Strategic Teaching of Astronomy: Reaching Space Thru Virtual Reality in Grade 9 Science (STARS VR-9)

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***Abstract*—Astronomy explores celestial bodies and the laws that govern the universe, but its abstract concepts often challenge students' understanding and interest, leading to disengagement. Traditional teaching methods often fail to convey effectively the vastness of astronomical concepts. This study developed and evaluated a Virtual Reality (VR)-integrated teaching material for Grade 9 Science, focusing on its content, VR integration, perceived usefulness, ease of use, and behavioral intention to use. Additionally, it examined students' experiences in learning astronomy. Using mixed—methods design, data were gathered through standardized and researcher-made questionnaires and interviews. The reliability of the instruments was confirmed using Cronbach's alpha, and data were analyzed using weighted means. The participants were Grade 9 science teachers and 48 students from Sta. Rita National High School, Division of Batangas City, Philippines. Results indicated that the material was well-aligned with the Department of Education's Learning Competencies, and the integration of VR significantly enhanced student engagement. VR was deemed effective, user-friendly, and fostered strong intentions among students to continue its use in studying astronomy. Students reported that VR improved their understanding, increased engagement and interaction, and heightened their interest in learning astronomy.**

***Keywords*—virtual reality, science education, astronomy, educational technology, instructional materials development**

I. Introduction

The universe has long inspired human curiosity, driving scientific exploration across generations. Astronomy, one of the oldest sciences, explores celestial bodies and the laws governing the universe. However, traditional methods of teaching astronomy, relying on textbooks and two-dimensional representations, often fail to engage learners, making complex concepts difficult to grasp. This gap can hinder students' understanding of astronomical phenomena and limit their appreciation for the vastness of the cosmos.

Virtual Reality (VR) offers a transformative solution in education by providing immersive, interactive learning experiences. Unlike conventional methods, VR allows students to visualize and explore complex astronomical concepts in three-dimensional environments. Globally, several countries, including China, the United States, and the UAE, have integrated VR into education, recognizing its potential to enhance learning outcomes [1]. In the Philippines, VR technology is seen as a significant step toward advancing the education system, particularly in science education [2].

VR in astronomy education promises to address the limitations of traditional approaches by offering an immersive platform for students to engage with celestial mechanics and cosmic phenomena. Prior research supports the claim that VR enhances comprehension and retention of complex astronomical concepts. For instance, immersive VR technologies improve spatial reasoning and conceptual understanding in astronomy education [3]. Similarly, it was found that VR applications foster deeper engagement and motivation among students studying celestial phenomena [4]. Rogers [5] emphasized that VR technologies are set to become a critical learning tool of the 21st century, capable of revolutionizing traditional teaching methods.

These studies have explored the general effectiveness of Virtual Reality (VR) in science and astronomy education. However, there is a notable gap in research specifically evaluating the integration of VR within the context of the Grade 9 science curriculum in the Philippines, particularly with alignment to the Department of Education (DepEd) learning competencies. Most existing studies focus on a broader scale or higher education levels, often overlooking localized and grade-specific contexts.

The present study addresses this gap by uniquely contributing to the development of an instructional material specifically designed for astronomy education in junior high schools. Unlike previous research that primarily evaluates generic VR tools or simulations, this study emphasizes the creation of curriculum-aligned, VR-based teaching materials tailored to meet the needs of Grade 9 students.

Furthermore, this study operates under the assumption that immersive technologies, particularly VR, can bridge gaps in conceptual understanding by providing experiential learning opportunities that traditional methods lack. It also assumes that students have sufficient access to VR tools and the necessary technological literacy to maximize the benefits of VR-based instruction.

Building on this premise, the researchers aimed to develop an instructional material called STARS-VR 9**,** which integrates virtual reality to enhance the teaching and learning of astronomy in the Grade 9 Science curriculum. Specifically, the study sought to address the following research questions:

1) How may the virtual reality integrated teaching and learning material STARS VR-9 for Grade 9 Science be evaluated in terms of: a) content; b) integration of virtual reality; c) perceived usefulness; and d) perceived ease of use.
2) What are the students' experiences in learning astronomy?

II. Literature Review

A. Teaching and Learning Junior High School Science

Education plays a vital role in shaping the future of individuals and societies. Within science education, junior

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high school serves as a critical phase where students begin to explore scientific concepts more deeply. This literature review examines key themes in teaching and learning junior high school science, student academic performance, and the integration of virtual reality in education. It begins by discussing broader perspectives and progresses toward more specific insights.

