical sessions, allowing students to become familiar with their functions and proper usage in a laboratory setting. Engaging in hands-on activities, such as practical experiments, actively involves students in testing and developing theoretical concepts (Hayati et al., 2019; Wiwin & Kustijono, 2018). Conversely, the skill of concluding received the lowest average score,

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which aligns with findings by Senisum (2021), who reported a low score of 36.4% for the concluding indicator. Senisum explained that science process skills related to concluding involve analytical activities that require a higher level of logical thinking (Ramadhani et al., 2023). Analyzing is a critical thinking skill, and the low performance in science process skills suggests that students also need help with critical thinking.

The use of podcast media supported enhanced learning outcomes and science process skills in the experimental group. Podcasts increase student learning flexibility, expand access to course content, provide substantial learning opportunities, and enrich the learning experience. They serve as effective educational tools, fostering a dynamic learning environment and enhancing student interaction during the learning process (Firoozehchian et al., 2019). Podcasts enable students to construct knowledge through exploration, observation, and interpretation (Saeedakhtar et al., 2021).

Despite these advantages, podcasts also present certain challenges. They may not always be compatible with the visualization of some chemicals, and issues with internet access and device availability can hinder their use. Additionally, the lengthy duration of some podcasts can lead to student disengagement (Widarti et al., 2024). Teachers must anticipate and address these challenges by integrating interactive discussions and supplementary learning content and maintaining student engagement to ensure an active classroom environment.

The study's limitations in identifying science process skill indicators suggest further research to explore additional indicators and comprehensively assess the CKCM's effectiveness. Investigating a broader range of chemicals can provide deeper insights and wider applications. The drawbacks of the podcast medium used in this study also highlight the potential for future research to develop improved podcast formats that address these issues. Combining CKCM with podcasts offers a promising approach to enhancing chemistry education, aligning with the demands of 21st-century learning.

5. CONCLUSION

The research demonstrates that applying the CKCM incorporating ethnoscience and podcasts significantly impacts 11th grade students' science process skills and learning outcomes. This indicates that the CKCM learning model, mediated by podcasts, can create effective and efficient learning environments, thus achieving educational objectives. The improvement in science process skills and higher learning outcomes suggests that the CKCM learning model and podcast media are viable for teaching. Additionally, integrating cultural context (ethnoscience) and delivering it through podcasts provides innovative learning experiences, fostering knowledge construction. The findings emphasize the potential of podcasts as a flexible and accessible medium to enhance the learning process, allowing students to engage with course content in diverse settings. Podcasts support the development of essential science skills and encourage active participation and critical thinking. Incorporating ethnoscience adds a cultural dimension to the learning experience, making it more relatable and enriching for students. The challenges associated with podcast-based learning, such as issues with visualization of certain chemicals and technology access, underline the importance of comprehensive preparation by educators. Educators can maintain an engaging and effective learning environment by addressing these challenges through interactive discussions and supplementary content.

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