International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Science Teacher's Perspective on Informal Science Learning at Planetarium

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A B S T R A C T

Promoting quality education requires inclusive, engaging, and learner-centered approaches that go beyond the boundaries of the traditional classroom. Informal Science Learning Centres (ISLCs) contribute significantly to this vision by offering immersive, experiential environments that spark curiosity and deepen conceptual understanding of scientific phenomena. Planetariums as ISLCs play a pivotal role in making science accessible and engaging promoting the vision of quality education. This study explores the role of planetariums as ISLC, through the lens of science teachers on educational visits to the sky shows at the planetarium. Employing qualitative research, a case study was conducted at Jawaharlal Nehru Planetarium (JNP) in Bengaluru, India. 10 science teachers provided insights into objectives, driving factors, relevance, impact of and recommendations for sky shows. Findings indicate that sky shows at the planetarium effectively support contextualizing scientific concepts, generate student interest in astronomy and provide experiential exposure. Teachers also emphasized the potential of planetariums to develop scientific temper and a positive attitude towards science. The study concludes that planetariums serve as powerful ISLCs that foster scientific understanding, inspire meaningful engagement with science, enhance classroom learning, promote curiosity and reinforce the importance of informal experiences into formal education.

Keywords: Quality Education, Informal Science learning, Planetarium, Experiential Learning, Scientific Literacy, Astronomy, Qualitative research, Sky Shows

1. Introduction

In the present highly globalized world, science education has increasingly been given importance by the rising demand for a skilled workforce in Subjects of Science, Technology, Engineering and Mathematics: STEM (STEM; National Academy of Sciences [NAS], 2007). Informal science has been advocated as a means to support school curriculum, student interest, and academic success (Dabney et al., 2015). Informal science learning (ISL) experiences have been found to provide valuable opportunities to engage with and learn about science and, as such, form a key part of the STEM learning ecosystem (DeWitt and Archer, 2017). It is an ongoing priority and challenge to teach science in elementary school (Zinger et al., 2020). Providing people with the information and abilities to manage an increasingly complicated environment, science education is a fundamental component of social advancement. Nonetheless, access to valuable learning experiences is hampered for pupils in rural regions by the gaps in educational possibilities that frequently exist there. Teachers and students have many challenges that could limit multicultural, high-quality science instruction (Miles et al., 2022).

Recognizing this challenge, the planetariums have emerged as a unique space where students can engage with scientific concepts through innovative and experiential methods which shall instil enthusiasm among students, children and laymen for understanding science and related fields (Jawaharlal Nehru Planetarium, 2023). To foster a scientifically literate society, Science Learning Centres play a critical role, particularly in areas with limited access to high-quality resources. For immersive teaching-learning experiences that might go beyond traditional limits, one such facility, The Jawaharlal Nehru Planetarium (JNP) set up in the city of Bengaluru in India is a shining example of informal scientific education. This study aims to explore the impact of JNP on understanding of science among school students.

JNP serves as a microcosm of innovative pedagogy intersecting with traditional learning environments. From among the many initiatives taken up by JNP, instilling enthusiasm and curiosity among students in astronomy, the sky show experience takes a front seat. The planetarium has received about 4 lakh visitors and a total of 2178 shows at the sky theatre in the year 2022-23 (Jawaharlal Nehru Planetarium, 2023), which is evidence for the outreach initiatives of the JNP including that of school student from difference parts of the state, adults and laymen from different walks of life.

In recent years, there has been a growing recognition of the importance of enhancing scientific understanding among school students (Freeman et al., 2019; Hawley and Sinatra, 2018). The JNP in Bengaluru, India, renowned for its commitment to science education since its inception in 1989, provides a unique setting for immersive teaching-learning activities by running consistent sky shows for public viewing. However, there is no literature available assessing its impact on the school students in their journey of understanding science from the teacher's perspective who visit the facility. Since, science teachers are the driving force for instilling interest about science learning among school students, it is essential to understand their perspective on informal science learning through planetariums. The study is guided by the following research questions:

RQ 1: What are the objectives of science teachers in conducting educational visits to planetarium for school students.

RQ 2: What are the factors contributing to perceived interest in Sky Shows at the Planetarium?

RQ 3: How are the Sky shows at the Planetarium relevant to academic science concepts taught at school?

RQ 4: How do the Sky shows at the Planetarium impact understanding of science concepts among school students?

RQ 5: What are the teachers' recommendations for improving the educational effectiveness of the planetarium?

2. Relevant Literature

2.1 Informal Science Education

Education is a collective process that takes place inside and outside the school ("Taking Science to School," 2007). Undoubtedly, science education is not limited to areas and situations that are customarily acknowledged for this purpose. Phrases such as "lifelong learning" highlight the need to view the acquisition of ideas, techniques, and scientific reasoning as a lifelong process that goes well beyond the confines of traditional schooling (Aspin and Chapman, 2000; Holliday and Lederman, 2013; Falk and Dierking, 2011). Among the many opportunities to learn science outside of school, museums and research centres hold a special place because they can offer a valuable and unique experience to all visitors (Stocklmayer and Rennie, 2017). These learning environments are considered 'informal' and are often described as environments where 'free choice learning' can occur (Falk, 2001; Falk and Dierking, 2011). The informal learning environment has important features that facilitate learning. Lander-Zandstra et al. (2020) define informal learning as "generally based on voluntary participation; without quality assessment, linked to one's interest through learning, and providing time for relationships with other participants."

Additionally, information in the informal environment will also support a particular process. It is the sum of thoughts, feelings and situations related to the learning process ("The Role of the Museums in Lifelong Learning for Adults," 2020b). Developing knowledge in the science center often helps create meanings of ideas and concepts by taking advantage of the audience's prior knowledge (Kirchberg and Tröndle, 2012). Learning skills in an informal setting (with technology and other peers) is a lifelong, lifelong process. Unlike education, which was called "science" at the time and taught students what they had learned, science permeates daily life in unlabelled and covert ways (Rennie, 2012).