The teaching and learning of science at the junior high school level involve a dynamic mix of pedagogical strategies, engaging content delivery, and fostering a curiosity-driven approach to scientific exploration. At this stage, educators play a crucial role in establishing a foundation for scientific understanding, encouraging inquiry-based learning, and preparing students for the challenges of more advanced science education.

Despite the critical nature of this phase, various challenges impact the effectiveness of teaching and learning science. A significant issue faced by educators is the lack of adequate and appropriate instructional materials, which hinders the teaching process and student performance. Effective science education relies on the proper utilization of instructional materials. When these materials are lacking, teachers often resort to explaining concepts without engaging students in activities that the integrated science curriculum recommends [6]. Students in such settings often rely solely on reading textbooks, which limits the interactive and hands-on learning experiences necessary for science education [7].

Incorporating modern tools and digital resources into the educational framework provides students with a dynamic learning environment that mirrors the technological advances of the 21st century. Integrating technology into junior high school education inspires and empowers students, preparing them for the challenges of the Fourth Industrial Revolution [8]. The use of technology in classrooms fosters increased engagement and active participation, resulting in deeper comprehension of the subject matter and the development of critical thinking skills.

Chavan highlights another challenge that science teachers face: effectively communicating complex scientific concepts to students. To address this, educators are encouraged to incorporate creativity into their teaching methods, particularly through the development and use of enhanced instructional materials [9]. This creative integration of technology and teaching strategies allows teachers to better engage students and foster a deeper understanding of intricate scientific concepts.

Additionally, the shift toward aligning instructional materials with technological advancements reflects the evolving nature of modern curricula. The use of digital tools and interactive resources has become increasingly integrated into educational practices. However, teachers must adapt to these changes to ensure that students receive not only relevant content but also essential skills for utilizing technology effectively in their learning environments. One area in need of innovative instructional materials is astronomy education. Given the vast and complex nature of the cosmos, educators require resources that capture student interest and provide a deeper understanding of astronomical concepts [10]. Unfortunately, outdated or inadequate materials may fail to ignite curiosity, potentially compromising the overall effectiveness of the learning experience.

B. Virtual Reality in Science Education

The application of Virtual Reality (VR) in education, particularly in science, represents an emerging area of interest. VR offers a unique opportunity to enhance the learning experience by allowing students to interact with scientific concepts in an immersive, three-dimensional environment. VR can make learning more engaging and enjoyable, promoting a deeper understanding of the subject matter by stimulating multiple senses [11]. By using VR, students can move beyond the limitations of traditional textbooks, experiencing scientific phenomena in ways that were previously unimaginable.

In astronomy education, VR has proven particularly effective. Understanding astronomical concepts can be challenging due to the vast scales and intricate relationships involved in space and time. VR technology allows students to interact with three-dimensional representations of astronomical scenarios, enabling a more intuitive understanding of these concepts [12]. Additionally, VR provides heightened perceptual engagement, offering students a hands-on learning experience that fosters a deeper connection with the material [13].

The integration of VR into education represents a shift towards more interactive and engaging learning experiences. However, research gaps remain in understanding how professionals in education and public outreach perceive the potential of VR in their fields. Investigating their perspectives is crucial for developing strategies to effectively incorporate VR into educational practices, ensuring that students gain the full benefits of this technology [14].

As technology advances, its application in education becomes increasingly relevant. Virtual Reality (VR), particularly in science education, addresses complex concepts like astronomy and aids in achieving curricular objectives. Educators can enhance the learning experience by integrating immersive VR activities into lessons, which can engage multiple senses and promote deeper understanding and retention of content. Through VR, students can go beyond traditional teaching methods, fostering a dynamic and interactive environment that offers practical, hands-on experiences [15].

Virtual reality transforms learning into an engaging, memorable journey, allowing students to interact with 3D models of complex subjects such as cells or celestial bodies. This experiential learning fosters a deeper internalization of theoretical knowledge, making it more accessible for real-world application. By providing immersive experiences, VR makes education more enjoyable and practical, aligning with modern education trends that prioritize multi-sensory engagement to deepen student comprehension.

Incorporating VR in science teaching, especially for understanding celestial cycles, significantly enhances student engagement. Immersive simulations of astronomical phenomena make learning more captivating and technologically aligned. As VR technology evolves, educators must stay updated with these advancements to better prepare students for future challenges [16]. The increasing adoption of VR in schools, allowing students to virtually explore global destinations and experience 360-degree learning environments [17]. These VR environments foster engagement and motivation, offering a unique and impactful learning experience.

