

Digital Simulation Of Space Tourism With Solar System Scope: A Pathway To Students' Science Literacy And Tourism Futures

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Abstract

This study aims to address the challenges of students' digital science literacy in learning astronomy by applying the concept of space tourism using the Solar System Scope as a digital learning medium.

Design/Methodology/Approach: A quantitative approach with a one-group pretest–posttest experimental design was employed. Data were collected through a digital science literacy test and a student response questionnaire. The intervention integrated Solar System visualization into the learning process to provide an engaging virtual exploration of space.

Findings: The results revealed a significant improvement in students' digital science literacy. The average pretest score of 64% increased to 85% in the posttest. The student response questionnaire also yielded a score of 79.91%, indicating positive attitudes and heightened interest toward the learning experience.

Research Limitations/Implications: This study was limited to a small sample and focused on the topic of astronomy. Future research could extend the application of space tourism–based digital media to broader science topics and larger student populations. The findings highlight the potential of immersive digital technology to enhance science education and student engagement.

Originality/Value: This study introduces the use of Solar System Scope within the framework of space tourism as an innovative digital learning medium to improve students' science literacy. It provides new insights into how virtual space exploration can connect abstract scientific concepts with real-world contexts, fostering both motivation and understanding among students.

Keywords: Space tourism, Digital science literacy, Solar System Scope, Astronomy education, Digital learning media, Generation Z

1. INTRODUCTION

Space tourism has emerged as one of the most intriguing frontiers of the tourism industry, offering opportunities to explore celestial environments beyond Earth through both physical and virtual experiences (Collins & Autino, 2019; Peeters, 2021). While commercial space travel is still limited, the concept of virtual space tourism supported by immersive digital applications provides an accessible and educational pathway for broader audiences, particularly students, to engage with the cosmos. Applications such as *Solar System Scope* allow users to navigate planetary orbits, visualize astronomical phenomena, and simulate interplanetary journeys, thereby creating an experiential bridge between scientific knowledge and tourism imagination.

The integration of digital simulation into space tourism aligns with the broader trend of digital transformation in tourism, where immersive technologies such as virtual reality, augmented reality, and mixed reality are increasingly used to enhance visitor experiences (Buhalis et al., 2023; Fan et al., 2022). These technologies not only provide entertainment but also serve educational and cultural purposes, enabling users to explore environments that are otherwise inaccessible. In the context of science education, space tourism simulations offer students opportunities to visualize abstract astronomical concepts, enhance engagement, and strengthen digital science literacy.

However, existing studies on astronomy education primarily focus on improving conceptual understanding and motivation (Imronah et al., 2022; Fauzi et al., 2023). Few have explicitly examined how space tourism–based digital simulations contribute to developing digital science literacy, which encompasses skills such as interpreting digital information, navigating virtual environments, and applying scientific reasoning in digital contexts. This indicates a gap in the literature concerning the intersection of tourism futures and educational technology.

The present study addresses this gap by employing the concept of virtual space tourism using *Solar System Scope* as a learning medium. By framing digital astronomy education within the paradigm of space tourism,

this research not only enhances students' science literacy but also prepares Generation Z to engage with the emerging discourse on space travel as part of the tourism futures agenda. Specifically, this study investigates the effectiveness of solar system visualization in improving students' digital science literacy while fostering their engagement and motivation through a tourism-oriented digital experience.

2. LITERATURE REVIEW

Space tourism and tourism futures

Space tourism has evolved from a speculative concept into a growing area of both academic inquiry and commercial practice. Defined as recreational or educational travel beyond Earth's atmosphere, space tourism represents a transformative frontier for the tourism industry (Collins & Autino, 2019; Peeters, 2021). While physical participation in orbital or suborbital flights is currently restricted to highly trained astronauts and wealthy individuals, digital and virtual simulations have made space exploration more accessible to the wider public. Within the tourism futures discourse, space tourism is positioned as a driver of innovation, sustainability debates, and new forms of cultural and educational engagement (Buhalis et al., 2023). This duality—commercial development and educational enrichment—underscores its potential as both an industry and a pedagogical tool.

