Science Education in Second Life

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Abstract

The purpose of the observational study was to investigate whether spaces in Second Life (SL) displaying interactive scientific exhibits can become potential avenues to promote inquiry in teaching scientific concepts. 42 SL spaces (islands) were selected using inclusion/ exclusion criteria out of 155 spaces that were found using three different sources of information. These spaces were then examined to further identify characteristics of their presence using nine measures: type of science discipline, context settings, number of exhibits, type of exhibits, media usage, clarity of instructions, realism, and level of students' engagement. Results suggest most of the SL spaces examined for this study showed a high score on all the characteristics indicating that SL can be considered as a potential avenue for promoting inquiry in Science education.

Science Education in Second Life:

Promoting Inquiry in a 3 Dimensional Virtual Learning Environment

One of Science educators' major concerns is the scientifically discrepant preexisting knowledge and beliefs that students bring to the classroom (Nussbaum & Novick 1982). Often this gives rise to misconceptions because students attempt to modify new knowledge to fit their preconceived notions. These misconceptions are referred to in the literature, as alternate frameworks, preconceptions, or subsuming concepts. Students' misconceptions consist of their own explanation about a scientific phenomenon. According to Hammer (1996), misconceptions has four characteristics: (1) they are different from scientifically accepted explanations, (2) they profoundly affect how students understand scientific explanations of a phenomenon, (3) they are strongly and deeply rooted pieces of information, (4) they must be eliminated or revised in order for students to gain scientifically acceptable understanding.

Several studies have reported detrimental effects of students' misconceptions on learning outcomes. (Norman & Clement, 1981; Novick & Nussbaum, 1978; Posner, Hewson, & Gertzog, 1981). More often than not, science educator fail to acknowledge that students do, in fact, come to class with many misconceptions. Most classroom learning in science is devoid of strategies and tools to assess and address these misconceptions. Typically, in practice, demonstration of experiments is considered as a sufficient condition to bring about a conceptual change (i.e. from misconception to the scientifically acceptable conception). Classroom learning environments are driven by the assumption that demonstration of scientific experiments and presentations of relevant information will help achieve desired learning outcomes irrespective of the existence of such misconceptions (Nussbaum & Novick, 1982). However, students are known to hold their own conception of scientific phenomena if they are not considerably challenged. Therefore, Vosniadou, Ioannides, Dimitrakopoulo & Papademetriou (2001) suggest it is important to address these misconceptions of students before teachers begin any instruction on scientific concepts.

Inquiry Based Approach

According to Posner, Strike, & Hewson (1982) and Strike & Posner (1985), conceptual change can best be attained if the learning process takes form of an *inquiry*. In an inquiry-based approach to learning, students are exposed to the scientific concepts and are encouraged to relate them to their understanding of the concepts (i.e. to their naïve conception). Through constant inquiry and exploration opportunities students are likely to revise their misconceptions if compelling evidence is provided in support of the scientifically acceptable understanding.

In some areas of science, the use of laboratory activities, problem solving sessions, and project based learning opportunities have aided students in recognizing their misconceptions, while providing evidence for more accurate views (Bishop & Anderson, 1990). This study takes a step further to hypothesize that coupling these activities with exploration of scientific phenomena in a computer mediated virtual environment can provide opportunities for students to identify, confront, and attain conceptual understanding that is scientifically acceptable. The purpose of this study, therefore, was to explore one of the most popular three dimensional (3D) virtual learning environments of Second Life (SL, described below) to examine the characteristics of the spaces in SL that display interactive scientific exhibits. The original hypothesis was to examine if these SL spaces can support an inquiry based learning environment.

Second Life Virtual Environment

Three dimensional (3D) virtual worlds have been the latest revolution in the field of computer technologies. There are many 3D virtual world software available such as Whyville, Active Worlds, and Quest Atlantis. Perhaps one that has gained unprecedented acceptance among educators is Second Life (SL) (Case studies and success stories, n.d.). Predictions are being made about SL's future pervasiveness and sustainability in different areas (e.g. business, education and social networking) (Gartner Inc, 2007). The wide-range acceptance of Second Life in education area is due to its highly interaction-centric design. The interaction-centric design of SL can be utilized to promote various student-centered learning environments based on several nontraditional philosophies (e.g. constructivist, inquiry, and experience based).

