A Study of the GLOBE Program and its Impact on Public School Teachers and Their Students

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ABSTRACT

The Global Learning and Observation to Benefit the Environment (GLOBE) program is an international science and education program that connects students, teachers, and scientists through educational activities. The GLOBE program purpose is to strengthen the connection between students and teachers by implementing courses that are being taught in schools and creating ways that facilitate the students' learning processes. Teachers assist students while collecting and analyzing data. The data is then uploaded onto a worldwide accessible database. The data can be used towards scientists' research and evaluation of the environment in a large-scale manner. This study focused on the implementation of the GLOBE Program in the classrooms of nine New York City public school teachers. Upon becoming GLOBE certified, the teachers incorporated GLOBE protocols into their given curriculum. We were interested in the teachers' perceptions of the GLOBE program and its impact on their students. Surveys were distributed to analyze the changes they observed within their students. The data show that the GLOBE program positively impacted the teachers and students in the classroom. The GLOBE program has introduced a new style of learning for 6-12 grade science education. The GLOBE program has helped improve the outlook on the difficulties of science for students all over the world. Teachers also concluded that the program increased their students' interest and added a layer to the inquiry-based learning into the curriculums.

INTRODUCTION

As education became compulsory in many countries, some feel that there has been a loss of hands-on learning. The Global Learning and Observation to Benefit the Environment Program (GLOBE) is an international science and education program that connects students, teachers, and scientists through educative activities. The GLOBE program implements learning protocols taught by teachers to involve students to participate in hands-on learning with observations and sample collection of the different natural systems present in their local neighborhoods.[1] The collected data

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[1] About GLOBE. The GLOBE Program: Global Learning and Observations to Benefit the Environment. The GLOBE program, (1995).

is uploaded onto a worldwide database that is accessible to scientists and the public and can be used to contribute to their environmental studies around the world.

The Global Learning and Observation to Benefit the Environment (GLOBE) program was first introduced on Earth day of 1994 by the United States government. The program began its implementation phase a year later in 1995 by Al Gore, former vice president of the United States. GLOBE program is multi-funded by the US National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA) and Department of State.[2] Funded and led primarily by NASA and NOAA, "GLOBE is implemented through inter-government agreements with each country partner responsible for in-country activities.[3]" GLOBE has created partnerships in 45 states in the US and 115 countries around the world.[4]

The GLOBE program stemmed from Al Gore's philosophies in his book *Earth in the Balance: Ecology and the Human Spirit.* Gore believed that if adults were to make the appropriate decisions regarding the use, protection and preservation of their environment, they must have a present appreciation and understanding of that environment.[5] This is one of the reasons that GLOBE focuses on implementing this program as early as kindergarten. The GLOBE program's major goals focus on creating a structured curriculum for teachers to engage students in hands-on activities, introduce the students to science, technology, engineering and mathematic (STEM) subjects, and train science teachers and their students in data collection, reporting techniques, and analysis.[6]

A characteristic of the GLOBE program is the focus on STEM teaching and inquiry-based

[2] The GLOBE Program: Global Learning and Observations
[3] The GLOBE Program: Global Learning and Observations
[4] The GLOBE Program: Global Learning and Observations
[5] Margaret G Finarelli, "GLOBE: A Worldwide Environmental Science and Education Partnership.," Journal of Science Education and Technology 7, no. 1 (1998): p. 77)
[6] David Rossiter et al., "Can Citizen Science Assist Digital Soil Mapping?" Elsevier Geoderma 2 (2015): p. 259)

learning while incorporating small-scale experiments that contribute to a large-scale community.[7] In traditional STEM classes, the majority of the teaching that occurs in classrooms is based on the teacher giving the students information needed to prepare for them an exam.[8] "A teacher-centered method of education assumes that all students have the same level of background knowledge in the subject matter and are able to absorb the material at the same pace.[9] In inquiry-based education, students of all levels become engaged in many of the activities that scientists use to produce new knowledge. Traditional classrooms are usually dominated by direct and unilateral instruction."[10].

Lecture-based teaching allows for the transfer of knowledge from teacher to student and is usually done in a way where students are not given the opportunity to ask questions or come to their own conclusions based on the given information.[11] Lecture-based teaching only targets a specific type of learner. Students who learn best with visual and verbal learning styles can excel in lecture-based classrooms; however, students who prefer kinesthetic, naturalist, logical, intrapersonal, or interpersonal learning styles fall behind.