Digital science literacy in the 21st century

Digital science literacy refers to the ability to interpret, evaluate, and apply scientific information in digital environments (Bayu et al., 2023; Putri et al., 2022). It extends beyond basic digital literacy by emphasizing competencies such as understanding simulations, conducting virtual experiments, and applying scientific reasoning in digital contexts. In science education, these skills are critical for preparing students to engage with complex global challenges through evidence-based and technologically mediated knowledge. Previous research indicates that students often struggle with abstract concepts in astronomy, particularly when learning about orbital mechanics, planetary environments, and cosmic phenomena (Imronah et al., 2022; Johnson & Hall, 2021). Digital literacy in science thus becomes an essential bridge for transforming abstract knowledge into meaningful learning experiences.

Immersive technologies and virtual tourism in education

The rise of immersive technologies—such as virtual reality (VR), augmented reality (AR), and mixed reality has reshaped both tourism and education by providing engaging and interactive experiences that transcend physical limitations (Fan et al., 2022; Guttentag, 2010). In tourism, these technologies simulate environments that tourists cannot directly access, including heritage sites, natural landscapes, or outer space. In education, they allow students to visualize abstract concepts, enhance motivation, and foster deeper engagement with content. Previous studies have shown that digital applications related to the solar system can improve conceptual understanding and stimulate interest in science learning (Fauzi et al., 2023; Nurhayati & Arifin, 2021). However, most of these studies have not explicitly framed such applications within the paradigm of space tourism, nor have they emphasized their role in cultivating digital science literacy.

Research gap

Although the literature highlights the potential of space tourism and immersive technologies in both tourism and education, little attention has been paid to their integration in developing digital science literacy. Studies on space tourism largely emphasize commercial and technological perspectives, while research in science education tends to focus on learning outcomes or motivation. The intersection of these domains—using virtual space tourism as a pedagogical medium for enhancing digital literacy remains underexplored. Addressing this gap, the present study introduces *Solar System Scope* as a space tourism-based learning tool to improve students' digital science literacy, thereby contributing both to the field of tourism futures and to innovative approaches in STEM education.

Conceptual Framework

The conceptual framework of this study integrates three domains: space tourism futures, immersive digital media, and digital science literacy in education. Space tourism, when framed not only as an industry but also as a pedagogical concept, provides students with opportunities to explore the cosmos virtually in ways that mimic tourism experiences (Collins & Autino, 2019; Peeters, 2021). This aligns with the discourse of tourism futures, which emphasizes innovation, digital transformation, and experiential engagement.

Immersive digital media such as *Solar System Scope* functions as a bridge between tourism imagination and scientific education. It enables students to visualize planetary orbits, distances, and environmental conditions that are otherwise abstract or inaccessible. By presenting astronomy learning as a virtual journey, the intervention transforms traditional classroom learning into an engaging, exploratory activity.

The ultimate goal is to enhance digital science literacy, which involves the ability to interpret scientific simulations, apply reasoning in digital contexts, and connect astronomical knowledge to real-world issues (Bayu et al., 2023). Through space tourism-based simulations, students not only gain conceptual understanding but also develop broader 21st-century competencies, including motivation, engagement, and critical digital skills. Thus, the framework posits that space tourism (independent variable), operationalized through immersive digital media, serves as an innovative approach to improve students' digital science literacy (dependent variable).

3. RESEARCH METHODOLOGY

This study applied a mixed-method approach, combining a bibliometric analysis with an experimental quantitative design. The bibliometric analysis was used to identify research trends and gaps at the intersection of space tourism, immersive technologies, and digital science literacy, while the experimental design provided empirical evidence on the effectiveness of a digital learning intervention in the classroom.

Bibliometric stage

The bibliometric analysis was conducted using the Scopus database due to its wide coverage of peer-reviewed literature in tourism, education, and technology. The search string included keywords such as “space tourism”, “virtual tourism”, “digital literacy”, and “astronomy education”. The search was limited to publications between 2010–2024, written in English, and categorized as articles or reviews. After screening and removing duplicates, a dataset of 143 documents was obtained.

The data were exported in BibTeX and CSV formats and analyzed using VOSviewer to generate keyword co-occurrence maps, thematic clusters, and citation networks. In addition, the Bibliometrix R-package was used for descriptive statistics, including annual publication trends, most productive journals, and highly cited authors. The bibliometric mapping helped to identify a clear research gap: while global scholarship on space tourism and immersive technology is growing, their integration into science education and digital literacy remains underexplored. This gap provided the rationale for the experimental stage.