SL with its interaction centric-design provides users with the capability to build 3D objects and spaces using the tools (affordances) of the software. Educational institutions across the globe have begun to utilize these affordances to create interactive and immersive learning environments. Some examples include the Harvard Law School Austin Hall, Hong Kong Polytechnic University, School of Hotel & Tourism Management, and University of Plymouth Health sim (Top 20 educational locations in second life, 2008, December 8, 2008). SL Wiki provides a list of educational institutions that have creatively utilized the affordances of SL for the purpose of teaching and learning.

The educational benefit of SL affordances to build 3D objects and spaces provides the ability to create real-life like environments, which create a sense of immersion. The three dimensionality of the objects, replicas of real-life places, movements, and interactions in real-life places create a perception of being actually present. Numerous of these phenomena and places are centered on scientific concepts and principles. Examples of such places include process of fertilization exhibit at the American Chemical Society's Island, medical examination rooms at

Ann Myers Medical Center Island, and the Galileo Observatory at the Info Island. Also, users can create environments that are more engaging by simulating phenomena and building places that otherwise are not accessible in real life. Some examples include experiencing a Tsunami from under the sea bed at the National Oceanic and Atmospheric Administration (NOAA) Island, exploring a cholesterol molecule at the Second Nature's Island, entering a giant cell to interact with the intracellular structure at the Genome Island, riding a spaceflight at the International Space Flight Museum's Island, and travelling in the galaxy at the Scifi Museum's Island.

To achieve the purpose of this study, the following questions were of specific interest:

Q1: What are the kinds of spaces that display scientific exhibits in SL?

Q2: What are the characteristics of these exhibits?

Q3: Can these characteristics provide students with an inquiry based learning environment that can address their misconceptions?

Method

Design

This study used an observational design to answer the research questions, and was conducted by visiting selected spaces in SL and systematically abstracting information about the characteristics of these spaces.

Sample

The author identified 155 spaces related to the discipline of Science in Second Life, during the period of October 2009 to March 2009. The researcher employed the following strategies to identify the virtual locations in SL: (1) conducted a series of Google searches using the search term "science museum in Second Life", (2) investigated Linden Lab's (developers of SL) official website that hosts an education page listing the top 20 educational sites, (Top 20 educational locations in second life, December 8, 2008) and (3) conducted a series of searches in SL, using its search tool. Upon identifying these spaces, the author personally visited each one to determine whether they qualified for the purpose of this study.

Inclusion and Exclusion Criteria

All 155 spaces found in SL were screened based on whether they displayed at least one scientific exhibit. Spaces that were built to establish the presence of a real life organization in the discipline of science were excluded. Spaces that were representing virtual offices of any projects undertaken in the field of Science were also excluded. Finally, spaces that had created meeting areas, classrooms, conference rooms, and auditoriums were not included in the study. Only those spaces that had displayed scientific exhibits for the purpose of *educating their visitors* were included.

Assessment of the Characteristics

Using the above mentioned exclusion and inclusion criteria, the author narrowed the list to 42 spaces that displayed some type of scientific exhibits. Further, these spaces were systematically assessed for eight unique characteristics: type of science discipline, settings, number of exhibits, types of exhibit, media usage, clarity of instruction, realism, and level of students' engagement. Following are details of the rationale and explanation of each characteristic used to examine the spaces systematically; further details on the scoring procedure can be found in Table 1.

Insert Table 1 Here

Description of the Characteristics

Type of science discipline.

The 42 SL spaces indentified in the study belonged to one of the following fields: Chemistry, Astronomy, Biology, Physics, Optics, Planets, Forensics, Genetics, Oceans, Energy, and Geology. For ease of understanding the author classified these spaces into four major categories of Science: Chemistry, Physics, Earth and Environmental, and Geology. Table 1 presents the numerical values assigned to each of the four broad areas for the purpose of coding.

Settings.

The exhibits examined in SL were displayed in a variety of different settings. These settings included laboratories, planetariums, space ships/ space crafts, aquariums, stand alone exhibits, and multiple settings. Table 1 depicts the numerical value associated with each type, for coding.

Number of exhibits.