The introduction to inquiry-based learning can help students see the importance and relevance of science on a day-to-day basis. It also gives the students another way to absorb the information that is being exchanged from the teacher. This enables students to be immersed in science and be given the opportunities to perform experiments and collect data just like scientists. This learning style emphasizes that teachers guide the students to conclusions based on their own experiences and research.[12] Inquiry-based learning is an important way for students to learn science in a long-term fashion. Instead of students trying to memorize information for an exam, students are exposed to real-life applications of scientific techniques. This allows them to

[7] William Penuel and Barbara Means, "Implementation Variation and Fidelity in an Inquiry Science Program: Analysis of GLOBE Data Reporting Patterns," Journal of Research in Science Teaching 41 (2004): p. 294)
[8] Penuel and Means, Implementation Variation and Fidelity, p 249
[9] Thomas R Lord, "A Comparison Between Traditional and Constructivist Teaching in College Biology," Innovative Higher Education 21, no. 3 (1979): p. 197)
[10] Ali Abdi, "The Effect of Inquiry-Based Learning Method on Students' Academic Achievement in Science Course," Universal Journal of Educational Research 2, no. 1 (2014): pp. 37-41)
[11] Ned A Flanders, Analyzing Teaching Behavior (Philippines: Addison-Wesley Publishing Co, Inc , 1970).
[12] Flanders, Analyzing Teaching Behavior

participate in something that is not only beneficial in the classroom but also for any future science learning. The approach to inquiry-based learning is based on evidence that people learn best when they are engaged in purposeful activity.[13] In this model, learners gain scientific knowledge as it becomes instrumental to their efforts to answer questions that they find relevant. Students work like adults trying to solve a problem. Rather than restricting themselves to a single discipline, they delve into math, science, technology, and any content that is appropriate for their project.

Science subjects taught in primary schools generally practice a certain amount of inquiry-based learning. The New York City (NYC) Department of Education (DOE) incorporates STEM at all grade levels, pre-kindergarten to 12th grade. "STEM education gets students to ask questions and solve problems that relate to the world they live in."[14] The NYC DOE focuses on including similar ideas as the GLOBE program into primary school classrooms, beginning with the students learning how to use new technology, conducting investigations in and out the classroom and learning to protect the living environment in their community. These programs are based on creating a citizen science environment in the classroom, where teachers guide the students in learning basic skills that can be further used outside the classroom.

Implementation into elementary science education is crucial for the GLOBE program. It helps the students get familiar with science and technology. Furthermore, it advances the students' interest in science majors at an early age. It also encourages critical thinking when doing research or conducting an experiment. For example, the soil protocol implemented by GLOBE stimulated students to study soils by structured data collection with standardized tools such as field pH kits, soil thermometers, and soil moisture sensors.[15]

Regarding students from kindergarten through fourth grade, the program has made available

[13] Rosalind Driver, The Pupil as Scientist? (Open University Press , 1983); Derek Edwards and Neil Mercer, Common Knowledge: The Development of Understanding in the Classroom (London: Methuen/Routledge, 1998); Jean Lave and Etienne Wenger, Situated Learning Legitimate Peripheral Participation (Cambridge University Press, 1991); Aleksei N. Leont'ev, Problems of The Development of the Mind (Moscow: Progress Publishers, 1981); Lev Semenovich Vygotsky, Thought and Language (Cambridge, MA: MIT Press, 1962); Lev Semenovich Vygotsky, Mind and Society: The Development of Higher Mental Processes (Cambridge, MA: Harvard University Press, 1978).
[14] New York City Department of Education STEM (NYC DOE), 2018)
[15] Rossiter et al., *Geoderma*

science-based storybooks that introduce key concepts in climate, water, soil, cloud, seasons, aerosols, and earth system studies.[16] GLOBE also designed classroom activities in the storybooks to keep students engaged. For students in higher education, the GLOBE program provides university students and faculty members the opportunity to participate in collaborative, science-based explorations of the world surrounding them.[17] Before students can begin their inquiry-based studies and contribute to a large-scale program, the instructors must receive certification through GLOBE training.

In 2014, New York City College of Technology was awarded a National Science Foundation Opportunity for Enhancing Diversity in the Geosciences (OEDG) program track one grant. The school's goal focused on creating partnerships with inquiry-based learning programs to establish and study new learning techniques with minority students in the classrooms of New York City. Once partnered with the GLOBE program, science teachers from the participating schools in the study attended a three-day GLOBE training and certification workshop at New York City Queens College. The workshop focused on outlining the protocols for numerous environmental science topics such as atmosphere, seasonal change, hydrology and land use. The workshop introduced the student activities for each protocol and all the corresponding instruments that would be used. Furthermore, they went over the Internet aspect of GLOBE and the GLOBE database entry, retrieval and navigation through their website. After attendance and completion of the workshop, the teachers were awarded GLOBE certifications that allowed them to teach the protocols to their students in their respective classrooms.[18] The certification broadened the teachers' aspects of implementing the use of the GLOBE program in their science classrooms and the different elements that they can include in doing so. The GLOBE protocols are unique to teaching because they include explicit directions and topic information for the teacher. This makes it easier for the teacher to be able to include it in their current school curriculum. The protocols also make it easier

[16] NYC, DOE, STEM
[17] About GLOBE, Global Learning and Observations
[18] Reginald Blake, Janet Liou-Mark, and Renata Lansiquot, "Promoting the Geosciences among Grades 8-12 Minority Students in the Urban Costal Environment of New York City," Journal of Geoscience Education 16 (2015): p. 29)

for teachers around the world who are not given an adequate curriculum to teach their students properly.

