

A Study of Applying a 3D Instructional Software of Popular Science (Science On a Sphere Explorer) in Earth Science Education of an Elementary School

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Abstract— The increasing popularization of information technology has gradually overcome the difficulties of educating earth science gradually. In the times of having only textbooks, we merely had 2D maps for references to educate earth science. However, it was known that the earth was round, but it was hard for students to understand flows of ocean currents, atmospheric flows, ship movements, or directions of typhoons from those 2D maps. Nevertheless, the development of information technology and computers had solved these problems. For instance, we could use software to simulate flight of airplanes, navigation direction of ships, and moving route of cars. Based on the evolvments of these computer technologies, our lab considered using 3D visual effects to display the earth and educate earth science; consequently, we designed the software “Science On a Sphere Explorer.” In it, we have integrated several hundreds of environmental science data from National Oceanic and Atmospheric Administration and utilized 3D visual effects to educate earth science. In this study, the authors introduce the software and describe the instructional outcomes.

Keywords— Science On a Sphere Explorer; SOSx; 3D; Visualization; NOAA

I. INTRODUCTION

For earth science, students are always highly interested in exploring various types of natural phenomena; yet, they have insufficient knowledge about them due to the limits of time, space or movement; this presents a huge challenge for instructors. Nonetheless, the rapid growth of information technology and computers have helped solve these problems. For instance, we can use software to simulate tracking flight of airplanes, navigation of ships, and tracking of cars. Based on the evolution of these computer technologies, our lab considered using 3D visual effects to display the Earth and educate earth science; consequently, we designed the software called “Science On a Sphere Explorer (SOSx)”. In it, we integrated several hundreds of environmental science datasets from National Oceanic and Atmospheric Administration and utilized 3D visual effects to educate earth science.

II. LITERATURE REVIEW

A. Earth Science

Earth science refers to all knowledge related to the studies about the earth; scientists generally study it from the perspective of physics, geography, geology, meteorology, mathematics, chemistry and biology [1]. As a highly fundamental and significant discipline, its vast scope includes the fields of geology, oceanography, meteorology, astronomy, and humanities etc. Geology is the study of the composition of the earth; oceanography is the study of oceanic movement and the physical and chemical characteristics of seawater; meteorology is the study of atmospheric composition, structure and movement; astronomy is the study of the effects of space factors on the earth; finally, humanities are the descriptions of the significant changes and impacts caused by humans on the earth.

B. Information Education

It refers to the learning methods applying various types of information technology in inspiring and assisting students based on various types of learning theories. Applying information technology in the instruction of all disciplines will be one of the major methods to improve instructional models for schools in the future.

Currently, most teachers will apply information technology in their teaching activities; however, as far as integrating information into teaching is concerned, it is more than just allowing teachers to be able to use computers and then achieve instructional objectives effectively. The key point of information education lies in smoothly introducing all types of usable resources and media to effectively instructional and learning processes of various subjects [2].

C. Mercator Projection

In the times without satellite monitoring, it was crucial to draw the Earth on paper because navigation needed a precise map [3]. Mercator was European cartographer from the 16th century. His method was to create a 2D map of the earth by extending the law of “parallels and meridians are straight and perpendicular to each other”. Therefore, the result showed on the map from one place to the other place conformed with the reality. Mercator projection had great benefits for navigation, and hence this 2D map has been widely used since the 16th century.

However, it is impossible to completely describe the 3D earth by a 2D map. One great flaw of using Mercator projection to draw maps is that it will distort the sizes of countries. Mercator projections distort the size of geographical objects far from the equator and convey a distorted perception of the overall geometry of the planet. Simply put, it will shrink the size of the countries near the equator and inflate the size of the countries near the poles, and the size of the countries at the poles is infinite!

As discussed in the results, this distorted perception lowered the spatial analysis scores of the students compared to those using spherical maps available in SOS Explorer. Spatial analysis is the ability to be aware of oneself in space. It is an organised knowledge of objects in relation to oneself in that given space. Spatial awareness also involves understanding the relationship of these objects when there is a change of position.

There are few instances where this spatial analysis flaw is visible.