Experimental stage

The experimental stage employed a One Group Pretest-Posttest Design, which belongs to pre-experimental quantitative methods (Sugiyono, 2017; Creswell, 2014). This design allowed measurement of students' digital science literacy before and after the intervention, as illustrated in Table 1. The design is presented in Table 1.

Table 1. One Group Pretest – Posttest Design

Group	Pretest	Treatment	Posttest
Experimental Class	O ₁	X	O ₂

Explanation:

- O₁ : Pretest, measurement of students' initial digital science literacy.
- X : Treatment, learning using digital media (Solar System Scope application).
- O₂ : Posttest, measurement of students' digital science literacy after treatment.

Participants and sampling

The participants were 22 students of Class X MA Muallimin UMN Al Washliyah Medan during the even semester of the 2023/2024 academic year. The sampling technique applied was purposive sampling, considering that students had previously studied basic physics concepts relevant to Kepler's Law (Sugiyono, 2017; Arikunto, 2013).

Instruments and validation

The main instrument in this study was a digital science literacy test adapted from the OECD-PISA 2018 science literacy framework, an internationally recognized standard for assessing science literacy. To contextualize it for physics learning, the instrument focused on the topic of Kepler's Law and consisted of 20 multiple-choice items covering four dimensions: (1) content knowledge, (2) procedural knowledge, (3) epistemic knowledge, and (4) contextual application.

A rigorous validation process was conducted:

1. Content validity – reviewed by two experts in physics education and one expert in educational technology. The Aiken's V coefficient was 0.86, indicating high validity.
2. Construct validity – examined through limited trials with students outside the sample. Item analysis (discrimination index and difficulty index) confirmed that all retained items were acceptable.
3. Reliability – tested using Cronbach's Alpha, which yielded a coefficient of 0.82, categorized as

high reliability.

Based on these results, the instrument can be considered valid, reliable, and aligned with international standards, making it appropriate for assessing students' digital science literacy in physics learning.

Data collection and procedure

The intervention consisted of two sessions. Students first completed a pretest (O1), followed by learning activities using *Solar System Scope* as a medium of virtual space tourism to explore planetary motion, distances, and environmental conditions. After the intervention, students completed a posttest (O2) and a student response questionnaire to capture perceptions of the learning process, including engagement, motivation, and perceived effectiveness.

Data analysis

Data analysis in this study was conducted in two stages. Bibliometric data were processed using *VOSviewer* to generate keyword co-occurrence maps and *Bibliometrix (R)* to provide descriptive statistics of publication trends. For the experimental stage, students' pretest and posttest scores were analyzed using a paired sample t-test with a significance level of $p < 0.05$ to determine whether there were significant differences before and after the intervention. To measure the magnitude of improvement, the normalized gain (N-gain) was also calculated (Sudjana, 2005).

Finally, questionnaire data were analyzed descriptively using percentages to identify patterns in students' responses toward the application of space tourism-based solar system media in learning.

ANALYSIS AND RESULT

Bibliometric Analysis

The bibliometric search in Scopus (2010–2024) produced 143 documents across four thematic clusters: space tourism, virtual tourism, astronomy education, and digital literacy. After removing duplicates, 245 documents were analyzed using *Bibliometrix (R)* for descriptive statistics and *VOSviewer* for network mapping. The trend analysis shows a steady increase in publications after 2015, with a notable peak between 2019–2023, reflecting the growing interest in digital learning, immersive tourism, and space exploration as part of educational innovations. Keyword co-occurrence mapping revealed four main clusters: (1) space tourism and futures studies, (2) virtual and immersive tourism technologies, (3) astronomy and science education, and (4) digital literacy and STEM learning. This indicates a potential research gap in integrating space tourism concepts with digital science literacy in education.

Experimental Results: Application of Solar System Scope

The learning intervention was implemented using the *Solar System Scope* application, an interactive platform that enables users to explore celestial bodies in the Solar System virtually and in real time. Students could zoom in and out, rotate planetary orbits, and access detailed information about planets, moons, asteroids, and comets. The application also allows adjustment of observation time and location, enabling the simulation of astronomical events as they would occur in reality. By using this application, students were able to visualize otherwise abstract concepts such as Kepler's Law, orbital motion, and planetary distances. These interactive features enhanced students' ability to connect theoretical knowledge with visual experiences, thereby contributing to the improvement of their digital science literacy.