Southeastern Oklahoma State University (SOSU) is a small university in Oklahoma that teaches approximately 4,000 students of which 31% are Native Americans. Only 5% of the teacher population belong to the same race. This is one of the reasons that the school holds in-service teacher workshops. These workshops focus on building connections between teachers and students, where there were no commonplaces. The school also adopted the GLOBE program and focused on teaching the students in a way where they can connect with what was being taught. The first workshop focused around environmental-technology, held in June of 1999 over a two-week period. The workshop included training with various protocols of the GLOBE program.[19] Teachers who attended the workshop were given a test on the first day. The exam included questions on the major GLOBE topics like atmosphere, hydrology, biology, soils and global positioning system. On the last day of the workshop, the participating teachers took a similar exam to compare the results. It was concluded that there was an overall improvement in the teachers' understanding and knowledge of the science topics and the GLOBE workshop. "Scores achieved by teachers were significantly higher after the workshop than those recorded before the workshop."[20] GLOBE also provided a "Workshop Participants Form", that asked participants how prepared they felt which helped determine the topics that they were less knowledgeable of. The two-week GLOBE workshop overall provided significant benefit to the teachers. The teachers were certified and gained knowledge on several science topics that they could teach their students.

Teachers are able to see first-hand how the students react to the GLOBE protocols. They can determine if the students understand the material if they show interest in the program and if they want to get involved. Overall, the teachers are the most reliable source of information on how the students react to the GLOBE protocols.[21] This paper focuses on the teachers' aspect of the impact of the GLOBE program implementation, its effects on their teaching styles, and the reactions to

[19] Margaret Avard and Byron Clark, "GLOBE in Preservice and Inservice Teacher Education," Journal of Geosciences Education 49 (2001): p. 461)
[20] Avard and Clark, GLOBE in Preservice and Inservice
[21] Penuel and Means, Implementation Variation and Fidelity.

the GLOBE protocols by the students' involvement and learning.

In 1995, Stanford Research Institute (SRI) International was chosen as GLOBE programs' evaluation partner.[22] From 1996 to 2001, the SRI studied the GLOBE program by surveying and observing hundreds of teachers and students in multiple countries. The SRI focused their study on multiple aspects of the GLOBE program: the accuracy of the students' data, the performance of the students participating in the program, and the teachers' response to their students' overall improvement. In 1997, the teachers viewed the program as an overall positive enforcement for their students.[23] The GLOBE program gave the students a new perspective on how science can be learned and practiced. They also felt a sense of value since the activities they were participating in contributed to more than just a class assignment.[24] The SRI compared students' test scores in GLOBE classes and non-GLOBE classes. They concluded that students that learned and participated in GLOBE activities scored better than the students who did not. In science classes, the GLOBE students spent more time using computers, working in groups with one another and helped other students learn while non-GLOBE students did more independent work by answering questions in a workbook or learning new vocabulary.[25]

The SRI also found a difference in teaching between the teachers who were implementing the GLOBE program into their curriculum and the teachers that were not. GLOBE teachers spent more time introducing hands-on science activities to their students. While non-GLOBE teachers focused on teaching their students vocabulary and concepts, paralleling with a teacher-centered method, where the students are not able to come to their own conclusions or given an opportunity where they can apply any of the concepts they are learning. The GLOBE program provides an alternate approach to reintroduce the importance of science in the classroom and shows students that they are surrounded by it and its ease and accessibility. They also are allowed to explore topics

[22] Barbara Means, "Melding Authentic Science, Technology, and Inquiry-Based Teaching: Experiences of the GLOBE Program," Journal of Science Education and Technology 7, no. 1 (1998): p. 97)
[23] Means, Melding Authentic Science
[24] Dixon Butler and Ian MacGregor, "Globe: Science and Education," Journal of Geoscience Education 51, no. 1 (2003): p. 9)
[25] Barbara Means and Elaine Coleman, GLOBE Year 2 Evaluation – Implementation and Progress (SRI International, 1997).

that in a regular classroom would not have been addressed.

RESEARCH STUDY

The GLOBE program purpose is to strengthen the connection between students and teachers by implementing courses that are being taught in schools and creating ways that facilitate the students learning processes.[26] This research project examines approaches that GLOBE program uses to reshape the way science is taught in the classroom and the transformation of the teachers' views about their students' learning and involvement as the result of the GLOBE protocols' implementation into their curriculum. This was accomplished by observing their classes as they taught their students and administering surveys to elicit feedback on the GLOBE program. Likert-Scale and open-ended questionnaires were given to the teachers to get a better insight into the teachers' perspectives and perceptions.

The City College of New York helped teachers from the New York City area become certified in the GLOBE program. A survey was designed to evaluate the impact of the GLOBE program on the students of the teachers involved. The survey was done using Likert-type and open-ended questionnaires. Both types of questions were methodically designed to help extract information that will give us insight into what teachers thought about using the GLOBE protocols in their classrooms. The Likert-type questions section included seven questions that were scaled between strongly disagree and strongly agree. The Likert-type section was scored on a five-point scale ranging from (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly agree. A copy of the Likert-type questionnaire can be found in Table 1.