2.2 Planetariums for Informal science learning

Planetariums have developed as dynamic venues to support traditional scientific instruction in response to this difficulty. Undoubtedly, one of the largest and most prominent platforms for educating the public about Science and related topics is a planetarium. Seyma and Topsakal (2017) opine that Planetariums make learning more enjoyable and efficient. The planetarium environment is spectacular as well as highly instructive. According to Yusof et al. (2022), teachers, being adept educators, organize school field trips so that pupils may acquire knowledge, as a school field trip serves as an educational draw for kids. A planetarium is an established informal science education tool. The planetarium experience can be an important gateway to learning for children who dislike learning in formal environments (Renninger, K.A., 2007). Planetariums inform the public on these matters and thus make the public understanding of science possible (Gutwill and Allen, 2012). A planetarium is generally considered to be a positive learning environment and a great tool to develop public interest. Educators, mediators, and facilitators of informal science education settings can help generate curiosity and positive attitudes towards, and interest in science and technology (Maria, 2023).

A study conducted by Karaca & Bektaş (2023) suggests the Pre-service science teachers view the planetarium as a fun, instructive, and meaningful environment for science education, promoting experiential learning, three-dimensional thinking, and engaging lessons that contribute to meaningful and permanent learning for students. Another study conducted by Almeida et al., (2017) revels planetarium as an effective non-formal educational environment for teaching about the Solar System, demonstrating significant improvements in students' understanding through a film exhibition and pre- and post-activity assessments, emphasizing its potential in astronomy education. The modern digital planetarium enhances science education by offering real-time, three-dimensional models of the universe, moving beyond traditional earth-centered views. This innovation allows for unique educational research opportunities, fostering a deeper understanding of astronomical concepts among learners. A study conducted by Slater & Tatge (2017) concludes that modern digital planetarium enhances science education by offering real-time, three-dimensional models of the universe, moving beyond traditional earth-centered views. This innovation allows for unique educational research opportunities, fostering a deeper understanding of astronomical concepts among learners.

Recent research related to planetariums show a much positive inclination towards the effectiveness of planetarium-based education. The planetarium-based science education experience enhanced pre-service teachers' understanding of science content through visual and physical modelling, promoting three-dimensional learning and phenomenon-based instruction, ultimately benefiting their future teaching practices and student-centric approaches (Graven, 2024). The Bogota Planetarium employs a Multi-approach Integrated Educational Model, focusing on constructivist theory, inquiry-based learning, and diverse audience engagement to promote scientific understanding, cultural rights, and community involvement in science education within a non-conventional learning environment (Leal et al., 2023). The National Planetarium Kuala Lumpur, utilizes multiple intelligence theory and cooperative learning, leading to positive impacts on students' personal and social contexts (Yusof et al., 2024).

3. Theories related to Informal Science Learning

3.1 Kolb's Experiential Learning Theory

David A. Kolb's learning model is also known as the 'experiential learning theory'. The basis of Kolb's model is that learning takes place within a 4 stage process - Concrete learning, Reflective observation, Abstract Conceptualization, Active Experimentation. Kolb's theory of experiential learning is applied to encourage students to actively engage in the learning process using their prior knowledge of the difficulties. A type of knowledge created via experiences; experiential learning is characterized as focusing more on the learning process than the results (Sugarman, 1987). It is a style of instruction that gets pupils ready for real-world encounters that will help them understand concepts, ideas, or topics better (Kolb & Kolb, 2005). Four learning modes are included in Kolb's theory of experiential learning: concrete experience, reflective observation, abstract conceptualization, and active experimentation. "Concrete experience" is defined as the students' capacity to participate in novel events and draw objective conclusions from their observations. Utilizing the knowledge to address challenging issues is referred to as "active experimentation." On the other hand, the ability to develop concepts that incorporate observations in a logical order is known as "abstract conceptualization." The capacity to see and reflect on experiences from many angles is known as reflective observation. This leads to the students being exposed to challenges and requiring them to think critically and make decisions.

3.2 Theory of Constructivism

Constructivism is based on the work of Jean Piaget, Jerome Bruner, Ernst von Glaserfeld, and Lev Vygotsky. It is a learner-centered approach that suggests that students actively "construct" their knowledge. Prior information, ideas, and experiences shape each individual's world. Each student's learning is unique since it is based on personal experiences. "Constructivist approaches emphazise learners actively constructing their own knowledge rather than passively receiving information transmitted to them from teachers and textbooks," in other words. According to Stage et al. (1998), "knowledge cannot simply be given to students: students must construct their own meanings." Constructivist learning theory is founded on several ideas, including the idea that pupils learn by doing. Constructivist such as Dewey believe that Physical actions, hands-on experience may be necessary for learning, especially for children, they also need to be provided with activities which engage the mind as well as the hands (Glassman, 2001). Constructivism stressed on providing with supportive learning environment with opportunities for hands-on experimentation, encouraging student collaboration, allowing to have ownership over learning experience (Main, 2023). Understanding constructivist theory is essential for educators since it affects both their teaching style and students' learning outcomes. Teachers may design experiences that support deeper learning and understanding and help construct knowledge by adopting constructivist learning theory.

3.3 Theoretical Framework

The constructs in this study are based on the theories of Constructivism and Kolb's experiential learning. Constructivist theory is a learning theory that emphasizes the active role of learners in building their own understanding. It is based on the idea that learners are active participants in their learning journey, and knowledge is constructed based on their experiences. The theory of autonomy in learning is supported by experiencing the learning first hand by the learners in Kolbs' experiential learning theory. Collectively, both the theories facilitate in understanding of science which forms the foundations for informal science learning at planetariums. The same has been presented in diagrammatic format in Figure 1.

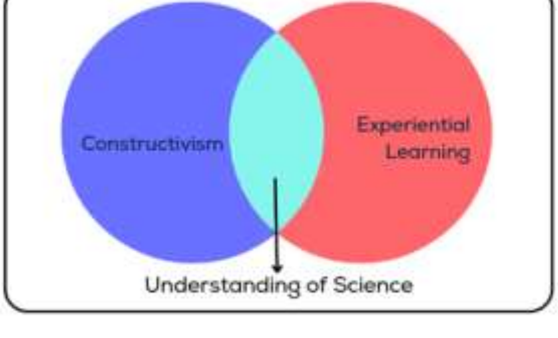

Fig 1: Theoretical framework for informal science learning

4. Methodology

The research methodology used in this study is qualitative, employing a case study research design. The study aims to understand the teaching-learning activities at a specific institution that provides informal science education through a Sky Theatre. Qualitative research explores and provides deeper insights into real-world problems by collecting and analyzing non-numerical data such as text, video, or audio to understand concepts, opinions, and experiences (Tenny, 2022). In this context, the study adopts qualitative data collection method and selected JNP as the case for investigation. Structured interviews, are the primary tools used to collect data to address the research questions.