5.3 Experimental Results: Pretest–Posttest

In the experimental stage, students' digital science literacy was measured before and after the intervention using the *Solar System Scope* application.

- The average pretest score was 64%, while the average posttest score increased to 85%, indicating a substantial improvement in students' digital science literacy.
- The paired sample t-test showed a statistically significant difference between pretest and posttest results ($p < 0.05$).
- The N-gain score was 0.58 (moderate to high category), suggesting that the use of space tourism-based digital media was effective in enhancing students' understanding of Kepler's Law and related astronomical concepts.
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Figure 1. Interface of Solar System Scope showing location settings for astronomical observation
 To further interpret the distribution of student scores, the results were classified into five levels of digital science literacy ability, as shown in Table 2.

Table 2. Criteria for Students' Digital Science Literacy Ability

No	Mark	Criteria
1	81-100	Very good
2	61-80	Good
3	41-60	Enough
4	21-40	Not enough
5	1-20	Very less

Based on this categorization, most students shifted from the Good category in the pretest toward the Very Good category in the posttest, reflecting the effectiveness of the learning intervention.

5.4 Students' Digital Science Literacy Ability

Data analysis of students' answers in answering the Kepler's law pretest question instrument using the media of the solar system to increase students' digital science literacy in Table 5 below.

Table 5. Pretest

		F	%	Percent Valid	Cumulative Percent
V	52	1	4.5	4.5	4.5
	53	2	9.1	9.1	13.6
	54	1	4.5	4.5	18.2
	55	1	4.5	4.5	22.7
	56	2	9.1	9.1	31.8
	57	3	13.6	13.6	45.5
	58	1	4.5	4.5	50.0
	59	2	9.1	9.1	59.1
	60	3	13.6	13.6	72.7
	61	3	13.6	13.6	86.4
	62	1	4.5	4.5	90.0
	63	1	4.5	4.5	95.5
	64	1	4.5	4.5	100.0
	Total	22	100.0	100.0	

Data analysis of students' answers in answering Kepler's law pretest question instruments using the media of the solar system to increase students' digital science literacy in Table 6 below.

Table 6. Posttest

		F	%	Valid Percent	Cumulative Percent
V	65	1	4.5	4.5	4.5
	70	1	4.5	4.5	9.1

	71	1	4.5	4.5	13.6
	72	3	1.3	1.3	27.3
	73	1	4.5	4.5	31.8
	75	3	13.6	13.6	45.5
	77	2	9.1	9.1	54.5
	78	1	4.5	4.5	59.1
	80	4	18.2	18.2	77.3
	82	3	13.6	13.6	90.9
	84	1	4.5	4.5	95.5
	85	1	4.5	4.5	100.0
	Total	22	100.0	100.0	

Descriptive statistical analysis of space tourism based on the scope of the solar system as a suggestion for students' scientific literacy in table 7 and table 8 below

Table 7. Descriptive Statistics

	N	Min	Max	Sum	Mean	Stdv.	V
Pre	22	52	64	1278	58.09	3,379	11,420
Post	22	65	85	1687	76.68	5,140	26,418

Table 8. Statistics

		Pretest	Posttest
N	Valid	22	22
Mean		58.09	76.68
Median		58.50	77.00
Mode		57	80
Stdv		3,379	5,140
Variance		11,420	26,418
Range		12	20
Min		52	65
Max		64	85
Sum		1278	1687
Percentiles	100	64.00	85.00

Analysis of student results on the pretest and posttest on space tourism instruments based on the scope of the solar system as suggestions for students' digital science literacy in graphic below.

