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# The Costa Rica GLOBE (Global Learning and Observations to Benefit the Environment) Project as a Learning Science Environment

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**Abstract** GLOBE is a global educational program for elementary and high school levels, and its main purpose in Costa Rica is to develop scientific thinking and interest for science in high school students through hydrology research projects that allow them to relate science with environmental issues in their communities. Youth between 12 and 17 years old from public schools participate in science clubs outside of their regular school schedule. A comparison study was performed between different groups, in order to assess GLOBE's applicability as a learning science atmosphere and the motivation and interest it generates in students toward science. Internationally applied scales were used as tools for measuring such indicators, adapted to the Costa Rican context. The results provide evidence statistically significant that the students perceive the GLOBE atmosphere as an enriched environment for science learning in comparison with the traditional science class. Moreover, students feel more confident, motivated and interested in science than their peers who do not participate in the project. However, the results were not statistically significant in this last respect.

**Keywords** GLOBE program · Science learning · Environmental education · Environment for science learning/Science Learning in High School

## Introduction

GLOBE: "Global Learning and Observations to Benefit the Environment" is a global educational science project for elementary and high school levels. Its purpose is to support students, teachers and scientists in a collaborative inquiry-based research of the environment and the land system close to NASA's Earth System Science Projects (ESSPs), NOAA (National Oceanic and Atmospheric Administration) and NSF (National Science Foundation) in the research and study of the dynamics of the Earth's environment.

GLOBE started in Costa Rica in 1998 as a project directed by the Ministry of Public Education (MEP, abbreviated in Spanish) and in 2002 by the Omar Dengo Foundation (FOD, for its acronym in Spanish) became the international partner in charge of the project's coordination in the country. Since then, GLOBE Costa Rica is developed in the form of science clubs in public high schools that belong to the National Program for Educational Informatics (PRONIE MEP–FOD, for its acronym in Spanish) aiming at the development of the scientific thinking through inquiry-based research.

In these clubs, students are introduced to the hydrology topic and the collection of environmental data using the scientific method during field trips, a portable digital system (Xplorer GLX), bio-monitoring techniques and other strategies to assess water's quality.

In 2013, an evaluation was made to determine the perception of the students about GLOBE Costa Rica as a science learning environment and the development of a positive attitude toward science. The design of this evaluation and the results obtained are detailed in this article.

### Implementation of the GLOBE Costa Rica Project

The overall objective of GLOBE Costa Rica is to develop scientific thinking and interest in science among high school students through the fulfillment of research projects

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in hydrology that allow them to relate science with environmental issues in their communities.

During 2013, GLOBE Costa Rica involved youth between ages 12 and 17 that decided to join these science clubs and then used time outside their regular school schedule productively. These clubs are offered in 14 different high schools throughout the country.

The specific objectives of this project are:

- Develop in the students formal skills of scientific research and use of new technological tools.
- Develop in educators skills to promote teaching of research processes in hydrology following the GLOBE protocol.
- Implement the GLOBE international educational proposal in public high schools, specialized in hydrology and the use of new technological tools.
- Promote the interaction of the project's students and educators with the GLOBE international expert network to exchange knowledge and resources.

Also, through the accomplishment of the objectives, the project aims to develop students' skills so that they may:

- Understand and execute field research projects.
- Understand the characteristics (properties of water) of transparency, temperature, dissolved oxygen, electrical conductivity, ph and nitrates.
- Determine the characteristics (properties of water) of the water resources near their communities by executing measurements of the above properties.
- Interpret the data collected and identify the sources that apply in each specific case (human use, agriculture, agro-industry, industry, tourism), moreover reaching conclusions about the quality of the water resources in their communities.
- Propose strategies both individually and as a community to improve the quality of the water's resources in their communities.
- Communicate the research procedures used and the results obtained.
- Implement actions for the conservation and improvement of the quality of the community's water resources.

All this is accomplished through the implementation of the learning activities and protocols of the Hydrology section of the GLOBE international project and the materials of the watershed dynamics out of the ESSPs content, translated and adapted to the Costa Rican context, with the support of national scientists. The focus of this learning program is the design and execution of research ideas that incorporate the analysis and interpretation of collected data. To achieve these, the key strategy has been to enable, guide and assist the GLOBE educators through professional development procedures such as formal training, knowledge updates, participation in International working groups or GLOBE Learning Expeditions (GLE) and regional or global GLOBE meetings, as well as constant communication and pedagogical resource exchange.