4.1 Population of the study

The planetarium has received over 4 lakh visitors to the facility in the year 2022-23. According to Ball and Forzani (2009), teachers play a central role in the learning that takes place in a classroom. Hence, for this study, the Population comprises the science teachers who accompany the students for these visits. A study conducted by Eupena (2012b) found that communication behavior of science teachers has great contribution and impact on the attitudes of students in learning science. This study laid emphasis on the teachers who accompany the students, since they are the authority on communicating about science concepts to the students within the classroom and at the planetarium.

4.2 Sample

A Purposive sampling method was adopted to select the respondents. Purposive sampling is 'used to select respondents that are most likely to yield appropriate and useful information' (Bourgeault et al., 2010) and is a way of identifying and selecting cases that will use limited research resources effectively (Palinkas et al., 2013). Since the aim of this study was to specifically explore the perspective of science teachers, a total of 10 teachers made up the sample for this study. The Science teachers who are currently teaching science as an academic subject to the visiting students were considered as the sample to ensure the responses are in line with the objectives of the study.

4.3 Instrument

An interview protocol was developed for this study. The study needed descriptive structured interviews to be conducted in order to examine the set research objectives. Hence the protocol was developed, validated and pilot tested before the data collection. To acquire high-quality interview data, a reliable interview protocol is essential. It should be simple to comprehend and address all study goals in order to provide valuable insights (Yeong et al. (2018). The 4-step Interview Protocol Refinement (IPR) Framework developed by (Yeong et al. (2018) was followed, deriving from the literature and previous studies conducted, to develop the questions by the researcher. The steps were (1) ensuring alignment between interview questions and research questions to increase utility of the interview questions (2) constructing an inquiry-based conversation, with prompts, social rules and variety in conversation (3) receiving feedback from Experts on the interview protocols and (4) pilot testing of the interview questions by getting feedback from actual sample respondents and testing of the interview setting. Following this framework, the interview protocol was prepared to collect data on the sky theatre, in bilingual language of English and Kannada, validated by 3 experts in educational research with experience in Science and STEM education and then pilot tested. The Overall opinion of all the 3 experts validating the open-ended questions was mentioned as "very adequate". The questions in the interview protocol were divided into 2 parts with open-ended and closed-ended questions. Questions collected the responses of teachers related to the teaching-learning activities at the sky theatre.

4.3 Data Collection Procedure

After the pilot study, the interviews were conducted with science teachers who are currently at the premises and those schools who had completed watching the Sky shows. The data collection was conducted in three stages: Stage 1 was confirmation of the sample by communication and consent with the sample at the premises. Stage 2 was the distribution of the hard copy of the open-ended questions. Stage 3 was collecting the responses from the teachers after 2 days of the visit. The procedure as illustrated in Figure 1 was followed for the data collection.

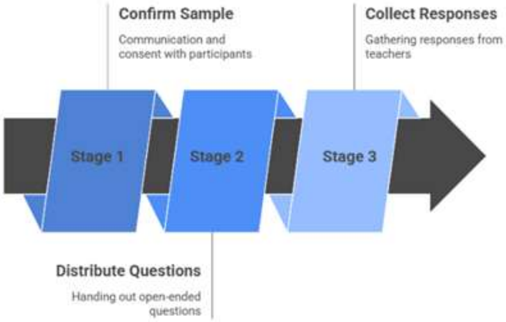

Fig 2: Data Collection Stages

4.4 Preparing the data for analysis

After the data collection, the responses were prepared for analysis into common themes utilizing the Braun & Clarke (2006) framework for further mapping. The data collected was screened for complete and relevant responses, then the data was transcribed to softcopy, responses given in regional language were translated, verified by language experts, Codes were identified from the quotes, codes were merged into emerging themes, themes were generated related to the predefined themes, reporting of the analysis was conducted. The data was read and re-read for any gaps, flaws and missing data. The process has been illustrated in Figure 3.

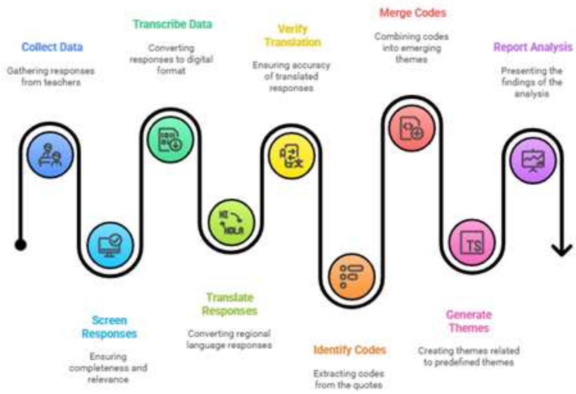

Fig 3: Data Analysis process

5. Results

5.1 Demography of respondents

The data collected from 10 respondents was analyzed using Braun and Clarke's framework for thematic analysis in qualitative research design (Braun & Clarke, 2006). The demographic information of the final respondents has been provided in Table 1.

Table 1 – Demographic details of Respondents

Participant	*Gender*	*Qualification*	*Number of years Teaching science*	*District*
P1	Female	Bachelor in Science and Bachelor in Education	11-15 yrs	Urban
P2	Female	Master in Science and Bachelor in Education	less than 2 years	Rural
P3	Male	Bachelor of Education	over 15 yrs	Urban
P4	Female	Master in Science	less than 2 years	Urban
P5	Female	Diploma in Education	over 15 yrs	Rural
P6	Female	Bachelor in Science and Bachelor in Education	2-5 years	Urban
P7	Female	Bachelor in Science and Bachelor in Education	11-15 yrs	Rural
P8	Female	Bachelor in Science and Bachelor in Education	2-5 years	Urban
P9	Female	Master in Science	2-5 years	Urban
P10	Female	Master in Science	11-15 yrs	Rural

5.2 Findings for RQ1: What are the objectives of teachers in visiting the planetarium (JNP)?

Theme 1: Real-Life Learning Experience

Three of the ten teachers emphasized the importance of exposing students to science concepts through tangible, experiential learning. The visit was perceived as a means to bridge classroom learning with real-world application as noted in the responses by the teachers, "To help students have practical experience of the science concepts" (P5), "Make students learn science by way of practical experience" (P6), "Help students to understand and gain practical knowledge in science concepts" (P8). The most frequently mentioned objective was to provide students with direct exposure to science concepts. These teachers believed that such real-life experiences would enhance understanding and make science more meaningful and engaging.