The architecture of the spaces in SL varies in terms of scale, ranging from one to multiple exhibits arranged over an entire island. There were spaces such as the International Space Flight Museum, the SploIsland, the Scifi Mueseum, and the Star Trek Museum that were large in terms of the number of exhibits they displayed. While the display of the exhibits can mimic real life-like environments such as mounted on the wall or displayed in the rooms, this is not a requirement in SL. Exhibits in SL can be displayed in the open air or floating in mid-air. The author was interested in finding how many of these spaces were large in size because if there were a large number of exhibits on the spaces, they were either encompassing a wide array of topics under the global theme of the island, or were displaying various facets of single concept. For the purpose of this study, spaces were classified into five categories ranging from very large to very small. Table 1 contains the scoring criteria used to assign these spaces to one of the categories.

Types of exhibit.

The exhibits examined in the spaces could be broadly divided into two categories: Interactive and Non-interactive. Interactive exhibits allow the users to perform some action on the exhibits. These actions include obtaining an informational note card from the object; sitting on an object; experiencing some Avatar movements (An Avatar is a digital representation of the users in SL); and changing the form, color, or size of an object. Non-interactive exhibits include static models of scientific phenomena, visual images displayed as posters, or Power Point slide presentations. This study used a Likert type scale (1 to 5) to classify spaces into the categories ranging from highly interactive to static. Table 1 provides more details on the scoring of this characteristic.

Media usage.

The SL environment can support a variety of media files such as graphics, audio, and video. Builders of the spaces assessed in this study used all of the above media in varying combinations and numbers. This study used a Likert scale to assign scores on this characteristic (1 to 3). Readers can refer to Table 1 for more details on scoring procedures used for this characteristic.

Clarity of instruction.

In SL, information about and instructions to interact with the exhibits can be displayed in several ways. A floating text feature can let text appear on the top of the object. Another way could be to provide an informational note card to the Avatars or to inscribe text on the face of the object. The author used a Likert type scale (0 to 1) to rate the spaces on this characteristic, details of which can be found in Table 1.

Realism.

Realism is one of the key elements to make the virtual learning spaces more immersive (McCellan, 1996). Realism (virtual reality) can be understood in of terms how much does a user attribute the experience in the virtual environment to the interface of the computer. A high level of realism (virtual reality) is attained when learners get the perception of the experience as being real for that moment. In this study, the author examined the level of realism created in displaying the exhibits on all the 42 spaces. This attribute of the exhibits was scored on Likert scale (1 to 4) to group spaces ranging from highly immersive to minimal depicted in Table 1.

Level of students' engagement.

Researchers have conceived students' engagement in a variety of different ways such as cognitive, mental, or contextual factors. For the purposes of this study the dimension of the contextual factor was considered (i.e. the SL environment). Researcher was interested in examining the overall effectiveness of the learning environment that was supported on the 42 SL spaces. The score on this characteristic constituted sum of the scores received on the characteristics of number of exhibits, types of exhibit, media usage, clarity of instruction, and realism. The maximum score a space could earn was 18 points; further break down of scores and scoring criteria are provided in Table 1.

Analysis

The author examined the distribution of scores for each of the eight characteristics by counting the frequency of their occurrence. These distributions were then converted into percentages.

The data for each of the characteristics were abstracted twice for all the 42 spaces and inter-rater reliability scores were calculated for each pair of abstractions. Results are presented in Table 2. Cohen's Kappa ranged between 0.73 to 1.00 indicating all the inter-rater reliability scores were above the level of high agreement and 57 % of them equaled to 1.00. The average inter- rater reliability score across all the characteristics was 0.88

Insert Table 2 Here

Findings

Delineated in Table 1 are the characteristics used to examine the 42 SL spaces, the scale for measuring each of these characteristics, and the distribution of scores for each. Findings are discussed below organized by the research questions raised in this study.

Q1: What are the kinds of Spaces that Display Scientific Exhibits?

To answer this question, scores on the characteristic of type of discipline and settings were considered. Of the 42 spaces examined, 36 % and 33% displayed exhibits from Physics and Biology respectively, 14 % had exhibits from the field of Earth and Environmental science, 12 % from Chemistry, and 5 % from Geology. These exhibits were built on topics such as solar systems; human visual perceptions principles; molecular and cell biology, human anatomy, weather and climatology; toxicology; food and nutrition; and oceanography.

Regarding the settings of these scientific exhibits 38 % were stand alone exhibits, 24 % were in laboratory settings, 14 % were in the settings of Space ships/ space crafts, 10 % were either set up in a planetarium like environment or had multiple settings, and 5 % were in form of aquariums. Example of these includes visitors riding a submarine to learn about different kinds of whales, expose their Avatar to toxic chemicals to experience its harmful effects, or examine a patient’s heart beats to determine health conditions.