In conclusion, science education at the junior high school level faces several challenges, from inadequate instructional materials to difficulties in conveying complex concepts. However, with the integration of modern technology and innovative teaching methods, these challenges can be mitigated. Virtual reality, in particular, offers promising possibilities for enhancing the educational experience, especially in areas like astronomy, where traditional methods often fall short. As the educational landscape continues to evolve, the incorporation of immersive technologies like VR will play an increasingly significant role in preparing students for the challenges of the future.

III. Materials and Methods

A. Research Design

The methodology employed in this study was adapted from a combination of appropriate research designs. The researchers used the Design-Based Research paradigm in the development and evaluation of the STARS VR-9 resource, integrating technological innovation into the teaching and learning process. This design is a methodological approach that involves iterative design cycles to generate insights and enhance educational practices [18]. In this study, the iterative process was applied by testing and revising STARS VR-9 based on the feedback from expert validators before implementation. To evaluate the design features of STARS VR-9, the researchers employed both standardized and researcher-made questionnaires. The study adapted the standardized questionnaire of the Department of Education's LRMDS Assessment and Evaluation and another main instrument that is based on the Technology Acceptance Model (TAM) of Fred Davis. It includes the perceived usefulness, perceived ease of use, and behavioral intention to use. To assess the integration of virtual reality in the teaching and learning material, the researcher-made questionnaire was used.

On the other hand, interviews and focus-group discussions were conducted to investigate the experience of Grade 9 students on the use of virtual reality in learning Astronomy.

B. Participants of the Study

The participants of this study were 44 Grade 9 students from a homogeneous class at Sta. Rita National High School. The students were selected based on their enrollment in the same astronomy-focused science class, ensuring consistency in curriculum exposure and prior knowledge. The class was composed of students aged 14 to 15 years old, with varying levels of familiarity with virtual reality technology. Prior to the study, students and their parents or guardians were informed about the study objectives, procedures, and potential benefits or risks. Written informed consent was obtained from all participants and their parents or guardians to ensure ethical compliance. Additionally, potential practical issues related to the implementation of VR, such as limited device availability, students' unfamiliarity with the technology, and the need for teacher support and stable internet connectivity were considered and addressed as part of the preparation process.

This study did not include a formal control group. However, future research could incorporate a control group to strengthen the validity of findings while ensuring that all students eventually receive equal access to VR-based learning interventions. Additionally, the study acknowledges the limitation of its sample size, which consisted of students from a single school and class. Future research should consider including a larger, more diverse sample to enhance generalizability and provide a broader understanding of VR's effectiveness in different educational settings.

C. Development of STARS VR-9

The researchers designed and developed a teaching and learning material with virtual reality called STARS VR-9 which is tailored specifically for Grade 9 science lesson on astronomy and aligned with the Most Essential Learning Competencies (MELCs) set by the Department of Education, particularly based on the CLMD-4A Budget of Work. This resource integrates highly interactive and visually dynamic virtual reality representations of celestial bodies and astronomical phenomena. These include detailed 3D models of planets, galaxies, and constellations that change position based on Earth's movement throughout the year.

The design and specifications for the virtual reality component integrated into the material were conceptualized by the researchers. To ensure both technical precision and educational relevance, the researchers partnered with a professional software engineer to develop the VR component in STARS VR-9. This collaboration allowed the seamless merging of educational objectives with cutting-edge VR design principles.

The development process is structured into several phases to ensure each objective is smoothly and thoroughly addressed in the material. The initial phase involved outlining the content and defining four primary objectives for the teaching and learning material. These objectives are: infer the characteristics of stars based on the characteristics of the Sun; infer that the arrangement of stars in a group (constellation) does not change; observe that the position of a constellation changes in the course of a night; and show which constellations may be observed at different times of the year using models.

The objectives were considered to ensure a detailed explanation of the topics in the material. This phase also included extensive research to find suitable references online. Once the content outline and references were finalized, the development team began curating assets and videos to integrate into the virtual reality software application. This included selecting relevant and high-quality videos as well as collecting appropriate background music and images to enhance the virtual reality experience.

Also, Grade 9 science teachers are considered experts in the subject matter that is why they validated the selected videos. Their recommendations guided further refinements and ensured the resources were suitable for the intended audience. After the validation of the resources, the final list of videos and assets was compiled. The researchers then proceeded to integrate these into a cohesive teaching and learning material. This phase required attention to ensure all components were aligned with the set objectives. In finalizing the teaching and learning material with virtual reality components, it underwent another round of validation by

Grade 9 teachers and faculty experts from a higher education institution.