Theme 2: Motivation and Interest in Science

A dominant theme among teachers was using the planetarium experience to inspire and sustain student interest in science through engaging, immersive settings. Three of the ten teachers viewed the planetarium as a motivational tool to capture students' attention and foster enthusiasm for science by stating, "To motivate students for science learning and practical experience" (P7), "To make children aware of new subjects by making them interested in science" (P2), "Cultivate interest in science through practical experiences" (P10).

Theme 3: Inculcating Scientific Temper and Attitude

Two teachers emphasized that the visit aimed to foster a scientific attitude and promote inquiry, observation, and rational thinking by stating, "To inculcate scientific attitude" (P3), "Help students to improve scientific attitude and scientific temper" (P9). Developing a scientific mindset including curiosity, critical thinking, and reasoning was seen as a key goal. Teachers believed that the planetarium environment encourages such attitudes by visually presenting complex scientific ideas and sparking student inquiry.

Theme 4: Education Through Edutainment

Yet noteworthy theme emerged around the idea of edutainment, combining education with entertainment to enhance students' science learning experiences. One teacher perceived the planetarium as an environment where enjoyment and education coexist to sustain students' attention and curiosity saying, "To engage, educate and also entertain students, which helps them in showing interest in science and research" (P4). This view recognizes that when learning is enjoyable, students are more likely to remain attentive, participate actively, and retain information. The planetarium's immersive format allows students to experience science in an exciting and memorable way, which can strengthen their emotional connection to the subject.

5.3 Findings for RQ 2: What are the factors contributing to perceived interest in Sky Shows at the Planetarium?

Theme 1: Visually Immersive and Emotionally Engaging Experiences

The teachers consistently described the Sky Show as a captivating and visually rich experience. Three teachers expressed fascination with how the concepts of astronomy were illustrated using 3D models, animations, and simulations that made them feel as though they were actually in space. They said, "The experience of as if you are in space and the explanation was very good" (P5), "The illustration of the space in form of cartoons, 3D models and animations" (P4), "How it was making the sky move and showing everything in the sky about stars and planets" (P6). These responses reflect how the immersive techniques appeared to create a sense of wonder and engagement, making the learning environment more appealing. Teachers appreciated how the sky appeared to move and reveal celestial elements, reinforcing the realistic aspect of the simulation. Teachers consistently highlighted how the visual format and presentation style of the sky show enhanced their interest. The use of 3D models, animations, and immersive visuals helped in simplifying complex topics like the solar system and space phenomena.

Theme 2: Creating Interest in Astronomical Content and Conceptual Clarity

In addition to the visual experience, the teachers also emphasized the content itself; especially the solar system, stars, planets, and gravitational waves as major points of interest. Two teachers noted how these elements appeared to tap into the students' innate curiosity about space and science. "Everything was interesting, the gravitational waves and the starry night" (P1), "The solar system and how it is in the night sky" (P9). Other two teachers noted how well the explanations were delivered, helping them to better understand complex topics like, "The detailed explanation of the solar system" (P7) and "The presentation of the concepts about the solar system" (P3). The responses reflect that teachers expressed specific interest in the content related to stars, planets, and the solar system, suggesting that astronomy-themed topics inherently carry an engaging and captivating quality. The teachers appreciated how these concepts were not only explained but also visualized in a manner that made them feel realistic and relevant.

Theme 3: Awe and Access to the Invisible Universe

Three of the ten teachers described their interest in the sky show as being sparked by the opportunity to witness celestial phenomena and cosmic elements that are typically invisible to the naked eye. Their fascination stemmed from seeing aspects of the universe like the starry night sky and gravitational waves in a clear, visual form, which evoked a sense of awe and deepened their curiosity. They said, "Everything was interesting, the gravitational waves and the starry night" (P1), "The solar system and how it is in the night sky" (P9), "Stars and the planets in the sky that we cannot see" (P10), These responses suggest that the planetarium show not only made abstract or distant scientific concepts accessible, but also allowed teachers to emotionally connect with the vastness and mystery of the cosmos.

5.4 Findings for RQ 3: How are the Sky shows relevant to academic science concepts taught at school?

Theme 1: Well-Aligned with School Curriculum

Two of the ten teachers noted that the content presented in the sky theatre closely mirrors the science curriculum, especially topics covered in textbooks. This alignment was appreciated as it reinforced what students learn in class, making abstract or large-scale concepts more tangible like, "Align with science text book" (P1) and "The alignment of concepts and presentation to the students level" (P3). These responses suggests that sky shows serve as an extension of classroom learning, providing a structured, curriculum-relevant supplement that can aid in knowledge retention and understanding.

Theme 2: Enhancement of Conceptual Understanding Through Visualization

Four teachers observed that sky show experiences help students visualize and internalize abstract scientific concepts such as gravity, planetary motion, and space phenomena. Teachers highlighted the value of these visual aids in making complex ideas accessible and memorable like, "Solar system models are more convenient to observe in person." (P2), "Helps in students learning by imagination as they are going through in their life practically." (P4), "Gravity of the earth was relevant for students." (P6) and "Was good for students to understand about physics in highschool level." (P10). These responses reflect how the planetarium fosters experiential and imaginative learning, making it easier for students to grasp key scientific principles that are often difficult to visualize in the classroom.

Theme 3: Relevance to Everyday and Future Science Learning

Three of the ten teachers linked the sky show content to practical, real-world applications and long-term scientific understanding. Topics like satellites, moon landing, and space exploration were mentioned as directly relevant and engaging for students such as, "Helps students in development of science in their daily life." (P5), "Knowing about the different satellites was good and relevant." (P7) and "The satellites and the landing on moon was relevant." (P9). These responses show that planetarium experiences not only reinforce textbook content but also connect students to contemporary science and technology, enhancing relevance and curiosity.

Theme 4: Grade-Level Relevance and Cognitive Appropriateness

Two teachers emphasized the importance of content being suited to the students' grade level, particularly for high school learners. Responses such as, "The alignment of concepts and presentation to the students level." (P3) and "Was good for students to understand about physics in highschool level." (P10). This show that the sky shows were not only relevant but presented in a way that was digestible and adaptable for different student age groups and backgrounds.