In order to get a better sense of how the teachers view the GLOBE program and its impact on students learning, and to provide them with a chance to more freely state their opinion, a set of short-answer questions was provided. A rubric that scaled their results was created in order to make the data manageable. This allowed for a standardized way to understand the data that the teachers provided. For three of the questions of the short answer section, the answers were scored on a rubric from one to five, where a score of 1 is negative, and a score of 5 is positive. A copy of the

[26] About GLOBE. The GLOBE Program: Global Learning, 1995.

short-answer questions can be found in Table 2.

RESULTS

The Likert-type questions included a 5-point scale from strongly disagree (1), disagree (2), neutral (3), agree (4) and strongly agree (5). The responses for the Likert-type questionnaire are presented in Figure1. The short-answer questions were used to receive more detailed responses from the teachers. Some short-answer responses were scaled similarly on a five-point scale using a rubric. Positive responses were ranked as a 5, more neutral responses were ranked as a 3 and negative responses to questions were given a value of 1. These responses can be shown in Figure 2. Short-answer questions that required a list of responses were graphed as a pie chart based on the percentage of respondents who had similar answers. This can be seen in Figure 3.

The data showed a positive response to each question. The respondents agreed that the teaching techniques from the GLOBE program increased their students' interest in learning STEM subjects, that the program was an effective catalyst in improving the relationship with their students, and the program has the ability to improve their students understanding of science. Furthermore, the participating teachers found the GLOBE teaching material and protocols easy to use, helpful, and worth integrating into their curriculum. Overall, the teachers provided positive feedback on the GLOBE program as a whole and its impact on their students, teaching, and curriculum.

The average responses from the questions asked were all positive. There was a positive response from the respondents when asked about their students' experiences, interest in learning, and whether they would recommend the GLOBE program to other teachers. Implementing the GLOBE program resulted in a positive impact on the participating teachers.

About half of the teachers found difficulty incorporating the program into the given curriculum. (See Figure 3). About a third of the responses were associated with the students having difficulty understanding the program. Seventeen percent of the responses found no challenges when implementing the program.

The teachers were asked to discuss useful attributes of the GLOBE program. (See Figure 4). The results show that 39% of the teachers found the GLOBE's explicit instructions useful; they were not left to figure things out on their own. Twenty-three percent of the teachers appreciated that they were part of a community of learners that were using the same protocols. Twenty percent of the teachers found the databases provided by GLOBE useful; it was a way for data to be shared and accessed worldwide. Twelve percent of the teachers found the teaching techniques to be creative. Finally, 6% of the teachers found the training sites to be useful. Overall, there were many useful features of the GLOBE program that helped the teachers include the program into their curriculum and made teaching their students easier.

The pie chart (Figure 5) shows the appreciation for the GLOBE program. A large percentage of participants, 43%, appreciated the teacher training sessions. This aspect was something new for teachers, and it was also a way to introduce them to a community. There was an appreciation for the hands-on activities that involved the students by 29% of the teachers. Fourteen percent of the teachers appreciated both the concept of citizen science and the usefulness of the protocols. Both unique to the GLOBE program, contrary to curriculums commonly used in public schools, the teachers are given general curriculums with no explicit instructions, nor are there many hands-on activities for the students to participate in.

DISCUSSION

The surveys collected from the nine participating teachers in the New York City area gave their perspective on the GLOBE program. The responses from each of the Likert-type questions were averaged and graphed. As seen in Figure 1, all questions received an average response close to 4.00. Some specifically helpful and positive responses seen were that the integration of the GLOBE protocol into the teachers' curriculum was worth the time and effort. This indicates that it is possible to integrate the protocols into the New York City curriculum, and it is also possible for students in the city to still go outside and participate in environmental experiments. There was an average response of 4.00 from the teachers agreeing that the GLOBE certification program set up by CCNY was helpful. This aligns with studies that state the certification program helps increase

the teachers' knowledge of environmental science topics and helps them become more familiar with the technology aspect of the program before teaching to their students.[27]

Furthermore, the teachers agree that the GLOBE program has the ability to improve their students understanding of science. This indicates that the GLOBE program includes students that may not be excelling in a lecture-based classroom setting and gives them an opportunity to learn science using a different learning approach. Hands-on experiments help students who excel in physical learning techniques. Each student can learn how to implement the information that they learned about a subject and reach their own conclusions based on the results of their experiments performed. The short-answer questions included asking the teachers of their personal experience with implementing GLOBE with their students; the overall responses were positive. The teachers strongly agree that there was an increase in their students' interest in learning. One of the primary goals of the GLOBE program is to increase the interest in students for science subjects. This goal has been achieved with the students of the teachers from this study.

When asked about useful features and characteristics of the GLOBE program, respondents described the program as a specific, community-based program. The program's protocols include unique experiments for the students to participate in. They also enjoyed the resulting student involvement stemming from their interest in the topics taught. Furthermore, teachers appreciated that there was a GLOBE certification program. The teachers learned about different environmental science topics and how to implement them in the classroom.