Q2: What are the Characteristics of these Exhibits?

The researcher used the score on the characteristics of number of exhibits, media usage, clarity of instructions, and realism to answer the second research question of this study. Most spaces examined in SL were considerable large in size. Nearly half (48 %) were very large, 31% were large, 17 % were medium sized, 2 % were small or very small. The large SL spaces had either displayed different aspects of a scientific phenomenon or multiple phenomena of a Science discipline. For example at the Star Trek Museum exhibits such as Astrometric labs, solar system simulation and Holodeck presents different Astronomical concepts. Alternatively, American Chemical Society displays variety of exhibits depicting harmful effects of Nitrogen on various kinds of living things.

Nearly half (47.61%) of the spaces were highly interactive, 30.95 % were interactive, 14.30 % were moderately interactive. There were very few that had minimal to no level of interactivity. Most (80.95 %) of the spaces preferred to use all the three media formats (i.e. graphics, video and audio) with an objective of making their exhibits highly engaging. The remaining 17 % of the spaces had at least any two combinations of the three media formats. Several spaces provided live streaming of NASA weather channel, some places displayed large graphics informing about the food safety and nutrition and others used audio capabilities to examine human body such as heart beats.

Of the 42 spaces that were screened 98 % (i.e. 41 spaces)had provided information and instructions about the exhibits. For example, Exploratorium Museum at Splo Island had displayed text informing the visitors about the perceptual principle presented each of their exhibits.

A substantial amount of spaces scored high on realism, 45 % of the 42 spaces examined satisfied the criteria of being highly immersive and 34 % were immersive. Of the remaining 19% were moderately immersive and 2 % were minimally immersive. Researcher found that most of these exhibits were capable of captivating learners’ attention because of the 3 dimensionality of the objects. This feature created an appearance of the object being real and not computer simulated. Realism (i.e. virtual reality) is considered an important factor to stimulate higher order, abstract and meta-cognitive thinking among learners. (Antonetti & Cantoia, 2000; Cai, Lu, Zheng, & Lin, 2006; Depradine, 2007; Lok, 2006; Millsa & Araujob, 1999).

Q3. Can these Characteristic Provide Students with an Inquiry Based Learning Environment that can Address their Misconceptions?

Researcher used a composited score on the characteristics of number of exhibits, types of exhibit, media usage, clarity of instruction, and realism to derive a score on students' level of engagement. Analysis of these composite scores informed the researcher to answer question three.

Level of students' engagement

The analysis of the scores on this characteristic suggests 54.76 % and 35.72 % of the SL spaces were capable of providing highly engaging to well engaging learning environment. Student‘s engagement is critical to student motivation during the learning process. The more students are motivated to learn, the more likely it is that they will be successful in their efforts (Wishart & Blease, 1999). The outcome of the data analysis suggests that 42 SL spaces supports highly engaging learning environment which may results into a high level of students' motivation and thereby positively impact the learning outcomes.

Discussion

The results of this study are encouraging because they highlight the potential that SL has for providing Science education students with an inquiry based learning environment. Along with displaying exhibits centering on a wide array of scientific concepts in the most appealing settings, these SL's exhibits also reflect critical characteristics of inquiry promotion. These include creating multiple representations of the concept, providing learners with the control to interact with the content, presenting content using multimodal designs, providing clear instructions to reduce working memory load, and conceptualizing scientific phenomena in virtually authentic environments. Research has shown that when learning environments are engineered using these characteristics there is a positive impact on the learning outcomes (Duffy & Jonassen, 1992; Brown, Collins, & Duguid, 1989; Cognition and Technology Group at Vanderbilt, 1992).

The majority of the spaces reviewed in this study had displayed a scientific concept in a variety of different ways. This strategy is the underpinning for one of the significant instruction design principle of using multiple representation of a concept to consolidate understanding. Multiple representations increase learners' motivation and deepen conceptual understanding (Ainsworth, 1999). Multiple representations of knowledge can be attained by using text, graphics, diagrams, tables, and formulae. In a computer mediated environment multiple representations can be presented using spread sheets, graphing packages, and customized software developed for instructional purposes (Thompson, 1992).