5.5 Findings for RQ 4: How do the Sky shows impact understanding of science concepts among school students?

Theme 1: Enhanced Conceptual Understanding Through Visual Experience

Four of the ten teachers emphasized that the sky theatre experience significantly contributed to students' grasp of scientific concepts, especially those related to astronomy and physics. The visual immersion helped make complex content more concrete and easier to understand. Responses such as, "Improves students understanding of science and physics in particular." (P1), "Enhances understanding of the textbook concept in visual sense." (P3), "Improves students understanding of astronomical concepts." (P8) and "It is good, because students can know the things they see in sky better." (P6). This suggests that the multisensory and dynamic nature of sky shows enables students to visualize otherwise abstract or invisible celestial phenomena, improving retention and clarity.

Theme 2: Bridging Textbook Knowledge and Practical Application

Three teachers observed that the sky shows serve as a crucial link between classroom learning and real-world application. By bringing textbook knowledge to life, the shows support experiential learning as noted by the teachers, "Enhances practical knowledge and thereby helping students remember the concepts forever." (P4), "Make students understand about abstract objects in real life." (P9) and "It is a good experience to witness celestial bodies in person." (P2). Teachers observed that sky shows enable students to move from passive textbook learning to active, experiential engagement.

Theme 3: Stimulation of Curiosity and Interest in Science

Alongside two teachers noted that the immersive and novel nature of the sky shows made science more exciting and enjoyable for students. Responses reveal this engagement factor plays a critical role in motivating students to learn more deeply noting, "It is very interesting and helps the students to understand about stars and the solar system and the space." (P5), Improves students knowledge of the celestial bodies." (P7). Such responses reflect how informal learning environments like planetariums spark curiosity and create positive emotional connections to science learning.

Theme 4: Awareness of the Relevance of Astronomy in Daily Life

However, one teacher pointed out that the sky show helped students recognize the practical importance of studying astronomy, encouraging them to see its value beyond academic settings as suggested by, "Show students the importance of studying about astronomy and how is it important in our life." (P10). This indicates a shift in students' perception, from seeing science as a school subject to understanding its broader significance in everyday life and human advancement.

5.6 Findings for RQ 5: What are the teachers' recommendations for improving the educational effectiveness of the planetarium?

Theme 1: Modernization and Relevance of Educational Content

Three teachers emphasized the importance of updating the existing content and models to align with current scientific advancements and ensure that the material remains engaging and meaningful for students. Suggestions included refreshing outdated exhibits and continually improving the visual and conceptual appeal of the programs. They said, "The solar system model is 30 years old, new concepts should be introduced so as to keep the interest of the students alive." (P3), "To benefit more students in future." (P2) and "Can enhance and make it more colourful and increase the duration of the show." (P1).

Theme 2: Duration and Accessibility of Sessions

Three teachers proposed extending the duration of the sky shows and other learning activities, particularly to accommodate the learning needs of students from rural backgrounds. The responses such as, "Since the students from rural schools are slow learners, the duration can be extended for up to 1 hour for the sky show." (P5), "Can enhance and make it more colourful and increase the duration of the show." (P1) and "To benefit more students in future." (P2). This show teacher belief that additional time would allow for deeper engagement and better understanding of complex concepts.

Theme 3: Instructional Quality and Satisfaction

While several teachers were satisfied with the current offerings, five of the ten pointed out that the quality of explanations during demonstrations could be improved. Clearer and more detailed explanations, especially for abstract scientific ideas, were recommended to enhance learning outcomes. The responses were, "The demonstration session was good, but the explanation was not satisfactory." (P4), "More explanations, for getting more clarity on complex physics concepts." (P8), "Nothing, everything is good." (P6), "No improvement needed, they are all good and relevant to school students." (P9) and "It is very nice, nothing to make more." (P10). This shows that a few teachers felt that no changes were necessary and expressed full satisfaction with the experience.

6. Discussion

6.1 Objectives of teachers in visiting the planetarium (JNP)

From the responses to Research Question 1 on the objectives for visiting the planetarium, it was evident that teachers perceived the visit as an opportunity to provide real-life learning experiences that go beyond textbook instruction. This reflects Kolb's Experiential Learning Theory, which emphasizes learning through concrete experience (Kolb & Kolb, 2005). The planetarium's interactive features, particularly the sky theatre, enable learners to engage in stages of Kolb's learning cycle, including active observation and reflection. Such experiential exposure supports literature that positions informal science education as crucial in fostering voluntary, curiosity-driven participation, enhancing both engagement and retention (Falk & Dierking, 2000).

Teachers also acknowledged the role of the planetarium in stimulating students' motivation and interest in science. This is consistent with previous studies that describe planetariums as affective learning environments capable of shaping learners' attitudes towards science and technology (Seyma & Topsakal, 2017; Yusof et al., 2022). These immersive environments particularly benefit learners who may not engage fully in traditional settings, supporting the perspectives of Renninger (2007) and Graven (2024). The visual and sensory appeal of the sky theatre mirrors similar findings on the impact of informal science spaces in triggering curiosity and deeper engagement (Almeida et al., 2017).

Further, teachers emphasized the potential of planetariums to develop scientific temper and a positive attitude towards science. This aligns with research highlighting the role of informal learning spaces in cultivating such dispositions (Gutwill & Allen, 2012; Maria, 2023). The approach also reflects constructivist theories that advocate for learning through active engagement and reflection (Stage et al., 1998; Main, 2023). Overall, the findings suggest that teachers visit planetariums with the objective of enhancing classroom learning by promoting curiosity, engagement, and enjoyment while cultivating meaningful science learning experiences.

6.2 Factors contributing to perceived interest in Sky Shows at the Planetarium.

From the responses to Research Question 2 on the factors contributing to perceived interest in sky shows at the planetarium, several key insights emerged. Teachers described the sky shows as visually immersive and emotionally engaging, aligning with prior research emphasizing the role of multisensory learning environments in enhancing comprehension and retention of abstract scientific concepts (Rennie, 2012). When science is presented through interactive and visually rich media, learners become more attentive and motivated, which is especially relevant in planetarium settings where the goal is to spark scientific interest through non-traditional instruction.

Teachers also noted that astronomical content, due to its vastness and mystery, naturally attracts learner curiosity when meaningfully presented, supporting Graven's (2024) assertion. These findings are consistent with studies indicating that planetariums effectively develop content-based knowledge and stimulate curiosity in astronomy (Maria, 2023).