In all, the implementation of the GLOBE program in classrooms was a success. Their goal of increasing students' interest and allowing the students to experience hands-on science projects was achieved. For teachers, they also saw an improvement in their students' attitudes towards science. They found the GLOBE training to be helpful, the protocols to be explicit, and they would recommend the program to other teachers.

However, it is noteworthy that the teachers faced some challenges. Figure 3 depicts the challenges that some of the teachers faced. For example, the biggest challenge was incorporating

[27] Vygotsky, Mind and society, 1978.

the GLOBE protocol into the given curriculum. This can be an issue that is unique to New York City public teachers. The New York Department of Education has specific curriculums for teachers of each subject. If a teacher teaches a general science course, it can be challenging to include a protocol that focuses on environmental science. For teachers who do not teach science in the classroom, the implementation of GLOBE protocols can be complicated. However, it was found that some protocols include geographical topics and topics that can include mathematical equations and problems. It was stated earlier; teachers still found that the time needed to implement the protocol into the curriculum was worth the time, while only three teachers found that incorporating the protocol with their curriculum was challenging. Two teachers found that their students were struggling to understand the GLOBE protocols. This may originate from a poor background on the subjects. The students, in particular, may not have been adequately taught about general science topics or the topics of the chosen protocol. A solution to this problem is for the teachers to choose a protocol for their students that they know they will excel and be interested in.

CONCLUSION

The GLOBE program has positively impacted the teachers and their students involved. The GLOBE program has introduced a new style of learning for science in K-12 education that can help improve the outlook on the difficulties of science for students all over the world. After conducting this research study, we were able to conclude that the GLOBE program successfully impacted teachers and how they teach science in their classroom. Teachers also concluded that the program increased their students' interest and added a layer to the inquiry-based learning in the New York City Department of Education citywide science curriculum. The GLOBE program increased students' interest and giving the students an opportunity to experience hands-on science projects. Furthermore, teachers saw an improvement in their students' attitudes towards science. They found the GLOBE training to be helpful, the protocols to be explicit, and they would recommend the program to other teachers. Our research data supports the integration of the GLOBE into NYC teachers' classrooms which provides students with an inquiry-based learning experience and hands-on activities. We hope to spread interest in the GLOBE program into more classrooms.

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TABLES AND FIGURES

Table 1. Questions used in Likert-type Questionnaire

1. Do you think the GLOBE teaching techniques helped increase your students' interest in learning STEM subjects?
2. The GLOBE program is an effective catalyst in improving the relationship between you and your students?
3. The GLOBE teaching material and protocols are helpful and easy to use.
4. GLOBE training processes set up by the City College of New York (CCNY) was helpful.
5. The GLOBE program can improve my students' understanding of science.
6. Integrating the GLOBE program into my curriculum was worth the time and effort I put into it.
7. Supplemental Instruction was worth the time and effort I put into it.

Table 2. Questions used in the short-answer questionnaire.

1. Write down a short description of your experience with your students while carrying out a GLOBE protocol?
2. What kind of challenges did you face in implementing the GLOBE program in your class?
3. Would you recommend the GLOBE program to other teachers? Why?
4. Do you think your students were more interested in learning when you perform a GLOBE protocol to them? How?
5. List three things you find useful about the GLOBE teaching protocols.
6. What did you appreciate most about the GLOBE program?