Upon approval, the software development team commenced work on the virtual reality application. To ensure the application met quality standards and functioned effectively, different testing stages were implemented together with the researchers. During the 30% Completion Testing phase, the initial round of testing took place to identify and address any major issues. This early testing focused on spotting any critical problems that could affect the functionality or user experience.

Next, the 50% Completion Testing phase followed. The focus here was on refining the functionalities and making improvements to enhance the overall user experience based on feedback and observations from the initial testing. Finally, as the project neared completion, the 80% Completion Testing phase was conducted. This final pre-completion testing ensured everything was in place and ready for full implementation, with a last check to guarantee that the system met all necessary requirements and was functioning as expected.

Once the virtual reality application reached 100% completion, a final round of testing was conducted with the researchers and the development team. Grade 9 teachers and the adviser of researchers verified the application's readiness for implementation. With their approval, the teaching and learning material with virtual reality was deemed ready for implementation in the classroom setting.

Fig. 1. Sample virtual reality assets incorporated in STARS VR-9.

By placing students "inside" a simulated universe, STARS VR-9 enables them to observe and interact with astronomical phenomena in ways that traditional classroom tools cannot replicate. For example, learners can explore how the visibility of constellations changes as Earth progresses along its orbital path. This hands-on virtual environment not only enhances their conceptual understanding but also fosters curiosity and deeper engagement with the subject matter (Fig. 1).

D. Implementation of STARS VR-9

The researchers obtained necessary permissions to conduct the study from the principal of Sta. Rita National High School. Subsequently, informed consent was sought from both students and their parents or guardians. Information regarding the study's objectives, procedures, and potential impacts was clearly communicated to ensure transparency and voluntary participation.

The implementation of the material was carefully structured and executed to ensure the seamless integration of virtual reality technology into the Grade 9 science curriculum. The researchers prepared extensively prior to the testing phase that makes the process efficient and well-organized. The breakdown of the implementation is structured into several phases. Upon reaching 80% readiness during the material development phase, the researchers prepared eight VR headsets. These were configured so that mobile phones could easily be inserted when students were ready to use them. By the time the material was 100% ready for testing, all necessary tools and equipment were in place.

The implementation involved grouping the Grade 9 students into eight groups which consists of six members. This was done with the guidance and assistance of the Grade 9 adviser. The implementation spanned seven days and was initiated by the Grade 9 science teacher, who introduced the topic and explained the objectives of the lesson. Thus, students were clear about the purpose of the lesson and what they were expected to learn. The session began with all groups forming circles with their respective group mates. To provide clarity and eliminate confusion, two students were invited to the front for a live demonstration of how to use the VR headsets (Fig. 2).


Fig. 2. Students using STARS VR-9.

After the demonstration, the activity progressed as follows. Each group was assigned a VR headset, and the students took turns using it to experience the content individually. After one student completed their turn, the headset was passed to the next member of the group. This systematic rotation made sure that every student had the opportunity to engage with the material. The implementation of the lesson was divided into two phases to ensure all learning objectives were achieved.

During Days 1–3, the focus was on addressing the first and second objectives. These days were dedicated to introducing the topic and helping students visualize specific scientific concepts through the virtual reality content, where they explored the characteristics of stars and observed how constellations maintain their arrangement. This gave them the chance to engage with the material in an interactive and immersive way.

By placing students "inside" a simulated universe, STARS VR-9 enables them to observe and interact with astronomical phenomena in ways that traditional classroom tools cannot replicate. For example, learners can explore how the visibility of constellations changes as Earth progresses along its orbital path. This hands-on virtual environment not only enhances their conceptual understanding but also fosters curiosity and deeper engagement with the subject matter (Fig. 2).

The following Days 4–7 were focused on the third and fourth objectives. These days provided students with an opportunity to dive deeper into the topic that allows them to analyze and synthesize information based on their VR experiences, as they observed the changing positions of constellations throughout the night and identified which constellations could be seen at different times of the year using models. By the end of the seven-day period, every student had completed their individual interaction with the VR material. Even though the VR-based portion of the lesson was completed within seven days, the topic was allotted a total of ten days in the curriculum.

On Days 8–9, students participated in teacher-led activities that helped reinforce and apply what they had learned from the VR sessions. Finally, on Day 10, a long test was administered to assess the students' understanding and retention of the material they had explored.

Following the two-week implementation phase, qualitative data were collected through semi-structured interviews with participating students. These interviews aimed to assess students' learning experiences, perceptions of the virtual reality material, and overall engagement with the astronomy content. The interview questions were designed to elicit detailed responses about the students' understanding of astronomical concepts, enjoyment of the learning process, and any challenges faced during the use of the VR material. While the two-week duration allowed for alignment with the prescribed curriculum guide for the Astronomy topic, and an immediate assessment of engagement and comprehension, it also presented certain limitations. The short timeframe may not fully capture the long-term effects of VR-based learning, particularly in terms of knowledge retention and deeper conceptual understanding. Future studies may benefit from extended implementation periods or follow-up assessments to explore the sustained impact of VR in astronomy education.