Teachers reported a strong emotional connection through the sense of being transported into space and gaining access to hidden realms of the universe. This aligns with Renninger's (2007) framework on situational interest, which emphasizes the role of aesthetic and emotional responses in sustaining attention and promoting deep learning. Planetariums function as affective learning environments, offering not only scientific information but also inspiration and wonder (Yusof et al., 2022). Learners highlighted the fascination of visually experiencing cosmic phenomena normally invisible to the naked eye, such as gravitational waves or distant celestial bodies. The findings underscore the value of planetariums as powerful informal science learning spaces that blend emotional engagement with content, stimulating curiosity and lasting interest in astronomy.

6.3 Relevance of Sky shows at the Planetarium to academic science concepts taught at school

The responses to Research Question 3 on the relevance of sky shows at the planetarium to academic science concepts taught at school indicated that the shows were perceived as well-aligned with the school curriculum. Teachers noted strong parallels between the sky show content and textbook topics, particularly in subjects such as the solar system and physics, which helped reinforce learning in a novel yet familiar setting. This aligns with research indicating that planetariums serve as effective supplements to classroom instruction, enabling visualization of complex phenomena like planetary motion and gravitational forces in three dimensions (Slater & Tatge, 2017; Karaca & Bektaş, 2023). The integration of digital projections and interactive storytelling transforms abstract concepts into meaningful and memorable experiences, enhancing experiential learning through sensory engagement and real-world simulation (Kolb & Kolb, 2005).

Teachers also highlighted how visual experiences provided by the sky shows supported comprehension of complex scientific concepts, particularly in astronomy and physics. Observing scientific phenomena in motion helped students move from abstract understanding to active experimentation, which is critical for internalizing science concepts. Immersive domes and 3D simulations supported this process by engaging multiple senses (Graven, 2024; Leal et al., 2023).

Further, teachers noted that the sky shows connected classroom learning to real-world experiences, helping students view science as part of everyday life. This supports informal science learning that links academic knowledge with real-world applications (Aspin & Chapman, 2000; Holliday & Lederman, 2013; Falk & Dierking, 2011). Grade-level appropriate programming was also observed to boost engagement and reduce cognitive overload, with inclusive approaches that cater to diverse learners (Main, 2023; Yusof et al., 2024).

6.4 The impact of Sky shows at the Planetarium on understanding of science concepts among school students.

The responses to Research Question 4 on the impact of sky shows at the planetarium in understanding science concepts among school students reveal how visual and immersive experiences with the sky shows support students' understanding of complex scientific concepts. Visual learning tools, particularly in the form of planetarium shows, can significantly improve cognitive processing of abstract scientific ideas (Plummer et al., 2014). Teachers noted that the sky theatre experience allowed students to "know the things they see in sky better" and "understand science and physics in particular," indicating that the integration of visual elements helps bridge the gap between scientific theory and perceptual understanding.

The responses suggest that the planetarium experience facilitates contextual and applied learning, helping students move beyond rote memorization towards meaningful understanding. This aligns with constructivist learning theories which assert that knowledge is best constructed when learners are actively involved (Mariyam, A. S., 2023). By witnessing celestial events simulated in a planetarium, students experience phenomena that textbooks cannot fully capture, such as the apparent motion of stars, planetary alignments, or the scale of the solar system. Teachers' statements, such as "enhances practical knowledge" and "helps students remember the concepts forever," suggest that the integration of informal learning experiences into formal education can lead to deeper, more durable learning outcomes (Maria, 2023).

Teachers also noted that students found the experience "very interesting" and it "helps the students to understand about stars and the solar system." Research by Falk and Dierking (2000) supports this, emphasizing that informal learning environments like planetariums stimulate curiosity and spark interest in science. Finally, some responses highlighted the importance of showing students "how astronomy is important in our life," supporting DeWitt & Archer's (2017) assertion that informal science education fosters scientific literacy and connects school science to real-world contexts.

6.5 Teachers' recommendations for improving the educational effectiveness of the planetarium.

Teachers offered recommendations in three key areas: (i) Modernization and Relevance of Educational Content, (ii) Duration and Accessibility of Sessions, and (iii) Instructional Quality and Satisfaction. Teachers emphasized updating the content and models used to maintain scientific accuracy and student interest. This aligns with the evolving demands of science education, where current and relevant content is essential for meaningful engagement (Çığrık & Özkan, 2015). Outdated material risks diminishing the educational impact of the experience.

The need to extend session durations, especially for rural students, was also highlighted. Longer sessions could support better comprehension and allow for deeper cognitive engagement, reinforcing the idea that time is a key factor in effective learning (Dabney et al., 2015). Feedback on instruction quality varied. While some teachers appreciated the current delivery, others suggested the need for clearer, more detailed explanations. This indicates differences in facilitation and expectations, supporting the idea that quality facilitation is vital for impactful informal science learning (Hakverdi-Can, 2013). Positive responses also affirm that JNP's foundational approach is effective, with scope for targeted improvements.

7. Conclusion

This study offers meaningful insights into the role of planetariums specifically JNP in Bengaluru as an ISLC and its impact on school-level science education. By gathering and analysing the perspectives of science teachers accompanying students to JNP, the study sheds light on how the planetariums enrich science learning and cultivate interest in scientific inquiry. Teachers emphasized that planetariums play a vital role in enhancing school student's understanding of science by making it interactive, exciting, accessible, and insightful for science learning. The sky shows especially highlighted as an immersive tool that sparks curiosity and reinforce conceptual understanding beyond textbook learning, while still maintaining the relevance to current school curriculum. This facility was seen not merely as a supplementary resource but as powerful platforms for fostering authentic scientific inquiry and cultivating a scientific mindset.

From a pedagogical perspective, teachers recognized planetarium as a space that inspires students to engage with science in more meaningful and experiential ways. Overall, the study affirms the value of informal science learning in cultivating curiosity, supporting conceptual clarity, and enhancing student understanding of science. The perspectives of participating teachers reinforce the role of planetariums like JNP as essential extensions of formal science education promoting equitable, engaging, and inquiry-rich learning opportunities for all learners making ISLCs centres a part of the larger ecosystem in encouraging science learning.

The findings from this study carry several educational implications that can inform policy, pedagogy, and practice in science education, particularly within the Indian context. Educational institutions and curriculum developers can consider systematically integrating visits to such ISLCs as part of the formal science curriculum to foster experiential learning and real-world application of scientific concepts. Teachers observed that their experiences at JNP encouraged them to adopt more hands-on, exploratory teaching methods. This reinforces the need for professional development programs that train educators in inquiry-based and experiential pedagogies. The study suggests that stronger collaboration between schools and institutions like JNP can enrich science instruction. Schools can build partnerships with planetariums and science centres to co-design learning modules, organize teacher training, and schedule periodic student engagements that align with curricular goals. Beyond curriculum goals, Schools and educational planners should view such experiences not as extras, but as essential to developing 21st-century scientific competencies.