According to Ainsworth, Bippy & Wood (2002) multiple representations of a concept engage learners in self explanation (i.e. where learners effectively monitor their own understanding). This cognitive process of internal self -dialogue can be beneficial for addressing some of the misconceptions that students may bring with them about a phenomenon. Spaces examined in this study had exhibits that presented a scientific concept in a variety of different contexts to provide comprehensive understanding. For example, at the SploIsland (a replica of the Exploratorium Museum situated in San Francisco) there were about 50 exhibits centered on the human visual perception processes. Exploring these exhibits could provide learners the opportunity to understand different physics principles relating to human visual perception such as the Mueller-Lyer optical illusion, the Coriolis Effect, and the simultaneous color contrast effects.

Educators have increasingly adopted virtual reality as an essential instructional design component across discipline for better learning outcomes (Auld & Pantellidis, 1994; Boyle, Stevens-Wood, Zhu, & Tikka, 1996). One of the main reasons why virtual reality is integrated for educational purpose is its capability of providing highly interactive 3D environments. Interactivity has a multifaceted impact on the learning process: it leads to cognitive engagement, encourages users to actively process information, and provides feedback to the users (Ritchie, 1996). Most of the SL exhibits provide users with high levels of control in order to interact with the displays, find clear instructions, obtain detailed information about the scientific phenomenon displayed in the exhibit, and receive feedback.

Benefits of using Multimedia in education have been established in a variety of learning contexts (Dillon & Gabbard, 1998). Multimedia tools are known to engage students' attention in the learning activities thereby promoting deep reflective thinking (Mayer, 2001). Reflective thinking is considered an important aspect of the learning process (Moon, 1999). Multimedia rich environment posses a variety of components that can foster reflective thinking such as performing authentic tasks in an ill-defined situations, revisiting the learning materials to reevaluate conceptual understanding, and exploring by asking questions that seeks reason and evidence (Lin, Hmelo, Kinzer, & Secules, 1999). Spaces in SL were rich in the media resources that were used to build the exhibits. These exhibits were appealing because they used a combination of various media formats to make the environment more immersive. Therefore, these exhibits can become more engaging for students to access, interpret, and create their understanding about the concepts.

Research has shown that if a learner has to acquire more information in a shorter time, the more difficult it is to process information in the working memory. Miller (1956), based on his experimental results suggested that there is a limit to the amount of instruction that one can hold in the working memory and therefore, providing excessive information would result in the loss of information before it being processed. Cognitive load theory has been designed to provide guidelines intended to assist in the presentation of information in a manner that encourages learner activities that optimize intellectual performance (Sweller, van Merriënboer & Paas, 1998, p. 251).

According to Sweller (1998), one of the ways to facilitate the process of information acquisition is to reduce the load on working memory by providing as much cognitive support to the learners as possible. One of the instructional implications of this theory is to provide all the required information and/or instruction at the appropriate place in a clear manner. Exhibits in SL spaces have used creative ways to provide information and instructions about the scientific phenomenon displayed. This reduces cognitive load on learners working memory and facilitates long term, profound acquisition of conceptual understanding.

Educational Psychologists have long been stressing the importance of creating authentic learning environment for deeper conceptual understanding. Creating an authentic environment involves making learning task as proximal to real life situation (Savery & Duffy, 1996). Learning and reflecting in these authentic settings provide a more constructivist learning environment for the students. Learning in such constructivist environment makes learners active creators of their conceptual understanding and they are not passive consumer of information given by their teachers (Jonassen, 1999). Given the advantage of learning in authentic environments, how can educators provide their students with rich authentic learning environments? Technology offers great advantage by providing tools that were not available before. SL is an example one such sophisticated technology that Science educators can use to create authentic learning environments. Learners on these SL spaces can experience phenomena such as Solar Eclipse, Tsunami from under a sea bed, and space flight. Acquiring information about the scientific concepts in these authentic settings makes the learner reflects on its real life relevance, contextual meaning, and understanding the concepts beyond factual information.

Contributions

This observational study contributes to two major areas of Science education. First, providing a useful strategy for those science educators, who are attempting to address the prevalence of misconceptions in their students. Misconceptions have been at the root for deficient learning outcomes. Addressing misconceptions using computer simulated learning environments may eradicate some of the pitfalls that interfere in achieving the desired learning outcomes. Second, there has been no other study conducted till date to the author's knowledge that examined SL spaces using the method and characteristics used in this study.

Limitations

The SL spaces examined are subjected to variations due a variety of reasons such as expansions, contractions, and deletion from SL either arbitrarily and/or due to lack of resources. Therefore, considering this ever-changing nature and complexities, search of these virtual locations may provide varying results in the future.

