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The Effects of Using Simulated-Conceptual Collage (SCC) in Enhancing Students' Conceptual Understanding in Physics

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Abstract— Conceptual understanding is one of the important factors in assessing students' overall performance in different academic areas. This study determined the students' levels of conceptual understanding regarding the use of Simulated-Conceptual Collage (SCC) intervention, which combines recorded-virtual simulation and metacards. This study employed a classroom-based research design, selecting 30 students through purposive and stratified sampling with random sampling under specific conditions. The researcher made a two-tiered test to gather data, and the rubric in the scoring method has been adapted to a certain study. Mean, standard deviation, frequency, and percentage, paired t-test, and one-way ANOVA were the statistical tools used in the study. Results show that students' conceptual understanding before using SCC intervention was within partial correct understanding, with a mean score of 61.27. After using the SCC intervention, students' level of conceptual understanding was still within partial correct understanding, but with a mean score of 89.07. Highly significant positive differences exist in student's conceptual understanding of Physics before and after the SCC intervention, with a calculated t-value of 13.66 and a corresponding p-value of 0.00. Moreover, there was also a highly significant difference in conceptual understanding among students in physics with different academic ranks after the SCC intervention, as evidenced by the One-Way ANOVA results ($F(1, 28) = 9.65$, $p = 0.004$). Additional improvements in students' conceptual understanding were also seen after using the SCC intervention. The effectiveness of SCC in enhancing students' grasp of physics concepts highlights the potential for targeted interventions to impact learning outcomes positively. Schools and educational institutions should consider implementing SCC intervention as part of their physics curriculum to address the notable room for improvement in students' conceptual understanding observed prior to intervention.

Keywords— academic rank, conceptual understanding, metacards, recorded-virtual simulation, simulated-conceptual collage.

I. CONTEXT AND RATIONALE

Conceptual understanding is a critical aspect of science education, enabling students to grasp scientific principles deeply and apply them in various contexts. In the 2022 Program for International Student Assessment (PISA), the Philippines scored 355 points in Science, substantially lower than the Organisation for Economic Cooperation and Development. (OECD) average of 485 points.

The country ranked 80th out of 81 countries in Science. Educators have implemented many teaching tactics to improve classroom effectiveness and increase student engagement (Xiangze & Abdullah, 2023). Researchers found out that students who focus on understanding key concepts perform better on tasks requiring the application of knowledge to new situations compared to those who prioritize rote memorization (Bransford et al., 2001)

In a certain high school institution in Ozamiz City, a classroom of Grade 9 students is facing challenges related to low conceptual understanding. This issue has been attributed to various factors, including limited instructional resources, innovative teaching methods, and a desire for increased student engagement. The curriculum may need adjustments to effectively cater to the students' diverse needs and learning styles, aiming to bridge gaps in their comprehension of key concepts. By refining teaching strategies, providing comprehensive support for students and teachers, and ensuring fair access to educational resources, students can engage more deeply with the material, improving conceptual understanding.

Effective science education should highlight the progressive growth of students' intuitive understandings while providing them with scientific material and developing reasoning skills (Vosniadou, 2019). Active learning methodologies, connected with student objectives and assessments, have demonstrated considerable improvements in students' conceptual knowledge, notably in biological sciences (Oiimpo & Esparza, 2020). Educators can better engage students and deepen their comprehension of scientific principles by incorporating active learning methods that align with learning objectives and assessments. Students' comprehension is improved when conceptual understanding is taught through science inquiry and word knowledge growth (Haug & Ødegaard, 2014).

Furthermore, using activities from science textbooks and additional teaching materials has been discovered to improve students' comprehension of scientific concepts in contrast to traditional teaching methods (Shahid et al., 2023). Strengthening students' comprehension of the Nature of Technology (NOT) can enable them to make well-informed decisions concerning the societal repercussions of Science and Technology (Lee & Lee, 2021). Thus, a comprehensive approach incorporating these findings can address the challenges faced by Grade 9 students in Ozamiz City, fostering a deeper conceptual understanding of science education.

The researcher identified an apparent theoretical gap in the prior research concerning using active learning strategies to enhance conceptual understanding in science education. Some prior theories appear important and serve as a foundation worthy of recognition. However, an investigation in terms of their applicability to diverse learning contexts, such as the Grade 9 classroom in Ozamiz City, and theoretical development is warranted.

Investigating these issues is important because it can lead to the refinement and adaptation of active learning strategies to meet better the needs of students facing challenges related to conceptual understanding. The previous theory focuses primarily on traditional classroom settings and does not encompass new paradigms in digital learning, personalized instruction, and culturally responsive teaching approaches (Miles, 2017).