While this study focused on science teachers' perspectives on planetarium-based learning, further research is needed to explore its broader impact. Future studies could examine the long-term effects of such experiences on students' scientific understanding, attitudes, and career interests. Including student voices would offer a more comprehensive picture of the learning outcomes in informal settings. Comparative studies across various informal science centres such as science museums and botanical gardens could help identify effective practices that enhance science education. Research should also explore how planetarium outreach and mobile programs impact rural and underserved communities to promote equitable access. Further investigation into teacher training models that support integration of informal learning into the classroom would be valuable. Additionally, studies on curriculum alignment and the role of emerging technologies like AR, VR, or AI in enriching planetarium-based learning could open new pathways for engaging science education.

8. Ethical Considerations

Researchers face ethical challenges in all stages of the study, from designing to reporting. These include anonymity, confidentiality, informed consent, researchers' potential impact on the teachers and vice versa. To start with the research, relevant permissions were taken from the authorities at JNP. The authorities provided with permission to collect data for a specific duration and with guidelines of ethics to be followed during and after the data collection. Some important ethical concerns that should be taken into account while carrying out qualitative research are: anonymity, confidentiality and informed consent. The researcher in the stage of sampling made it clear to the teachers that the responses would be anonymous and confidential. Since the responses were to be collected in written form at a later date, the researcher had to collect the names of the respondents, however the anonymity and confidentiality of the respondents was maintained by the researcher by coding the respondents to report the findings as P1 (Participant 1). During the sampling stage only those samples among the population who gave their consent to participate in the research were selected for the study. Since the teachers were accompanying the students and had little to no time in responding on the same day, the teachers were given time to respond considering the ethics of involvement in the duty and activities of the teachers being disrupted. All the schools that visited in the duration of the study were approached, reducing the bias in sampling by the researcher. The consent from the teachers was collected by providing all relevant information about the research study, objective and purpose of the study to reduce any personal bias on part of the researcher.

9. Limitations of the Study

While this study provides valuable insights into the educational potential of planetariums as informal science learning centres, several limitations must be acknowledged. Firstly, the sample size was limited to a small group of teachers (N=10) from a specific geographical location (Bengaluru, India), which may not fully represent the diverse perspectives of educators across different regions or educational contexts. Secondly, the data were based solely on self-reported teacher perceptions, which could be influenced by personal biases or recent experiences. Thirdly, the study did not include direct feedback from students or empirical measures of learning outcomes, which limits the ability to assess the actual impact of the planetarium experience on student learning. Finally, the focus was restricted to one planetarium, which may limit the generalizability of the findings to other informal science centres with different facilities or programming approaches.

Acknowledgement: The authors extend sincere gratitude to participating school teachers for sharing their valuable insights. The Authors also extend special thanks to Director, Administrator, Scientist mentor, Deputy Administrator and the entire staff at Jawaharlal Nehru Planetarium for support and assistance facilitated during the research.

Consent: The authors collected written consent from the respondents to use the data for research purpose.

Disclosure: The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

Almeida, G. de O., Zanitti, M. H. R., Carvalho, C. L. de, Dias, E. W., Gomes, A. D. T., & Coelho, F. O. (2017). O planetário como ambiente não formal para o ensino sobre o sistema solar. Revista Latino-Americana de Educacao Em Astronomia - RELEA, 23, 67–86. https://doi.org/10.37156/RELEA/2017.23.067

Aspin, D., & Chapman, J. (2000). Lifelong learning: concepts and conceptions. International Journal of Lifelong Education, 19(1), 2–19. https://doi.org/10.1080/026013700293421

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. Journal of Teacher Education, 60(5), 497–511. https://doi.org/10.1177/0022487109348479

Bourgeault, I. L., Dingwall, R., & De Vries, R. (2010). The SAGE Handbook of Qualitative Methods in Health Research. In SAGE Publications Ltd eBooks. https://doi.org/10.4135/9781446268247

Braun V., Clarke V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Çığrık, E., & Özkan, M. (2015). The investigation of the effect of visiting Science Center on Scientific Process skills. Procedia - Social and Behavioral Sciences, 197, 1312–1316. https://doi.org/10.1016/j.sbspro.2015.07.405

Dabney, K. P., Tai, R. H., & Scott, M. R. (2015). Informal science: family education, experiences, and initial interest in science. International Journal of Science Education Part B, 6(3), 263–282. https://doi.org/10.1080/21548455.2015.1058990

DeWitt, J., & Archer, L. (2017). Participation in informal science learning experiences: the rich get richer? International Journal of Science Education, 7(4), 356–373. https://doi.org/10.1080/21548455.2017.1360531

Eupena, R. G. (2012b). Teacher communication behavior: It's impact to the students' attitude in learning science. IAMURE International Journal of Social Sciences, 3(1). https://doi.org/10.7718/ijss.v3i1.35

Falk, J. H. (2001). Free-Choice Science Education: How We Learn Science outside of School. Ways of Knowing in Science and Mathematics Series. Teachers College Press, PO Box 20, Williston, VT 05495-0020 (hardback: ISBN-0-8077-4065-9, $53; paperback: ISBN-0-8077-4064-0, $24.95).

Falk, J. H., & Dierking, L. D. (2011). Lifelong Science Learning for Adults: The role of Free-Choice Experiences. In Springer eBooks (pp. 1063–1079). https://doi.org/10.1007/978-1-4020-9041-7_70

Freeman, B., Marginson, S., & Tytler, R. (2019). An International view of STEM Education. In BRILL eBooks (pp. 350–363). https://doi.org/10.1163/9789004405400_019

Glassman, M. (2001). Dewey and Vygotsky: Society, Experience, and Inquiry in Educational practice. Educational Researcher, 30(4), 3–14. https://doi.org/10.3102/0013189x030004003

Graven, B. (2024). Using a planetarium to support pre-service elementary teachers' development of NGSS-aligned science teaching. https://doi.org/10.18297/etd/4306

Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a Science Museum field trip. Journal of the Learning Sciences, 21(1), 130–181. https://doi.org/10.1080/10508406.2011.555938

Hakverdi-Can, M. (2013). İlköğretim öğrencilerinin bilim merkezindeki davranışlarının incelenmesi. Eğitim ve Bilim 38(168), 347-361.