The qualitative data collected from student interviews were analyzed through a rigorous thematic analysis process. Initially, the researchers transcribed all interview recordings verbatim to ensure accuracy and preserve the depth of the participants' responses. The transcripts were then read multiple times to familiarize the researchers with the content and context of the data.

Next, an open coding process was conducted, where segments of the data were assigned descriptive labels or codes that captured key ideas or experiences shared by the participants. These codes were systematically reviewed and grouped into broader categories to identify recurring themes and patterns relevant to the learning experience with the STARS VR-9 resource.

To ensure the reliability of the coding process, inter-rater reliability checks were performed by involving a second researcher to independently code a subset of the data. Any discrepancies between coders were discussed and resolved through consensus, enhancing the credibility of the findings.

Additionally, several strategies were employed to minimize potential bias in students' self-reported data. First, triangulation was used by comparing interview responses with classroom observations and performance assessments, ensuring that students' reported experiences aligned with actual engagement and learning outcomes. Second, anonymity was assured during the interview process to encourage students to provide honest and uninfluenced responses. Third, the researchers employed member checking, where participants were given the opportunity to review and confirm the accuracy of their responses, reducing the likelihood of misinterpretation or response bias. Finally, neutral and open-ended questioning techniques were used to prevent leading questions that could shape participants' answers in a particular direction.

Once themes were identified, the researchers analyzed their relationships and significance in the context of the study's research objectives. For example, themes related to student engagement, conceptual understanding, and ease of use were linked to the effectiveness of the STARS VR-9 resource in enhancing astronomy education.

Finally, the results were interpreted and synthesized into a cohesive narrative, providing nuanced insights into the participants' experiences and perceptions of using virtual reality as a learning tool in Grade 9 science education. While this comprehensive approach to thematic analysis ensured that the findings were both rigorous and meaningful, it is important to note that the results are inherently limited by potential biases in the students' self-reported data.

IV. Result and Discussion

A. Evaluation of STARS VR-9

1) Content

This study aims to evaluate the content of the STARS VR-9, a virtual-reality integrated teaching and learning material developed for Grade 9 astronomy, against the Most Essential Learning Competencies (MELCs) established by the Department of Education (DepED).

As shown in Table 1, Grade 9 teachers evaluated the content of the teaching materials, noting a high level of alignment with the Department of Education's (DepED) Learning Competencies for the intended subject and grade level. The Most Essential Learning Competencies (MELCs) serve as a foundation for designing and developing lesson materials. MELCs begin by establishing clear goals and objectives, thereby providing a roadmap for the teaching and learning process. These competencies assist educators in crafting effective learning experiences that align with curricular needs and objectives [18].

Table 1. Evaluation of the virtual reality integrated teaching and learning material in terms of content

Descriptors	Mean	Interpretation
1. Content is consistent with topics/skills found in the DepED Learning Competencies for the subject and grade/year level it was intended.	3.80	Strongly Agree
2. Concepts developed contribute to enrichment, reinforcement, or mastery of the identified learning objectives.	3.40	Agree
3. Content is accurate.	3.50	Strongly Agree
4. Content is up-to-date.	3.50	Strongly Agree
5. Content is logically developed and organized.	3.70	Strongly Agree
6. Content is free from cultural, gender, racial, or ethnic bias.	3.30	Agree
7. Content stimulates and promotes critical thinking.	3.40	Agree
8. Content is relevant to real-life situations.	3.60	Strongly Agree
9. Language (including vocabulary) is appropriate to the target user level.	3.10	Agree
10. Content promotes positive values that support formative growth.	3.00	Agree
Composite Mean	3.43	Agree

The evaluation of the Virtual Reality Integrated Teaching and Learning Material, as shown in Table 1, provides insightful data on the perceived effectiveness of the content delivered to Grade 9 students. The composite mean score of 3.43 indicates an overall agreement among educators regarding the material's quality and alignment with educational standards.

Firstly, the highest score was given to the descriptor stating that the content is consistent with the DepED Learning Competencies, with a mean of 3.80, which received a "Strongly Agree" interpretation. This aligns with previous research by Zalun [19], which emphasized the importance of aligning educational materials with the Most Essential Learning Competencies (MELCs) to ensure that teaching resources are relevant and effective for learners. Such alignment fosters a coherent teaching framework, as it establishes clear learning objectives that guide both educators and students.