Intervention: Simulated-Conceptual Collage (SCC) Integration

The study explores the effects of implementing a combination of recorded virtual simulations and metacards strategies on students' conceptual understanding in physics education. The combination of recorded virtual simulations and metacards strategy is called Simulated-Conceptual Collage (SCC). It presents an innovative strategy for enhancing conceptual understanding.

Metacards are tactile and visual tools used in science teacher education environments to help students better understand and conceptualize complex theoretical frameworks (Enduran et al., 2021). Using metacards as a medium of expression during middle school lessons may benefit adolescent mental health concerns (Gray, 2023). In addition to its applications in science education, metacards mix the joy of utilizing a straightforward, cost-free, and vibrant technology inside and outside the classroom with actual learning objectives (Christensen & Abildgaard, 2021).

Moreover, using interactive simulations complements the effectiveness of metacards integration in facilitating learning. Interactive simulations like Java applets and PhET effectively enhance students' critical thinking and creative problem-solving skills in modern physics education (Candido et al., 2020). Introducing simulation tasks in laboratory preparation improves students' conceptual knowledge and engagement, increasing maximum marks and improving knowledge confidence (Coleman & Hosein, 2022). Simulation-based learning effectively reduces abstract physics and chemistry concepts, improving students' conceptual understanding and reducing misconceptions in secondary school chemistry and physics teaching (Iyamuremye et al., 2023).

The SCC intervention addresses the challenges of conceptual understanding by providing a multi-sensory and interactive learning experience that caters to diverse learning styles. Combining virtual simulations with metacards encourages students to actively participate in learning, leading to deeper conceptual understanding and knowledge retention.

Action Research Questions

This action research addressed the conceptual understanding of Grade 9 students in Science.

The research questions that follow were investigated in this study:

1. What is the conceptual understanding level of students before using SCC intervention?
2. What is the conceptual understanding level of students after using SCC intervention?
3. Is there a significant difference in conceptual understanding of students in Physics before and after the SCC intervention?

4. Is there a significant difference in conceptual understanding among students in Physics with different academic ranks after the SCC intervention?
5. Are there additional improvements in the students' conceptual understanding after using SCC intervention?

IV. ACTION RESEARCH METHODS

Research Design

This study employed a classroom-based research design, conducting research within an actual classroom setting to assess the effectiveness of SCC intervention and its effects on enhancing the conceptual understanding of Grade 9 students in Science. This design allowed for a close study of the intervention's implementation and direct impact on the targeted student population. It gave useful information on the possible benefits and outcomes of introducing the SCC intervention into the classroom. The decision to do classroom-based action research reflected a genuine interest in acquiring knowledge by questioning, inquiry, observation, listening, and analysis to create new knowledge.

Site

The study occurred at one of the public high school in Ozamiz City, Misamis Occidental. This educational institution complies with the Department of Education's criteria and requirements, demonstrating its commitment to providing a high-quality education to students. It operates on a regular curriculum.

Participants

The research involved Grade 9 students with two sections, selected through purposive sampling. Certain criteria were used to select the responders: they must be enrolled as Grade 9 students for the 2023-2024 academic year, exhibit a partial conceptual understanding of physics, and express willingness to participate. In each section, the researcher selected 15. If fewer than 30 students are identified with incomplete understanding, a random sampling method may be employed to select participants from the eligible pool of partial conceptual understanding. Conversely, if more than 30 students are identified with partial conceptual understanding, a random sampling may exclude participants from said eligible pool. Before conducting the survey, the researcher verified that the selected respondents meet all specified conditions. Overall, the respondents were determined through a combination of purposive sampling and random sampling under specific conditions.

Research Instruments

The instruments used in this study include lesson plans, recorded virtual simulations, metacards, a two-tiered multiple-choice test, and an interview guide. The lesson plans provide structured instructional guidance, integrating recorded virtual simulations to visually and interactively demonstrate Physics concepts. Metacards are used to facilitate students' conceptual understanding after the lessons. The two-tiered multiple-choice test assesses students' conceptual understanding before and after the intervention, with the first tier evaluating content knowledge and the second tier probing reasoning. Finally, the interview guide is used to gather qualitative insights from students about their learning experiences and perceptions of the SCC intervention. These combined instruments offer a comprehensive approach to evaluating the effectiveness of the SCC intervention in enhancing conceptual understanding of Physics.