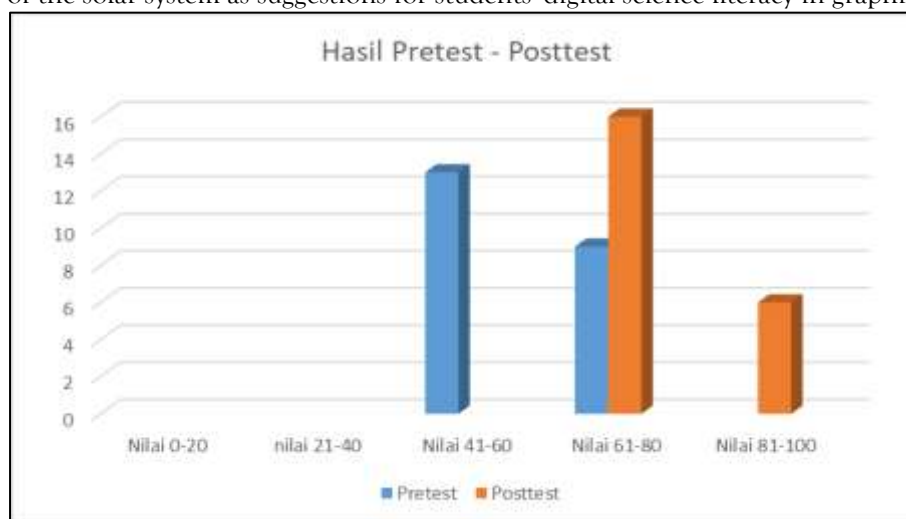


Figure 2. Distribution of Students' Pretest and Posttest Scores on Kepler's Law Using Solar System Scope Student Response Questionnaire

The student response questionnaire was analyzed using percentages and the TCR (Respondent Achievement Level) formula. Results showed an overall positive response, with an average score of

79.91%, categorized as good. Students reported that the use of space tourism visualization through the Solar System Scope application made learning more engaging, helped them visualize abstract astronomical phenomena, and increased their motivation to learn physics. The student response questionnaire was used to determine student perceptions of the learning process and to evaluate whether the application of space tourism learning through the Solar System Scope could improve digital science literacy in the physics subject on Kepler's Law. This questionnaire employed a Likert scale consisting of five response options, as shown in Table 3.

Table 3. Likert Scale

Criteria	Symbol	Score
Strongly agree	SS	5
Agree	S	4
Disagree	K.S	3
Don't agree	T.S	2
Strongly Disagree	STS	1

The criteria for the results of the student response questionnaire are to see the students' reactions after learning about space tourism based on the scope of the solar system at school in the physics subject on Kepler's law material using the TCR (Respondent Achievement Level) formula as follows :

The following is the TCR classification which can be seen in Table 4.

$$TCR = \frac{Rata - rata\ skor \times 100}{Skor\ maksimum}$$

Table 4. TCR classification

No	Percentage of Achievement	Criteria
1	85% - 100%	Very good
2	66% - 84%	Good
3	51% - 65%	Enough
4	36% - 50%	Not good
5	0% - 35%	Not good

Based on the results of the student response questionnaire, it can be concluded that the student response questionnaire results were 79.91%, where this percentage is a reference that students feel happy and motivated to learn about space tourism based on the scope of the solar system as a means of student digital science literacy. This is proven by the TCR results obtained with good criteria. Thus it can be said that MA students. Muallimin UNIVA Medan gave a positive response or attitude after answering space tourism learning based on the scope of the solar system as a means of digital science literacy for students and after answering the research instruments provided and shown in the following Table 5

Table 5. Recapitulation of Student Responses to Solar System Scope-Based Space Tourism Media

No	Question	TCR
1	Solar system scope-based space tourism is interesting and increases my desire for digital science literacy	81%
2	Using a solar system scope is interesting and fun, so it makes me like physics	79.4%
3	Using a solar system scope helps me understand space visualization well	80.9%
4	I feel happy and challenged to explore space using the solarsystem scope	81.2%
5	The questions given are relevant to everyday life	78%
6	I worked hard on the questions given	78.6%
7	The sails provided are in accordance with the space tourism that I explored visually using a solar system scope	8.3%
Total		79.91%

Summary of Findings

The combined results demonstrate that:

1. Bibliometric analysis highlights an emerging research gap at the intersection of space tourism and digital science literacy.
2. Experimental results confirm that the integration of space tourism-based solar system visualization significantly improves students' digital science literacy.
3. Student responses reflect a high level of engagement and positive attitudes toward the learning approach.

Together, these findings suggest that incorporating space tourism concepts into digital learning media provides a promising pathway to foster both conceptual understanding and digital literacy among students.