The descriptors concerning the accuracy and logical organization of the content also scored high, at 3.50 and 3.70, respectively, both categorized as "Strongly Agree". Rapanta *et al.* [20] highlight that well-structured content aids learners in understanding the material's organization and expectations, enabling them to track their learning progress effectively. This organization is crucial, especially in complex subjects like astronomy, where conceptual clarity can significantly impact student understanding and retention.

In terms of content relevance to real-life situations, a mean score of 3.60 reflects strong agreement from the educators. Riaz [21] supports this finding, noting that when educational content connects with students' everyday experiences, it enhances their motivation and critical thinking skills. The inclusion of real-life scenarios encourages students to apply their knowledge practically, promoting deeper engagement with the material.

However, the evaluation revealed lower scores in areas promoting positive values (3.00) and appropriateness of language (3.10), which were categorized as "Agree". The integration of values in science education has been noted as challenging due to the empirical nature of the discipline [22]. This limitation suggests that while the STARS VR-9 effectively engages students with scientific concepts, there remains a need for intentional efforts to weave positive values into the curriculum. Additionally, Alexander [23] emphasizes the importance of using language that matches the students' comprehension levels, arguing that misalignment can hinder learning and student engagement.

Overall, the evaluation outcomes highlight the effectiveness of the STARS VR-9 teaching and learning material in delivering high-quality, relevant, and organized content while also pointing to areas for improvement in fostering values and language appropriateness in educational

2) Integration of virtual reality

This study evaluated how well the VR elements are incorporated into the teaching and learning material and their impact on students' learning experiences.

As presented in Table 2, the evaluation of the Virtual Reality Integrated Teaching and Learning Material reveals a strong endorsement of the effectiveness of Virtual Reality (VR) integration in enhancing educational experiences for Grade 9 Science students, with a composite mean score of 3.51, indicating a "Strongly Agree" interpretation.

Table 2. Evaluation of the virtual reality integrated teaching and learning material in terms of integration of virtual reality

Descriptors	Mean	Interpretation
1. The virtual reality components were seamlessly integrated into the teaching material.	3.60	Strongly Agree
2. The virtual reality components were appropriately synchronized.	3.70	Strongly Agree
3. The integration of virtual reality components contributed positively to the overall engagement of students.	3.90	Strongly Agree
4. The virtual reality components complemented the traditional teaching methods in Grade 9 Science.	3.30	Agree
5. The virtual reality components were effectively utilized to simulate real-world applications of constellations.	3.40	Agree
6. The integration of virtual reality added value to the depth of understanding of Grade 9 science concepts.	3.60	Strongly Agree
7. The virtual reality component facilitated interactive learning experiences.	3.80	Strongly Agree
8. The use of virtual reality technology enriched the visual and spatial aspects of the constellation topic.	3.50	Strongly Agree
9. The virtual reality components were seamlessly embedded within the broader teaching framework.	2.90	Agree
10. The integration of virtual reality in teaching constellations contributed positively to the educational objectives.	3.40	Agree
Composite Mean	3.513	Strongly Agree

The highest-rated item was the contribution of VR integration to overall student engagement. This finding is supported by Varthana [24], who notes that the synchronous alignment of visuals and audio in VR technology fosters immersive and interactive educational experiences. Such engagement is crucial, as it helps students better grasp complex concepts, making learning not only more effective but also more accessible.

Following closely, the item stating that VR facilitated interactive learning experiences scored a mean of 3.80, also reflecting a "Strongly Agree". This aligns with the notion that VR technology promotes active participation, allowing students to explore scientific concepts dynamically rather than passively receiving information. Additionally, the item indicating that VR elements were appropriately synchronized received a mean score of 3.70, reinforcing the importance of coherence in educational technology to maintain the flow of learning and prevent disorientation among students.

Conversely, the evaluation identified areas for improvement, particularly in items related to the seamless embedding of VR within the broader teaching framework and the complementarity of VR features with traditional teaching methods. These findings suggest a need for a more integrated approach, as technology alone cannot replace the invaluable human interaction inherent in traditional teaching. While technology serves as a valuable supplement, it cannot fully replicate the nuanced and varied nature of in-person teaching [25].

Furthermore, the items regarding the effective utilization of VR components to simulate real-world applications of constellations and the contribution of VR to educational objectives also ranked lower. These results resonate with research studies which highlights that while VR has successfully simulated real-world applications and provided immersive learning experiences, its impact can vary based on implementation. The ability of VR to create a risk-free environment for students to explore complex concepts is indeed beneficial, but there is still a gap in fully realizing its potential in achieving educational goals [26].