Data Gathering Method

This action research was gathered quantitatively and qualitatively. The students' levels of conceptual understanding of science among grade 9 students will be assessed using a researcher-made instrument such as the two-tiered test. After that, the students were interviewed using Google Forms, which sent them links to see if there were additional improvements after using the SCC intervention. These are the following phases of implementation

A. Pre-Implementation Phase. The researcher examined the existing difficulties students encounter in comprehending Physics concepts. A comprehensive review of relevant studies was conducted to deepen the researcher's knowledge of the subject. Subsequently, the research proposal was drafted, and approval was sought from the Superintendent of the Division of Ozamiz City, as well as authorization from the principal and collaborating teacher, to conduct research at an Ozamiz City's secondary school.
B. Implementation Phase. Data collection commenced with the administration of a pre-test to the participants. The researcher implemented the planned intervention over a specified period, closely monitoring participant performance. The intervention was implemented for the whole class regardless of whether the students were participants or non-participants of the study. A post-test assessment followed them. The researcher will

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assess the strategy's effectiveness and determine its significance through data analysis.

C. Post-Implementation Phase. Following the implementation, the researcher drew conclusions, offered recommendations, and meticulously reviewed, edited, and finalized the research study. Additionally, the research findings were structurally shared with a targeted audience.

Ethical Issues

When engaging with individuals, it is imperative to uphold commitments and practice transparency (Resnick, 2015). Participants must receive accurate information regarding the study, their involvement, rights, incentives, and potential risks. It is crucial to convey that participation is entirely voluntary, and individuals can withdraw at any point, even after data collection, without facing repercussions or discrimination. Confidentiality, especially during data collection, is paramount, with restricted access for unauthorized individuals. Only pertinent data will be collected for the research, and no mental, emotional, or physical harm will be inflicted on participants (Amdur & Bankert, 2010).

The study adhered to ethical standards by securing informed consent from the subjects before conducting the survey. In alignment with ethical practices, researchers provided participants with a comprehensive overview of the Data Privacy Act of 2012. This measure was implemented to underscore the dedication to safeguarding personal information and maintaining accountability in handling sensitive data. Throughout the process, participants received detailed information about the study's goals, their potential advantages, and their involvement's significance. Researchers emphasized the confidentiality of the collected data, assuring participants that their anonymity would be safeguarded throughout the study.

Data Analysis

The examination of data collected during the intervention employed various analytical tools facilitated by the computer statistical software Minitab, the following tools were employed:

- Mean and Standard Deviation were used to assess students' level of conceptual understanding before and after implementing the SCC interaction strategy.
- Frequency and percentage were conducted to present a comprehensive overview of the distribution of responses or outcomes on the students' level of conceptual understanding before and after implementing the SCC interaction strategy.
- Paired T-test: was used to determine if there is a statistically significant difference in conceptual understanding of students in Physics before and after the SCC intervention.
- One-way Analysis of Variance (ANOVA) was used to determine if there were significant difference in conceptual understanding among students in Physics with different academic ranks after the SCC intervention.
- Thematic Analysis using Hyper Research was used to determine if there were additional improvements in the students' conceptual understanding after using SCC intervention

V. RESULTS AND DISCUSSION

A. Student's Level of Conceptual Understanding before the SCC intervention

Table 1 presented the conceptual understanding of Grade 9 students in Science before using the Simulated-Conceptual Collage (SCC) intervention. Overall, the students' conceptual understanding has partially correct understanding (M=61.27; SD=8.93). The highest level of understanding recorded was Partial Correct Understanding, with 40% of the students (n = 12) falling into this category (M = 70.67, SD = 5.30). Incomplete Understanding was the next most common, with 60% of the students (n = 18) (M = 55.00, SD = 3.73). There were no students in the No Understanding or Correct Understanding categories.

The findings suggest that before the SCC intervention, most students exhibited an incomplete understanding of the science concepts, with a significant portion demonstrating partial correct understanding. It indicates that while some students have grasped parts of the concepts, none fully comprehend them, and many are still struggling with substantial portions of the material.

Virtual environments and simulations are widely and effectively used in many disciplines (Yılmaz & Hebebci, 2022). The active use of VR technology may enhance science education by potentially making learning more engaging and enjoyable (Litchaweerat et al., 2024). Virtual reality can create meaningful learning by directly involving students in constructing their cognitive structures related to facts, concepts, procedures, and metacognition (Aswie & Abdu, 2023) and making it more effective in conceptual understanding (Gupta & Sharma, 2023).

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The absence of students in the Correct Understanding category suggests a gap in teaching strategies or resources used to convey scientific concepts effectively. Recommended activities include engaging virtual simulations, concept mapping to clarify scientific ideas, and formative feedback sessions to help students advance from incomplete to correct understanding. Additionally, teacher professional development focused on effectively implementing the SCC strategy could support more aligned and responsive teaching practices, helping students' better grasp complex scientific concepts.