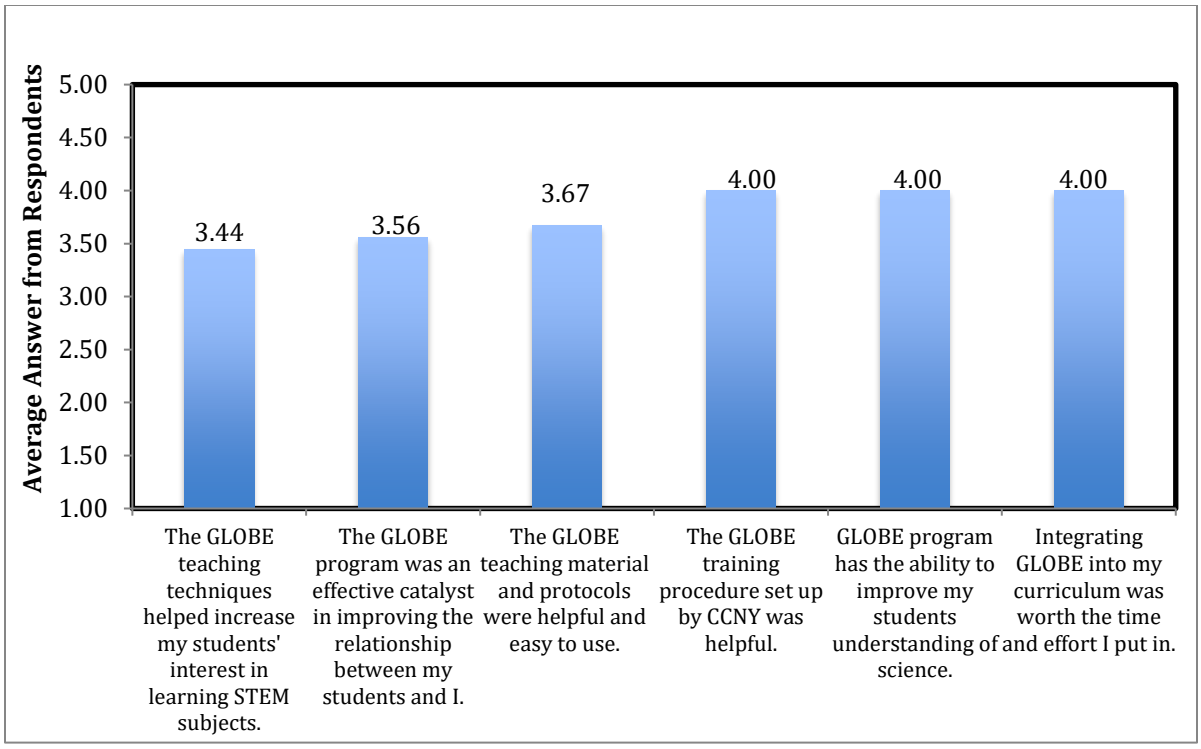

Figure 1. Averages of responses for each question of the Likert-type questionnaire.

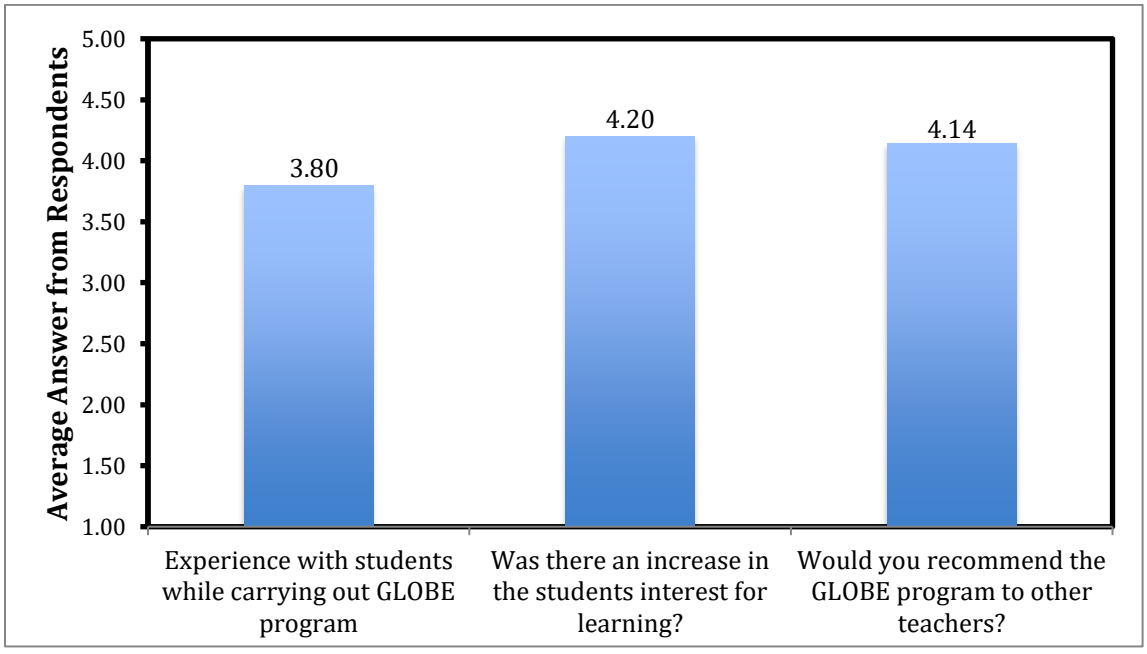

Figure 2. Averages of the short-answer responses were numerically scaled using a rubric.