In summary, while the integration of virtual reality in teaching astronomy has shown significant promise, particularly in enhancing student engagement and interactive learning, further efforts are required to ensure that VR is effectively embedded within existing teaching frameworks. This will enhance its ability to complement traditional teaching methods and maximize its contribution to educational objectives.

3) Perceived usefulness

The perceived usefulness is the users' subjective belief that employing specific technologies will enhance their performance in a certain task or subject. This concept is a key component of the Technology Acceptance Model by Davis. The specific technology being used is the virtual reality in the teaching and learning material in Grade 9—Science, particularly in astronomy.

Table 3 presents the evaluation for the content of the virtual reality integrated teaching and learning material in terms of perceived usefulness.

Table 3. Evaluation of the virtual reality integrated teaching and learning material in terms of perceived usefulness

Descriptors	Mean	Interpretation
1. Using virtual reality in learning Astronomy enabled me to accomplish tasks more quickly.	3.52	Strongly Agree
2. Using virtual reality improved my academic performance in astronomy.	3.60	Strongly Agree
3. Using virtual reality increased my learning productivity.	3.29	Agree
4. Using virtual reality would enhance the effectiveness of learning astronomy .	3.88	Strongly Agree
5. Using virtual reality made it easier to do my learning tasks in astronomy.	3.40	Agree
6. Using virtual reality is useful in my learning of astronomy.	3.48	Agree
Composite Mean	3.53	Strongly Agree

As shown in Table 3, students overwhelmingly agreed that using Virtual Reality (VR) enhances the effectiveness of learning astronomy, with this item receiving the highest response. This finding aligns with the research that VR has significant potential to transform astronomy education by providing immersive and innovative learning environments that facilitate a deeper understanding of the subject matter [27]. The ability of VR to create engaging experiences makes it a valuable tool for improving students' comprehension of complex astronomical concepts.

Conversely, the item regarding the use of virtual reality to increase productivity received the lowest response from students. It is to be noted that future learning experiences enhanced by VR are anticipated to be more efficient, cost-effective, and conducive to productivity [28]. However, the effectiveness of these experiences is contingent upon students' self-management skills and their ability to complete tasks within designated timeframes. This highlights the importance of developing students' time management abilities alongside the integration of VR technologies in the learning process.

4) Perceived ease of use

The perceived ease of use is the extent to which a person believes that using a particular technology will require minimal effort. It can be described by the design of the user interface and the complexity of the virtual reality technology. This concept is another key component of the Technology Acceptance Model.

Table 4 presents the evaluation for the content of the virtual reality integrated teaching and learning material in terms of content.

Table 4. Evaluation of the virtual reality integrated teaching and learning material in terms of perceived ease of use

Descriptors	Mean	Interpretation
1. Learning to use virtual reality in STARS VR-9 is easy for me.	3.54	Strongly Agree
2. STARS VR-9 is designed in a way that makes it user-friendly.	3.63	Strongly Agree
3. The interactive use of virtual reality in STARS VR-9 accorded a seamless experience for me .	3.27	Agree
4. Navigating STARS VR-9 is clear and understandable which made it easy to use for me,	3.77	Strongly Agree
Composite Mean	3.55	Strongly Agree

As illustrated in Table 4, the item receiving the highest response from students indicates that Virtual Reality (VR) is perceived as clear and understandable, facilitating ease of use. This finding is supported by a research that highlighted the effectiveness of VR hinges on its ability to provide a comprehensive and coherent display [29]. Clarity is crucial in any technological application, particularly in VR environments, where clear interfaces, controls, and interactions significantly enhance the overall user experience. A user-friendly interface not only fosters comprehension but also encourages students to engage more deeply with the material.

In contrast, the item with the lowest student response pertains to the perception of seamless interaction within the VR environment. This suggests that while students may appreciate the clarity of the technology, they do not always find the interactive aspects compelling. Holo [30] noted that the level of interaction in VR can vary significantly, with the degree of immersion influencing the user experience. Some students may not perceive certain types of VR as engaging, indicating that the interactive components may need further refinement to capture and maintain interest.

B. Students' Experiences in Learning Astronomy Using STARS VR-9

Thematic analysis was used in the exploring the students' experiences in learning astronomy using STARS VR-9, as derived from Focus Group Discussions (FGDs). Several recurring themes emerged from the transcriptions, enriching the analysis and interpretation of the gathered data.