Table 1: *Conceptual Understanding of the Learners' before the use of SCC intervention*

Conceptual Understanding	Frequency	Percentage	Mean	StDev
No Understanding	-	-	-	-
Incomplete Understanding	18	60	55.00	3.73
Partial Correct Understanding	12	40	70.67	5.30
Correct Understanding	-	-	-	-
Overall Conceptual Understanding	30	100	61.27	8.93

Note: Scale - 0-30 No Understanding (NU); 31-60 Incomplete Understanding (IU); 61-90 Partially Correct Understanding (PCU); 91-120 Correct Understanding (CU).

B. Student's Level of Conceptual Understanding after the SCC Intervention

Table 2 presented the conceptual understanding of Grade 9 students in Science after using the Simulated-Conceptual Collage (SCC) intervention. Overall, the students' conceptual understanding was partially correct understanding (M= 89.07; SD=11.92). The highest level of understanding recorded was Correct Understanding, with 50% of the students (n = 15) falling into this category (M = 98.40, SD = 5.97). Partial Correct Understanding was the next most common, with 50% of the students (n = 15) (M = 79.73, SD = 8.49). There were no students in the No Understanding or Incomplete Understanding categories.

The findings from Table 2 indicate that the Simulated-Conceptual Collage (SCC) intervention positively affected Grade 9 students' conceptual understanding of Science, as reflected in their post-intervention performance. Notably, half of the students achieved Correct Understanding, demonstrating that the SCC strategy effectively helped these students grasp complex scientific concepts. The fact that no students fell into the No Understanding or Incomplete Understanding categories suggests that the intervention successfully raised all students' understanding to a partially correct level.

While 50% of students are in the Partial Correct Understanding category, while still indicating improvement, this highlights an area for further instructional refinement. These students may have grasped the key ideas but require additional support to move beyond partial comprehension to a more thorough, accurate understanding. The relatively high mean (M = 89.07, SD = 11.92) for overall understanding suggests that the SCC intervention is a promising strategy but may need to be supplemented with targeted activities to address any lingering misconceptions or incomplete grasp of concepts.

Combining traditional physics labs with digital tools, such as PhET simulations and videos, improves students' conceptual understanding (Uwamahoro et al., 2021). Virtual labs and simulations can significantly improve students' understanding of theoretical concepts and physical phenomena (Kharki, 2020 & Alsharif, 2022). Moreover, it reveals that immersive virtual reality simulations can be particularly useful in helping students grasp complicated scientific concepts (Georgiou, 2020).

The significant increase in the number of students achieving Correct Understanding highlights the effectiveness of the intervention. Educators and curriculum developers should continue integrating SCC and similar methods into their teaching practices to support this improvement further. Suggested activities to maintain and enhance this progress include using the SCC intervention through interactive metacards paired with virtual physics simulations to reinforce understanding. Collaborative group work and peer-teaching sessions can help students engage more deeply with complex topics. Periodic two-tiered assessments should evaluate conceptual understanding and address specific learning gaps as they arise. Furthermore, teacher training on implementing SCC with differentiated instruction will ensure that all students, regardless of their learning pace, can benefit fully from this innovative approach.

Table 2: *Conceptual Understanding of the Learners' after the use of SCC intervention*

Conceptual Understanding	Frequency	Percentage	Mean	StDev
No Understanding	-	-	-	-
Incomplete Understanding	-	-	-	-
Partial Correct Understanding	15	50	79.73	8.30
Correct Understanding	15	50	98.40	6.14
Overall Conceptual Understanding	30	100	89.07	11.92

Note: Scale - 0-30 No Understanding (NU); 31-60 Incomplete Understanding (IU); 61-90 Partially Correct Understanding (PCU); 91-120 Correct Understanding (CU).

C. Significance Difference in Conceptual Understanding of Physics before and after Using SCC Intervention

The results from Table 3 demonstrate a significant improvement in the conceptual understanding of Physics among students following the implementation of the Simulated-Conceptual Collage (SCC) intervention. The mean score before the intervention (M = 61.27; SD = 8.93) reflects a relatively lower level of understanding, significantly increase (M=89.07; SD = 11.92) after the intervention. The substantial rise in scores, confirmed by the paired t-test (t = 13.66; p = 0.00), suggests that the SCC intervention was highly effective in enhancing students' grasp of Physics concepts. The rejection of the null hypothesis indicates that the difference in conceptual understanding before and after the intervention was not due to chance but rather the result of the applied teaching strategy.

This significant increase implies that the SCC intervention facilitated deeper learning and better retention of complex Physics concepts. Interactive collages and simulations helped students form stronger connections between abstract ideas and their real-world applications, improving conceptual understanding.