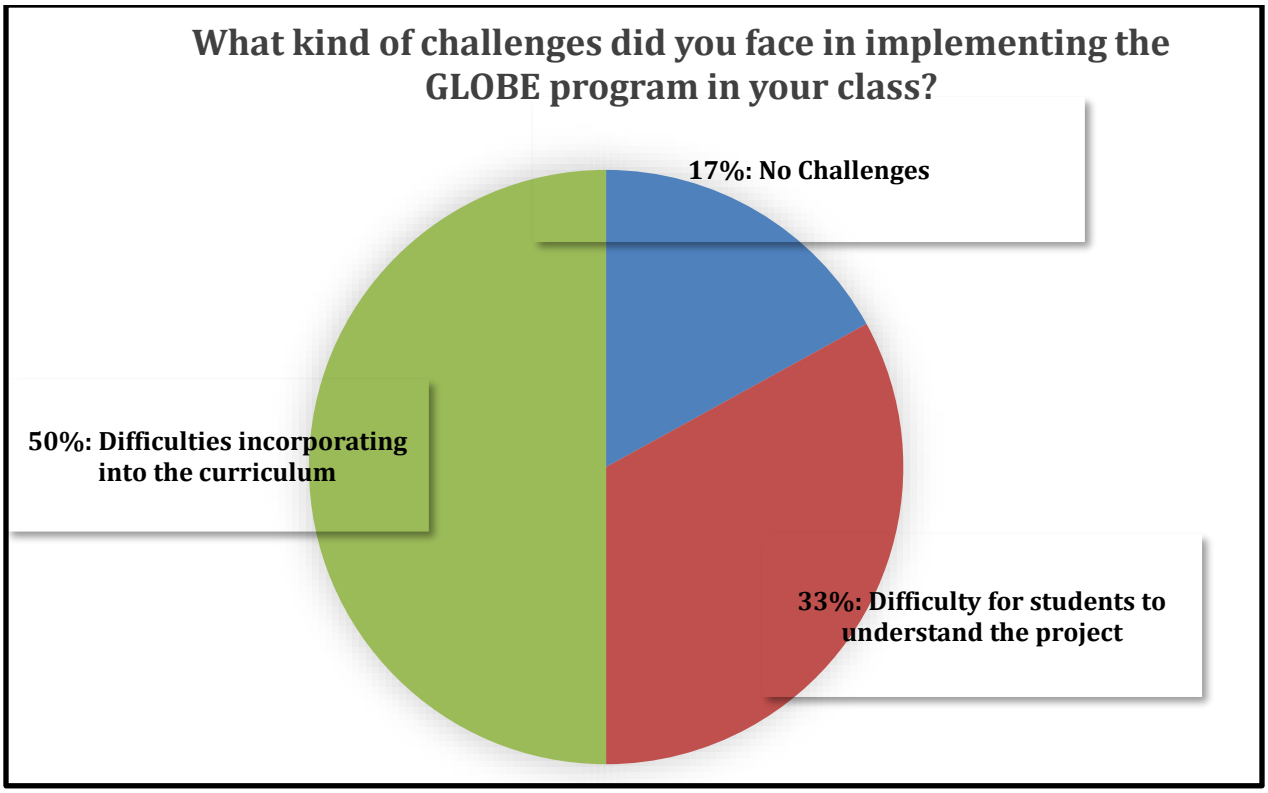

Figure 3. The pie chart above shows the challenges the teachers faced when implementing the GLOBE program.