This study examined the SL spaces using the framework of eight characteristics including type of science discipline, context settings, number of exhibits, types of exhibit, media usage, clarity of instructions, realism, and level of students' engagement. This list of characteristics is not exhaustive and may reflect authors' subjective bias. There is a likelihood that author may have not included some other characteristics that may prove insightful to further understand the dynamics of these spaces. However, the characteristics included in the study were chosen by the author based on an extensive and systematic literature review (in the area of technology integration in education and instructional design) conducted for the purpose of this study.

This study is the first and only one to the authors' best knowledge that has created a framework of the characteristics to examine SL spaces. However, no prior study is conducted to test the validity and reliability of these characteristics. In order to ensure that this study is not completely influenced by author's subjective bias two raters examined the spaces to provide scores on these characteristics including the author.

Directions for Future Research

Second Life is a comprehensive package of components useful for creating inquiry based learning environments. The discipline of Science is one such field where students must assimilate knowledge by constantly evaluating its validity in a real life context rather than acquiring it as mere chunks of information. Educators will find Second Life as an ideal environment for promoting inquiry in a computer simulated environment for their students to test and build their understanding of a scientific phenomenon. Science educators would do well in terms of attaining positive learning outcomes of their instruction if they can incorporate these SL spaces in their instructional activities. Teachers will have to carefully design their instruction to include these spaces as availability of the tool does not guarantee its use. Educators must adopt these technologies into their classrooms and embed SL activities in their instruction in a way that encourages students to take advantage of these SL spaces. A step further of this study would be to delineate a framework for incorporating each of the identified spaces in the curricula of school Science subjects. A final step would be to test and evaluate the learning outcomes using these SL spaces.

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Table 1

Criteria for assessment of 42 reviewed spaces on eight characteristics and frequency distributions for each characteristic.

Characteristics	Scale for measurement	Distribution of characteristics among 42 spaces reviewed	
		Frequency (n)	Percent (%)
Discipline of Science	Chemistry = 1	05	11.90
	Physics = 2	15	35.71
	Biology = 3	14	33.33
	Earth and Environment = 4	06	14.29
	Geology = 5	02	4.77
Settings	Laboratories = 1	10	23.80
	Planetariums = 2	04	9.55
	Spaceships/ space craft= 3	06	14.28
	Aquariums = 4	02	4.67
	Stand alone exhibits = 5	16	38.09
	Multiple settings = 6	04	9.5
Number of Exhibits	Very large (20 or < exhibits) = 5	20	47.62
	Large (11 – 15 exhibits) = 4	13	30.95
	Medium (6 -10 exhibits) = 3	07	16.67
	Small (2- 5 exhibits) = 2	01	2.38
	Very small (1 exhibit) = 1	01	2.38
Types of Exhibits	Highly interactive = 5 (75 % or < interactive exhibits)	20	47.61
	Interactive = 4 (50 % -75 % interactive exhibits)	13	30.95
	Moderate = 3 (25 % - 49 % interactive exhibits)	06	14. 30
	Minimal = 2 (11% - 25 % interactive exhibits)	02	4.76
	Static = 1 (5 % - 10% interactive exhibits)	01	2.38
Media usage	Tri Modal = 3	34	80.95
	Bi Modal = 2	07	16.67
	Single Modal = 1	00	2.38
Clarity of instructions	Presence of instructions = 1	41	97.62
	Absence of instructions = 2	01	02.38

Realism	Highly immersive = 4	19	45.28
	Immersive = 3	14	33.35
	Moderate = 2	08	19.04
	Minimal = 1	01	2.38
Level of students' engagement	Very highly engaging = 5 (Total score of 16- 18)	23	54.76
	Highly engaging = 4 (Total score of 13- 15)	15	35.72
	Engaging = 3 (Total score of 10- 12)	02	4.76
	Moderate = 2 (Total score of 5 - 9)	02	4.76
	Minimal = 1 (Total score of 0- 4)	00	0.00

Table 2

Results of Cohen's Kappa calculated for each of the eight characteristics.

Characteristics	Inter-rater reliability scores
Discipline of Science	1.00
Settings	1.00
Number of exhibits	0.73
Types of exhibits	1.00
Media usage	0.75
Clarity of instructionS	1.00
Realism	0.74