Combining real and virtual experiments promotes conceptual understanding better than a single type of experimentation (Wörner et al., 2022). It was reported that there was higher knowledge gain in students who underwent simulated teaching (Campanati, 2021). Virtual reality can advance understanding of a person's experiences with dementia (Bard et al., 2022). Cock (2021) developed a model for early prediction of conceptual understanding in interactive simulations.

These results imply the effectiveness of the SCC intervention in promoting conceptual understanding of Physics among Grade 9 students. Educators and curriculum developers should consider integrating similar interactive and experiential learning strategies into their teaching practices. Creating simulated-conceptual collages, inquiry-based discussions, hands-on Physics experiments, and problem-solving tasks can complement the SCC approach. These activities will ensure that students engage deeply with scientific concepts and develop the critical thinking skills necessary to achieve higher levels of understanding in Physics.

Table 3: *Difference in Conceptual Understanding of Physics before and after the SCC intervention*

Variable	N	Mean	SD	T-value	P-value	Decision
Before using SCC intervention	30	61.27	8.93	13.66	0.00	Reject Ho
After using SCC intervention	30	89.07	11.92			
Difference						
95% CI for mean difference		(23.64, 31.96)				

Ho: There is no significant difference in conceptual understanding of Physics before and after the intervention.

D. Significant Difference in Conceptual Understanding among Students in Physics with Different Academic Ranks after the SCC Intervention

Table 4 presented the differences in conceptual understanding among students in Physics with different academic ranks after the SCC intervention. Their pre-test scores determined the student's academic rank. The analysis revealed that there was in conceptual understanding among students in Physics between upper-rank group (M= 96.33, SD = 10.01), and the lower-rank group (M=84.22; SD = 10.75) after the SCC intervention a significant difference in the conceptual understanding. The findings of the One-Way ANOVA show a highly significant difference in conceptual understanding between the two groups (F(1, 28) = 9.65, p = 0.004), leading to the rejection of the null hypothesis.

This significant difference between the upper- and lower-ranked groups suggests that while the SCC intervention improved overall conceptual understanding, it may have had more impact on students with a stronger academic foundation in physics. The higher pre-test scores of the upper-rank group likely positioned them to benefit more from the SCC intervention's advanced, simulation-based, and interactive nature. In contrast, students in the lower-rank group, who started with lower pre-test scores, might have required additional support to engage fully and benefit from the intervention.

This disparity highlights the need for differentiated instructional strategies when implementing the SCC intervention. Lower-ranked students may need supplementary scaffolding, such as more targeted instruction, one-on-one tutoring, or simplified conceptual introductions before transitioning to more advanced tasks like simulations and conceptual collages. Additionally, frequent formative assessments can help identify students who need further intervention and ensure that all learners progress toward higher levels of conceptual understanding.

A range of studies have explored improving conceptual understanding in different academic groups. Kelly et al. (2021) emphasize the need for diverse teaching methods focusing on reasoning, self-confidence, and working memory. Ashley et al. (2019) further underscore the need for tailored approaches, as differences in conceptual understanding among international business undergraduates were found to be influenced by factors beyond the curriculum. These studies suggest combining diverse teaching methods, tailored approaches, and multidimensional strategies can improve conceptual understanding in different academic groups.

Learning outcomes increase when the teaching approach accommodates each student's preferred learning style. Computer-based environments help meet students' needs by visualizing chemical and physical processes and improving conceptual comprehension (Trindade et al., 2002). Students' conceptual understanding of physics improved due to using virtual laboratories. (Gunawan et al., 2018). Simulations work to improve understanding of the concept of Science, not only students' understanding but also pre-service teachers' understanding (Widiyatmoko, 2018).

The findings indicate that, while the SCC intervention effectively improves conceptual understanding, students with lower pre-test scores may require additional assistance, such as personalized tutoring, frequent formative assessments, targeted feedback, and teacher training in differentiated instruction, to achieve gains comparable to their higher-ranked peers.

Table 4: *Difference in Conceptual Understanding among Students in Physics with Different Academic Rank after the SCC Intervention*

Source	Degree of Freedom	Sum of Square	Mean Square	F-value	P-value
Academic Rank	1	1056	1056	9.65	0.004
Error	28	3066	109		

Academic Rank	N	Mean	St.Dev	Decision
Lower Rank	18	84.22	10.75	
Upper Rank	12	96.33	10.01	Reject Ho

Note: **p<0.01 (Highly Significant); *p<0.05 (Significant); p>0.05 (Not significant)
Ho: There was no significant difference in conceptual understanding among physics students of different academic ranks after the SCC intervention.
Note: Academic Rank is determined by their pre-test scores. 0-60 Lower Rank; 60-120 Upper Rank