First, Africa is quite vast but its size appears relatively small on the 2D map because it is on the equator. Conversely Japan and the UK appear bigger than they are. [4] Generally, most will think that Japan's size is smaller. Finally, we have the impression that Antarctica's size is extremely large, but it is much smaller than Africa's size.

D. SOSx

SOS Explorer Mobile (SOSx) is a mobile version of the widely popular Science On a Sphere® (SOS). [5] The application takes SOS datasets, usually only seen on a 6-foot sphere in large museum spaces and makes them more accessible. The visualizations show information provided by satellites, ground observations and computer models. It is built using the Unity game engine. [6] While a game engine may seem a strange choice for environmental science, the author's philosophy is to take advantage of existing technology whenever possible. Video games are a multibillion-dollar industry and are quite simply the most powerful tools for pushing millions of points of data to a user in real-time.

SOSx is a tool that can be used in many ways. In this section we describe some examples of how we have used SOSx Mobile and provide examples to help you get started. SOSx Mobile datasets can be a powerful tool for inquiry. In large part, this is because, SOSx Mobile datasets can be complicated. This makes them perfect for inquiry learning and

initiating deeper scientific and geographic research topics. In addition, each SOSx Mobile dataset has a written description and can be good exercise in scientific literacy.



Figure 1. Science On a Sphere Mobile version [7]

Combining inquiry and literacy, here are a few examples of a modified KWL format. KWL is a commonly used graphical organizer using the themes: Know, Want to know, Learned.

Using these examples, a teacher can display the dataset, have students fill out the boxes Know and Want to Know, come up with good questions about what they see, read the dataset description, fill out the box Still Want to Know, and plan a research investigation to answer one of their questions. What the student learned could be shared, presented or written.

III.METHODS

Through reviewing literature, the authors pose the following questions based on the considerations of the current elementary school curriculum, the integration of information technology into teaching, and difficulties of teaching earth science in the teaching sites:

1. Are students' learning outcomes different after applying SOSx in teaching?
2. What are students' perspectives and attitudes towards using SOSx to learn earth science?

For the above research questions, the following research activities were studied.

1. Analysing the differences of students' learning outcomes when using different teaching models in teaching units of earth science
2. Understanding the perspectives and attitudes of students from the experimental group towards applying SOSx in earth science of elementary schools

IV.RESULTS

A. Subject

In this study, Hwa-Kang Xing-Ye Foundation had invited three classes of the 6th graders of an elementary school to attend the course, and their learning levels were close. For these three classes, the first one was taught by the traditional lecture method without using SOSx (Group A); in the second class, the teacher first taught some concepts in the first lesson and the students used SOSx in a computer classroom in the

second lesson (Group B-1); in the third class, the students used SOSx in the first lesson, and in the second lesson the teacher then taught significant concepts based on their prior experiences of using SOSx (Group B-2). Gender, quantity, using SOSx, and evaluation time of the students from the 3 classes were shown in Table 1.

TABLE 1. DATA OF SAMPLE STUDENTS OF THE TEACHING EXPERIMENT

Class	Male	Female	Total Quantity	SOSx Operation
Control Group Group A	12	13	25	Lecturing on both lessons without using SOSx
Experimental Group Group B-1	11	14	25	Lecturing first and then using SOSx
Experimental Group Group B-2	11	14	25	Using SOSx first and then lecturing

TABLE 2. TABLE 2. INSTRUCTIONAL CONTENTS

Group Instructional Design	Control Group Group A	Experimental Group Group B-1	Experimental Group Group B-2
The 1st Lesson	In both lessons, teacher gave traditional lectures and used paper teaching materials and presentation software to teach.	1. In the first lesson, the teacher gave traditional lectures and used textbooks and presentation software to teach.	In the first lesson, the students went to computer classroom to use SOSx and the teacher provided software operational materials at the beginning of the lesson. Students needed to answer the teacher's questions, and the teacher didn't teach anything related to the course.