4. DISCUSSION AND IMPLICATION

The results of this study provide important insights into how space tourism-based digital media can be integrated into science education to enhance students' digital science literacy. The bibliometric analysis confirmed that research on space tourism, astronomy education, and digital learning has shown consistent growth, especially after 2019. However, the clustering of keywords revealed that studies often focus on separate themes such as *virtual tourism*, *STEM learning*, and *digital literacy*, with limited attempts to unify these perspectives. This gap validates the relevance and novelty of the present study, which explicitly connects space tourism and digital science literacy in the context of physics learning on Kepler's Law.

The experimental findings reinforce the benefits of using interactive visualization tools in science classrooms. The significant increase in posttest scores (from 64% to 85%) with a moderate-to-high N-gain (0.58) demonstrates that the Solar System Scope application effectively supports students' understanding of abstract astronomical concepts. These findings are consistent with earlier research emphasizing the value of virtual simulations in enhancing conceptual mastery and critical thinking (Imronah et al., 2022; Johnson & Hall, 2021).

Moreover, the positive student responses (79.91% "good") highlight that learning through space tourism not only supports cognitive development but also improves motivation and engagement. This finding aligns with studies on digital learning environments that emphasize the dual role of technology as a cognitive scaffold and a motivational driver (Rahman et al., 2022; Smith & Brown, 2024).

Theoretical Implications

Theoretically, this study expands the conceptual understanding of digital science literacy. It shows that literacy development is not limited to content mastery but also involves the capacity to interpret, evaluate, and apply knowledge in interactive, digital contexts. By integrating space tourism as a thematic and technological medium, this research contributes to bridging the gap between astronomy education and digital literacy studies.

Practical Implications

Practically, the findings suggest that teachers can use applications such as Solar System Scope as an accessible and cost-effective tool to teach abstract physics concepts. The immersive features of the application help students visualize and contextualize scientific phenomena, making lessons more engaging and meaningful. This approach can also be extended to other STEM subjects, thereby providing a replicable model for digital-based instructional strategies.

Policy Implications

At the policy level, the results underscore the importance of integrating digital innovation into national science curricula. Supporting the adoption of interactive digital media aligns with global educational agendas such as OECD's digital competence framework and UNESCO's Sustainable Development Goal 4 (Quality Education), which emphasizes equitable access to innovative and high-quality learning resources. Policymakers and curriculum developers should therefore consider formalizing the inclusion of space tourism-based learning experiences to strengthen both STEM education and digital literacy competencies.

5. CONCLUSION

This study investigated the effectiveness of space tourism-based learning media, specifically the Solar System Scope application, in improving students' digital science literacy on the topic of Kepler's Law. The findings demonstrate that integrating interactive digital visualization into science learning can significantly enhance students' understanding and motivation.

Key conclusions are as follows:

1. Bibliometric findings show increasing research interest in the intersection of space tourism, astronomy education, and digital literacy, yet few studies explicitly connect these domains.

2. Experimental results indicate that students' average digital science literacy scores improved from 64% (pretest) to 85% (posttest), with an N-gain of 0.58 (moderate-to-high).

3. Student responses were positive (79.91% "good"), reflecting the motivational and engagement benefits of digital learning media.

4. The Solar System Scope application was proven to be a practical, engaging, and effective medium for bridging abstract scientific concepts with digital learning competencies.

These results suggest that space tourism-based media can play a dual role as both a cognitive scaffold and a motivational tool, making it highly relevant for 21st-century science education.

Future Research Directions

Although this study produced promising results, several limitations should be addressed in future research:

1. Sample size and generalizability – The study was conducted with a relatively small sample of 22 students in one institution. Future studies should involve larger and more diverse samples to increase the generalizability of the findings.

2. Longitudinal impact – This study measured short-term improvement. Longitudinal research is needed to explore whether the observed gains in digital science literacy are sustained over time.

3. Integration with other STEM areas – Future research could investigate how space tourism-based digital tools can be applied to other domains such as environmental science, mathematics, or engineering.

4. Comparative studies – Further studies should compare the effectiveness of Solar System Scope with other immersive technologies, such as augmented reality (AR), virtual reality (VR), or AI-driven learning platforms.

5. Policy and curriculum alignment – Future work could also explore how space tourism-based media can be systematically embedded into national or international science curricula in line with global frameworks such as OECD and UNESCO SDGs.

By addressing these aspects, future studies can further strengthen the theoretical foundation and practical application of digital science literacy through innovative media such as space tourism.

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