E. Additional Improvements in Conceptual Understanding with SCC Intervention

To enhance educational strategies, the Simulated-Conceptual Collage (SCC) intervention, combining metacards and recorded-virtual simulations, has emerged as a promising tool for improving students' conceptual understanding of Physics. Through a detailed analysis of student feedback, several key themes have been identified that highlight the impact of SCC on learning. These themes include enhanced understanding and retention, increased engagement and motivation, real-world application of concepts, preference for interactive and visual learning tools, and positive feedback on the learning experience. These themes

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provide a comprehensive view of how SCC intervention facilitates deeper comprehension of complex Physics concepts and fosters a more engaging and practical learning environment for students.

Enhanced Understanding and Retention

Many students reported that metacards and recorded virtual simulations helped them better grasp complex physics concepts like projection motion and momentum. These tools' visual and interactive nature made it easier for them to understand and remember the material.

"It interests me a lot because it's easier to understand the topic." (P8)

"The metacards and recorded virtual simulation make it easier for me to understand the lesson. It's easier to retain the topic." (P3)

Together, their responses highlight the tools' dual benefits of enhancing engagement and comprehension, making challenging subjects more accessible and memorable for students.

"These tools have made learning more accessible, engaging, and effective, ultimately enhancing interest and comprehension in subjects like projection motion and momentum." (P12)

"Learning with metacards and virtual simulation was really fun. It piqued my interest, such as learning motion and impulse. It makes grasping complex ideas in physics easier and has served as an effective study method for me." (P11)

Based on the findings highlighted above, it can be deduced that using strategic intervention materials (SIMs) in science classes enhanced effective learning and assisted the Grade 11 students develop good knowledge retention (Sinco, 2020). To help bolster these findings, an experiment using project-based instruction during high school chemistry and physics education positively affected the domain (Schneider et al., 2022).

The results show that metacards and recorded virtual simulations in a real-life setting improve students' grasping of complicated aspects within physics and their recall ability, which improves learning as it is more fun and productive. From this, it is clear that schools should incorporate some of these interactive tools in the curriculum and teacher training so that they can effectively use them.

Increased Engagement and Motivation

The interactive elements of SCC, such as virtual labs and real-time simulations, significantly increased students' engagement and motivation. Students were likelier to participate in class discussions and explore topics more deeply.

"It gives me energy to participate in the class. Especially like the impulse." (P7)

"The metacards and recorded-virtual simulations have increased my interest and participation in the study of physics concepts. I am more interested and motivated to learn." (P4)

Participants 7 and 4 highlighted the positive impact of metacards and recorded virtual simulations on their engagement, motivation, and interest in learning physics, particularly concepts like impulse. Their responses underscore the role of interactive and visual learning methods in capturing students' attention and fostering a genuine enthusiasm for learning complex subjects like Physics.

"We like the class more when there is a virtual lab and sticky notes instead of always discussing. For me, it's the best because we can engage and then we can have fun." (P4)

"Metacards and recorded-virtual simulations make me more interactive in class compared to traditional methods. They provide visual experiences, making hard topics easier to understand." (P3)

Participants 4 and 3 emphasized how metacards and recorded virtual simulations enhance engagement and motivation in physics by making lessons interactive, enjoyable, and effective for understanding challenging topics.

The context of science laboratory learning and the interest in learning Science emerged as highly relevant when predicting the science learning motivation and, as a result, the learning engagement of non-science students (Haw et al., 2022). Enhancing science learning self-efficacy from various perspectives is crucial to enhancing access and participation in sciences (Lin, 2021).

The findings underscore the importance of integrating interactive and visual learning tools, such as metacards and recorded virtual simulations, into the Physics curriculum. These tools significantly enhance student engagement, motivation, and comprehension, suggesting a shift from traditional teaching methods to more dynamic, interactive approaches. Schools should invest in these technologies and train teachers to implement them effectively.

Real-World Application of Concepts

Students appreciated the practical applications demonstrated through SCC. This real-world context helped them see the relevance of physics in everyday life and other subjects, making the learning experience more meaningful.

"Yes, projectile motion helped me better predict the trajectory of a ball when playing sports like basketball, allowing me to make more accurate shots." (P3)

"Yes, sir, I have applied what I learned from the metacards and recorded virtual simulation to real-life situations. Example, momentum helped me understand the importance of wearing a seatbelt in a car." (P2)

Participants 3 and 2 demonstrated how metacards and virtual simulations enhance practical understanding in physics, with Participant 3 applying projectile motion to basketball and Participant 2 recognizing momentum's relevance in everyday safety, like wearing seatbelts. Their responses underscore the tangible impact of Physics education on daily life, demonstrating how theoretical knowledge translates into practical applications, ultimately promoting safety and informed decision-making.