Hawley, P. H., & Sinatra, G. M. (2018). Declawing the dinosaurs in the science classroom: Reducing Christian teachers' anxiety and increasing their efficacy for teaching evolution. Journal of Research in Science Teaching, 56(4), 375–401. https://doi.org/10.1002/tea.21479

Holliday, G. M., & Lederman, N. G. (2013). Informal Science Educators' Views about Nature of Scientific Knowledge. International Journal of Science Education, 4(2), 123–146. https://doi.org/10.1080/21548455.2013.788802

Jawaharlal Nehru Planetarium. (2023). Annual report 2022-23. In Bangalore Association of Science Education. Bangalore Association for Science Education.

Karaca, M., & Bektaş, O. (2023). Pre-service science teachers' opinions about the planetarium. Nevşehir Hacı Bektaş Veli Üniversitesi SBE Dergisi. https://doi.org/10.30783/nevsosbilen.1271718

Kirchberg, V., & Tröndle, M. (2012). Experiencing Exhibitions: A review of studies on visitor experiences in museums. Curator: The Museum Journal, 55(4), 435–452. https://doi.org/10.1111/j.2151-6952.2012.00167.x

Kolb, A. Y., & Kolb, D. A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher education. Academy of Management Learning and Education, 4(2), 193–212. https://doi.org/10.5465/amle.2005.17268566

Land-Zandstra, A. M., De Bakker, L., & Jensen, E. (2020). Informal Science education. In WORLD SCIENTIFIC eBooks (pp. 91–117). https://doi.org/10.1142/9789811209888_0005

Leal, M. A., Molina, C., Valbuena, M., Guerra, Y., Carvajal, M., Tovar, D., Prada, N., Guevara, J., Ruiz, W., Guerrero, C., Sepulveda, K., Caicedo, D., Benavides, J. S., Ceferino, M. T., Montenegro, O., Altafulla, J. L., Cuartas, K., Pulido, C., Cano, J. F., & Cuervo, J. (2023). A multi-approach perspective for the attention of the diversity of the audiences in science museums: the pedagogical model of the Bogota Planetarium. Research Square (Research Square). https://doi.org/10.21203/rs.3.rs-2967624/v1

Lee, O., Luykx, A., Buxton, C. A., & Shaver, A. N. (2007). The challenge of altering elementary school teachers' beliefs and practices regarding linguistic and cultural diversity in science instruction. Journal of Research in Science Teaching, 44(9), 1269–1291. https://doi.org/10.1002/tea.20198

Main, P. (2023, January 29). Embracing the learning theory: constructivism. Structural Learning. https://www.structural-learning.com/post/embracing-the-learning-theory-constructivism

Mariyam, A. S. (2023). The Importance of Planetarium as Astronomy Education Center in Universitas Muhammadiyah Surabaya: A Preliminary study. In Advances in social science, education and humanities research (pp. 59–71). https://doi.org/10.2991/978-2-38476-022-0_8

Miles, R., Annetta, L., Moore, S., & Miles, G. (2022). Teaching multicultural science education to underserved and underrepresented populations in rural areas. In Springer international handbooks of education (pp. 457–486). https://doi.org/10.1007/978-3-030-83122-6_23

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2013). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. HHS Author Manuscripts, NIH, 42(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y

Rennie, L. J. (2012). The practice of science and technology communication in science museums. In Communication and Engagement with science and technology (Vol. 1, pp. 197–211). Taylor & Francis. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203807521-16/practice-science-technology-communication-science-museums-l%C3%A9onie-rennie

Schultz, S. K., & Slater, T. F. (2022). Who Are The Planetarians? A Demographic Survey Of Planetarium - Based Astronomy Educators. Journal of Astronomy and Earth Sciences Education, 7(1), 25–30. https://doi.org/10.19030/jaese.v7i1.10355

Seyma, A., & Topsakal, Ü. U. (2017). Planetariums as a source of outdoor learning environment#. Educational Research and Reviews, 12(5), 283–287. https://doi.org/10.5897/err2016.2956

Slater, T. F., & Tatge, C. B. (2017). Overview of Planetarium Education Research Methods (pp. 29–52). Springer, Cham. https://doi.org/10.1007/978-3-319-57202-4_2

Stage, F. K., Muller, P. A., Kinzie, J., & Simmons, A. (1998). Creating learning centered classrooms. What does learning theory have to say? ASHE-ERIC Higher Education Report, Volume 26, No. 4. https://eric.ed.gov/?id=ED422778

Stöcklmayer, S., & Rennie, L. J. (2017). The Attributes of Informal Science Education: A Science Communication Perspective. In Springer eBooks (pp. 527–544). https://doi.org/10.1007/978-3-319-50398-1_26

Sugarman, L. (1987). Experiential learning: Experience as the source of learning and development, David A. Kolb, Prentice-Hall International, Hemel Hempstead, Herts., 1984. No. of pages: xiii + 256. Journal of Organizational Behavior, 8(4), 359–360. https://doi.org/10.1002/job.403008040

Taking Science to School. (2007). National Academies Press eBooks. https://doi.org/10.17226/11625

Tenny, S. (2022, September 18). Qualitative study. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK470395/

The role of the museums in lifelong learning for adults. (2020b). International Journal of Heritage and Museum Studies (Print), 2(1), 136–145. https://doi.org/10.21608/ijhms.2020.188763

Yeong, M. L., Ismail, R., Ismail, N. M., & Hamzah, M. I. (2018). Interview Protocol Refinement: Fine-Tuning Qualitative Research Interview Questions for Multi-Racial Populations in Malaysia. The Qualitative Report. https://doi.org/10.46743/2160-3715/2018.3412

Yusof, M. M. M., Alias, N. H., Luaran, J. E., Aris, S. a. M., & Zulkipli, Z. A. (2022). Planetarium pedagogy and learning experience: exploration into planetarium education program. International Journal on e-Learning and Higher Education, 17(1), 49–68. https://doi.org/10.24191/ijelhe.v17n1.1713

Zinger, D., Sandholtz, J. H., & Ringstaff, C. (2020). Teaching Science in Rural Elementary Schools: Affordances and Constraints in the age of NGSS. The Rural Educator, 41(2), 14–30. https://doi.org/10.35608/ruraled.v41i2.558