The 2nd Lesson		2. In the second lesson, students went to the computer classroom to use SOSx, and the teacher provided software operational materials at the beginning of the lesson. Students needed to answer the teacher's questions. While the students used SOSx, the teacher gave lectures on the concepts.	2. In the second lesson, the teacher first taught concepts based on the students' experiences in using SOSx from the 1st lesson, and then asked them questions about the concepts that they understood in using SOSx.
Teaching Evaluation	Quiz: Giving a quiz test after the lessons about causes of tsunami	1. Quiz test: Giving a quiz test after the lessons; the same with the control group 2. Operation evaluation: Answering the teacher's questions through using SOSx in the second lesson 3. Reflections and thoughts in using SOSx: After the lessons, asking the students to write down their reflections and thoughts	

A. Learning Performance

1. According to the results, there was no significant difference of test scores between the experimental and control groups; however, the scores of spatial analysis in simulated scenario of the experimental groups were higher than the class's using traditional lectures.
2. Those students had recognized that using SOSx could clarify the concept of spatial analysis when applying SOS in educating earth science.
3. There were plenty of concepts to teach in a lesson and therefore students could not absorb the key points; it was suggested that lesson arrangement should be adjusted if there was enough time for the teacher.

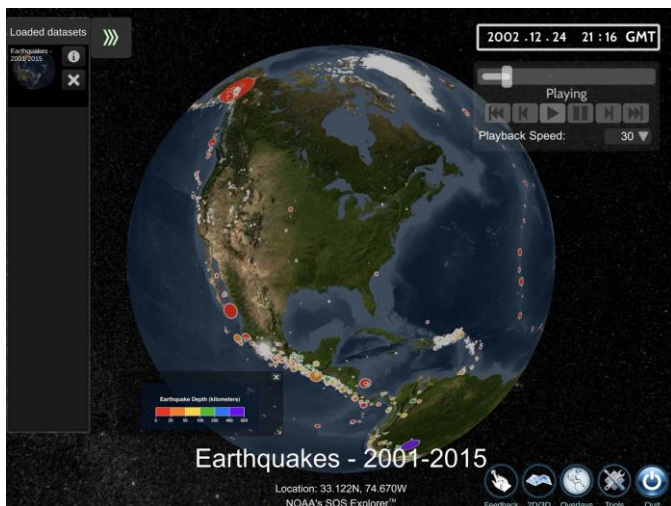


Figure 2. The Earthquakes course by using SOSx

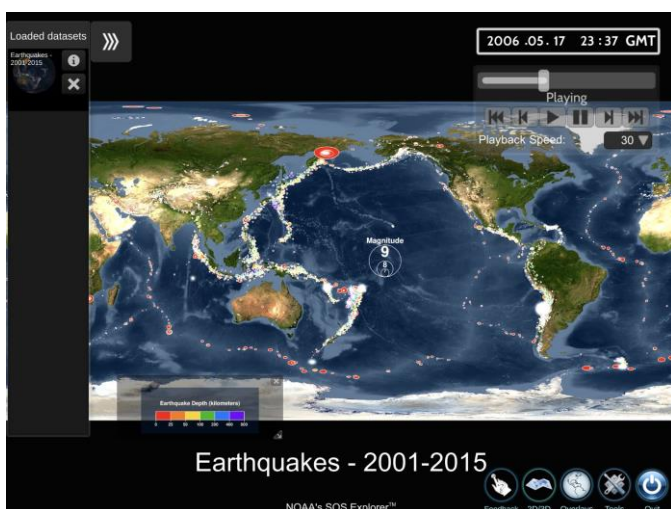


Figure 3. The Earthquakes course by using SOSx – flat map

B. Learning Attitude:

1. Using SOSx and integrating teaching materials could improve the students' learning outcomes, enhance their classroom participation, and attract them to taking a course in earth science.
2. When their classmates encounter difficulties, they could help one another and enjoy sharing their achievements.
3. Few students mentioned that it was difficult to use SOSx because it was novel to them. However, as they became familiar with its interface they could easily master it and finish the assignments. Furthermore, they were enthusiastic about learning without feeling frustrated; they felt interested and had the sense of achievement.

V. CONCLUSIONS

In this study, the authors applied SOSx and integrated 3D environments into the course of earth science and allowed the students to solve and understand significant problems in their lives to learn the contents of earth science through the usage of SOSx; this method followed the teaching objective and covered the two goals of cognitive and affective domains in teaching. This instructional method designed by the authors of this study offered references for teachers in teaching sites. The authors hope the use of SOSx can show contributions for earth science.

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