"Yes, sports is the best example." (P12)

"Yes, it answers why a bullet discharged from such a firearm is difficult to stop because the greater speed means greater momentum." (P10)

Participants 12 and 10 highlighted the real-world relevance of physics, with Participant 12 connecting projectile motion to sports and Participant 10 relating momentum to bullet trajectories, showcasing how physics empowers understanding and informed decision-making in daily life.

Yıldırım (2020) found that relating scientific concepts to students' daily lives enhances retention and application. However, Derman and Senemoğlu (2020) noted that classroom science often lacks real-life relevance, particularly for seventh graders, highlighting the need for improved teaching strategies. Saragih et al. (2023) propose using a scientific method to promote engaging, meaningful, and interactive learning opportunities.

The findings suggest that incorporating real-world applications into Physics education enhances student engagement and understanding. Educators should continue to integrate practical examples and simulations into the curriculum to demonstrate the relevance of Physics in everyday life. Students can use their knowledge in practical, real-world scenarios, such as hands-on experiments or project-based learning, to reinforce these concepts.

Preference for Interactive and Visual Learning Tools

Most students preferred SCC over traditional methods due to the tools' engaging and visually appealing nature. They found that these methods facilitated a deeper understanding and made learning more enjoyable.

"I prefer simulation because it's like a reality." (P8)

"Compared to traditional methods, I found learning with metacards and recorded-virtual simulations much better. It was interactive and made the concepts easier to understand and remember." (P2)

Both participants highlight the interactive nature of these tools, emphasizing how they enhance understanding and memory retention of complex concepts. Their responses highlight the importance of incorporating interactive and visual elements into the learning environment to provide a more engaging and effective educational experience.

"It enhanced my capabilities in learning and made it easy for me to grasp the lesson handed before me. I prefer the former option because giving information is fun and precise. But I also like the traditional methods because they give you experience and not from a simulation." (P11)

"Both are a great learning experience helps in your study's and learnings." (P9)

Participant 11 acknowledges that while interactive tools enhance learning by providing fun and precise information, traditional methods offer valuable hands-on experience. Similarly, Participant 9 appreciates the strengths of both methods, acknowledging their contributions to study and learning. Their responses emphasize the importance of combining various teaching approaches to fit various learning methods and maximize educational outcomes.

Hasanah and Sudira (2021) observed that integrating computers and images in scientific education improves students' self-directed learning using VLIM. Similarly, Islamyati (2021) validated the use of multimedia in science teaching. However, the experiments examined in this study indicate that, while integrating innovative teaching approaches with interactive and visual aids helps scientific learning, it may have a detrimental impact if balance and individual variations are not carefully handled.

Educators should integrate more interactive and visual learning tools into the curriculum to align with student preferences. Training teachers to effectively use these tools and incorporating both traditional and interactive methods can enhance the learning experience. Regular feedback from students will help refine these approaches, creating dynamic and engaging environments that promote deeper understanding and knowledge retention.

Positive Feedback on Learning Experience

Overall, students gave positive feedback on their learning experience with SCC. They felt it provided a comprehensive and effective way to learn physics, balancing theoretical knowledge with practical application.

"Writing down key concepts on sticky notes forces me to actively improve my understanding compared to passive listening in a lecture. The ability to pause, rewind, and replay specific simulation parts gives me a deeper understanding. I prefer the recorded virtual simulation because of real application." (P10)

"It gives a great learning experience." (P9)

"It is a great way of teaching because we can engage. I like this." (P5)

Overall, students expressed overwhelmingly positive feedback on their learning experience with Simulated-Conceptual Collage (SCC). They found it a comprehensive and effective way to learn physics, emphasizing its ability to balance theoretical knowledge with practical application. Participant 10 highlighted the active engagement facilitated by writing key concepts on sticky notes and the immersive experience of recorded virtual simulations, enabling a deeper understanding. Participants 9 and 5 echoed this sentiment, describing their experience as a great way of teaching that fostered engagement and enjoyment. These responses indicate that SCC effectively promotes active learning and facilitates a deeper understanding of physics concepts, contributing to a positive overall learning experience.

The positive feedback from students regarding their learning experience with Simulated-Conceptual Collage (SCC) indicates its effectiveness in facilitating a comprehensive understanding of physics concepts. Students appreciated the balance between theoretical knowledge and practical application offered by SCC. They found interactive elements; examples include writing key concepts on meta cards and using recorded virtual simulations, which are engaging and conducive to deeper learning. Overall, the feedback suggests that SCC promotes active engagement and enjoyment in learning, contributing to a positive educational experience for students.