1) Understanding and comprehension

Students' experiences serve as powerful educational tools, allowing them to engage directly with material and deepen their understanding. Virtual reality (VR) technology enhances comprehension by enabling students to visualize complex astronomical concepts in three dimensions, thereby facilitating easier understanding. Participants in the FGD consistently highlighted how VR features contributed to their grasp of astronomical topics. One student remarked, "*The fact that virtual reality creates everything in 3D makes it easier to understand the topic*." Another noted, "*I feel like I am actually floating through space, surrounded by stars and planets*." Such immersive experiences not only enhance engagement but also support deeper learning by allowing students to visualize and interact with astronomical phenomena in a realistic manner. VR has revolutionized astronomy education by offering environments that would otherwise be inaccessible, providing a sense of presence that traditional learning lacks [31].

Furthermore, VR allows students to explore celestial bodies and understand their characteristics more intuitively. For example, several participants shared experiences that clarified their understanding of specific concepts, such as star colors and constellations. One student stated, "*I thought the star was yellow, but through this virtual reality, I noticed different colors of stars*." Another expressed, "It is hard for me to understand before how to determine if a star shines brighter." VR can bridge gaps in students' understanding by transforming abstract concepts into concrete experiences. By visualizing how different factors affect a star's appearance, students can reconcile theoretical knowledge with real-world observations, leading to enhanced comprehension and retention [32].

The ability of VR to simplify complex astronomical ideas was further emphasized in student responses. One participant shared, "Through virtual reality, I found it easier to grasp concepts related to the scale and distances in the universe." The immersive nature of VR helps students visualize the vastness of space and the relationships between celestial bodies in a way that traditional methods cannot achieve.

2) Engagement and interaction

The multisensory engagement offered by VR enhances students' learning experiences, making complex ideas more accessible. Participants noted that the immersive nature of VR technology made them feel as if they were truly exploring space. One student stated, "*The immersive nature of the technology allows users to feel like they are actually inside the virtual world*." Another mentioned, "*The most engaging part of virtual reality is the feeling that you are truly seeing the space or stars*." Such feedback reflects how VR increases student engagement through its ability to create a realistic and interactive learning environment. VR has emerged as a groundbreaking educational tool, offering opportunities for engaging and interactive learning experiences [33].

Additionally, the integration of visual and auditory elements in VR significantly contributes to student engagement. Realistic textures, dynamic lighting, and authentic environmental sounds create an immersive atmosphere, allowing students to feel genuinely part of the virtual environment. One participant expressed, "*The combination of spatial audio with visual elements makes my experience more captivating*." The importance of these elements is echoed in a study by the University of Silicon Valley [34], which highlights that audio cues enhance the emotional impact of the experience and validate the visuals, making the learning experience more believable and engaging.

3) Impact on interest in astronomy

Virtual reality has significantly heightened student interest in astronomy by transforming the way they explore the universe. Participants expressed how VR allows them to experience space up close, with one stating, "*It makes me want to know more about outer space*." Another noted, "*It made me realize the beauty and complexity of the subject*." The immersive nature of VR sparks curiosity and motivates students to explore astronomical concepts further, underscoring how technology can enhance learning experiences [35].

In conclusion, the integration of VR in astronomy education not only aids comprehension but also fosters engagement and interest among students, demonstrating the potential of innovative technologies to enrich learning experiences.

V. CONCLUSION

The study concludes that that the content presented in the Virtual Reality (VR) lessons aligns well with the Department of Education (DepEd) learning competencies. This integration of VR not only meets curriculum standards but also enhances students' overall engagement in the learning process. The immersive nature of VR technology has been shown to significantly boost the effectiveness of learning, allowing students to interact with complex astronomical concepts in a more tangible and relatable manner. Furthermore, participants noted that the clarity and intuitive design of VR tools made them accessible and easy to use, fostering a positive learning environment. Consequently, students expressed a strong intention to continue using virtual reality as a learning aid in their astronomy studies, indicating a shift towards more innovative educational practices.

The integration of virtual reality in astronomy education serves as a powerful tool for enhancing student engagement, comprehension, and interest, aligning with modern pedagogical approaches that emphasize interactive and experiential learning. The findings of this study underscore the importance of adopting innovative technologies in the educational landscape to foster a deeper understanding of complex subjects and inspire the next generation of learners.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dr. Sherryl M. Montalbo conceptualized the research topic and provided overall direction for the study. Ms. Baby Apple Perada, Ms. Kristine Hazel Peñaverde, and Mr. Anthony Parayno conducted the research and drafted the full-length manuscript under Dr. Montalbo's guidance. Dr. Montalbo took the lead in writing and finalizing this journal article. All authors had approved the final version.

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