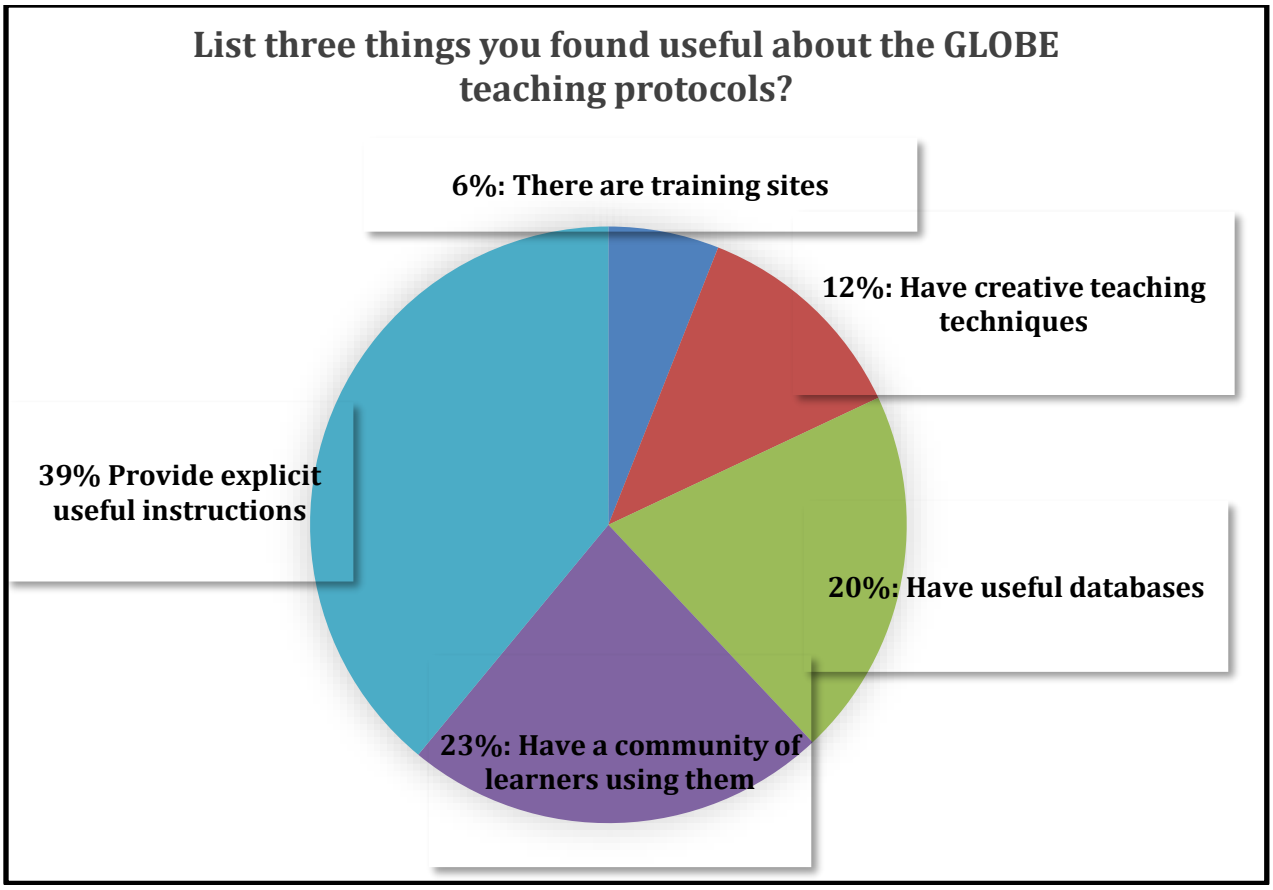

Figure 4. Positive aspects of the GLOBE program as seen by participating teachers.

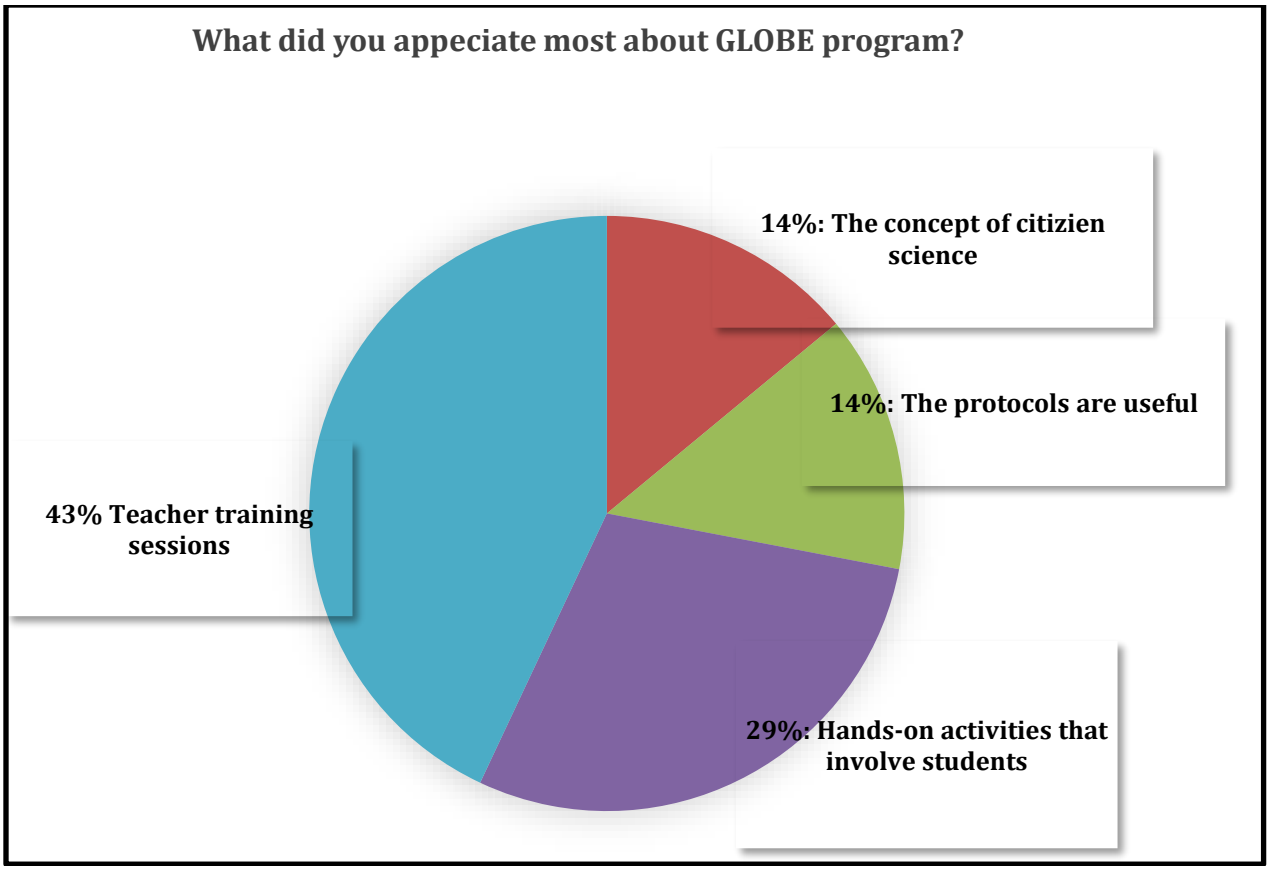

Figure 5. Pie chart of what teachers appreciate about GLOBE program.