According to Asiksoy (2023), virtual laboratories had a good effect on students' learning outcomes and opinions of physics lab activities, while González-Mena et al. (2024) discovered that visuo-haptic simulations improved engineering students' engagement and comprehension of fundamental physics topics. All of these research highlight how virtual simulations might enhance the physics education process.

The positive feedback on SCC underscores the importance of integrating interactive and practical learning tools into the curriculum. Educators should continue to leverage SCC and similar approaches to enhance student engagement and understanding of physics concepts. Providing training and support for teachers to implement these tools effectively is crucial. Additionally, schools should seek opportunities to expand access to SCC resources and ensure equitable access for all students. Continuous evaluation and improvement of SCC based on student feedback will further enhance its effectiveness in promoting active learning and student success in physics education.

VI. SUMMARY, FINDINGS, CONCLUSION, AND RECOMMENDATIONS

Summary

The study was conducted to improve grade 9 students' conceptual understanding of Physics using SCC intervention, a combination of metacards and recorded-virtual simulation, during the academic year 2023-2024 in a certain secondary public school in Ozamiz City. This study employed a classroom-based research design, selecting 30 students through purposive and stratified sampling with random sampling under specific conditions. The researcher made a two-tiered test to gather data, and the rubric in the scoring method has been adapted in the study of Baluyos to enhance students' conceptual understanding of Genetics. The data analysis used in the study includes calculating the mean and standard deviation, conducting a paired t-test, and using one-way ANOVA. Especially the objectives of the study were to (1) determine the level of conceptual understanding before the use of SCC intervention, (2) the level of conceptual understanding after the use of SCC intervention, (3) identify significant differences in conceptual understanding of Physics before and after the SCC intervention; (4) identify significant difference in conceptual understanding among students in physics with different academic rank after the SCC intervention; (5) explore additional improvements of the student's conceptual understanding after the use of SCC intervention.

Findings

The following key findings of the study:

1. The conceptual understanding level before using SCC intervention was within partial correct understanding, with a mean score of 61.27.
2. The conceptual understanding level after using SCC intervention was also within partial correct understanding, with a mean score of 89.07.
3. There was a significant difference in conceptual understanding of Physics before and after the SCC intervention.
4. After the SCC intervention, there was a significant difference in conceptual understanding among physics students of different academic ranks.
5. The additional improvements in students' conceptual understanding after using the SCC intervention included enhanced understanding and retention, increased engagement and motivation, real-world application of concepts, a preference for interactive and visual learning tools, and positive feedback on learning experiences.

Conclusion

The following conclusions were taken from the data shown in the tables:

1. There is notable room for improvement in students' conceptual understanding of physics concepts prior to the implementation of SCC intervention, indicating a potential need for said intervention.
2. After the SCC intervention, the level of conceptual understanding significantly improved, reaching a mean score of 89.07. The study demonstrates the effectiveness of SCC in enhancing students' comprehension of physics concepts.
3. The significant improvement in conceptual understanding of Physics before and after the SCC intervention underscores the effectiveness of SCC in enhancing students' grasp of physics concepts and highlights the potential for targeted interventions to positively impact learning outcomes.
4. The significant difference in conceptual understanding among physics students of different academic ranks after the SCC intervention suggests that SCC has the potential to reduce disparities in academic achievement and support students of varying abilities in mastering physics concepts.
5. The comprehensive set of additional improvements observed post-SCC intervention suggests that incorporating interactive and visual learning tools into the curriculum can yield multifaceted benefits, ranging from deeper understanding and retention of concepts to heightened engagement and motivation. These findings underscore the importance of adopting innovative teaching approaches like SCC to enhance students' academic performance and foster a more positive and enriching learning experience.

Recommendations

Based on the study's conclusions, the following recommendations suggested:

1. Schools and educational institutions should consider implementing SCC intervention as part of their physics curriculum to address the notable room for improvement in student's conceptual understanding observed prior to intervention.
2. Educators should receive adequate training and support in effectively utilizing SCC and similar innovative teaching approaches to enhance students' comprehension of physics concepts.
3. The significant improvement in conceptual understanding before and after SCC intervention highlights the potential for targeted interventions to positively impact learning outcomes. Schools should identify students who may benefit the most from SCC and provide additional support as needed.
4. Efforts should be made to ensure equitable access to SCC resources for all students, regardless of their academic rank or background, to reduce disparities in academic achievement and promote inclusive learning environments.
5. Schools should continuously evaluate the effectiveness of SCC and other interactive learning tools through feedback from students and

educators. Any identified areas for improvement should be addressed promptly to optimize learning outcomes.

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