With these objectives in mind, it was proposed to gather the perception of the students about the learning environment for science that is generated within the GLOBE Costa Rica project sessions. For this, the students' perception on four different dimensions was taken into account: (1) the instructions provided by the teachers; (2) the interaction with teachers and peers during the GLOBE sessions; (3) the scientific inquiry and (4) the understanding of the scientific contents developed in the project. It was important to know the students' insight, because the nature of the educational environments has great influence in the students' accomplishment level of educational goals (Allchin 2011; Wang and Lin 2009).

We also wanted to know the effects of student participation in the GLOBE Costa Rica project on the student's motivation and interest on science. We also analyze the relationship of possible selves to science, because self-concept and possible selves both are powerful regulators of behaviors that mediate processes such as information processing, affect and motivation (Markus and Wurf 1987). It is possible to think that if an individual is interested in science and has an enriched environment for learning science, that individual could imagine him or herself related to science in the future.

## Learning Environment for Science

Assessment of learning environments makes it possible to offer teachers materials to reflect upon their pedagogical conceptions and the possibilities of implementing changes in their practices in order to obtain better results. Different educational purposes and goals require a different approach in instructions and changes in the learning environments to accomplish the best possible results (Wang and Lin 2009). In this sense, in recent decades, teaching and learning have experimented changes that tend to go from students acquiring information to the development of scientific literacy. Enger and Yager (2001) states that a learning environment that promotes scientific literacy must provide an environment that facilitates: scientific inquiry, application of concepts in students' life, conceptual understanding and understanding of the nature of science.

Also, the emotional aspect of science education is just as important as the cognitive and psychomotor components (Wang and Lin 2009). Developing a positive attitude toward science is therefore a fundamental aspect of any program introduced in science education (Abd-El-Khalick et al. 2001; Allchin 2011; Wang and Lin 2009).

In this regard, several studies have found that there is an association between attitudes and class environment (Wang and Lin 2009). Therefore, the in-class learning environment evaluation may offer valuable information for people deciding on educational politics, for curriculum specialists, researchers and teachers, in order to adapt these environments with proposed aims (Abd-El-Khalick et al. 2001; Allchin 2011; Wang and Lin 2009).

## Motivation and Interest in Science

Proceeding with the objectives proposed by the GLOBE project, it was also taken into consideration to evaluate whether the participation in this project and its learning environment of science affects the interest and motivation to learn science, the motivation to pursue scientific careers and the increase of specific science-related knowledge. Skate and Mares (Stake and Mares 2005) found, in a follow-up assessment, that gifted students that had participated in summer camps oriented to science learning after 7 months of the events, acknowledged an impact in their motivation and attitudes toward learning science, as well as an increase in their confidence when studying scientific content. Such effects and their intensity were associated with the achievement levels of the students in school.

The importance of specific programs accomplishing a change in the attitude of students toward science is related to specific concerns, such as the lack of interest and the poor performance of students in science, the scarce interest of girls in scientific areas that decreases when they move from basic to superior education levels, evidence of this is the particularly low female representation in science orientated college careers and job positions (Abd-El-Khalick et al. 2001; Allchin 2011; Wang and Lin 2009; Stake and Mares 2001, 2005).

## Self-Concept

Markus and Wurf (1987) claim that self-concept reflects ongoing behavior and also mediates and regulates this behavior. In that sense, self-concept is dynamic, it interprets and organizes self-relevant actions providing the incentives, plans, rules and scripts for behavior and adjusting it in response to challenges from social environment.

The self-concept is a set of images, schemas, conceptions, prototypes, theories, goals and tasks about the self, which are different in their importance, elaboration level and they can be positive or negative. Some of them are representations of what the self actually is, and other ones are about what the self would like to be, could be or is afraid to be (Markus and Wurf 1987; Unemori et al. 2004).

Self-representations, contained in the self-concept, derive from different sources: from people inferences about their attitudes and dispositions, psychological reactions, cognitions and emotions; second, from self-assessment about personal performance in specific tasks or challenges; and third from other people, through social comparisons and direct interactions with them. In that sense, one of the most powerful determinants of self-conceptions is the configuration of the immediate social environment (Markus and Wurf 1987; Unemori et al. 2004).

## Possible Selves

Possible selves function as motivator for behaviors giving images of the future self, in desired or undesired states (Markus and Wurf 1987). As self-relevant cognitions of enduring goals, aspirations, fears and threats, possible selves act as a framework and guide for individual development (Markus and Nurius 1986), enabling people to achieve some behavioral control and self-directed growth by guiding the development of specific plans and strategies for individual's action (Unemori et al. 2004).

Concepts of both current and possible selves are shaped by a person' s experiences of normative sociocultural participation patterns (Unemori et al. 2004).

## Possible Selves in Science

It is necessary to understand how the attitudes toward science may develop and maintain through time, because interest in and self-trust in the ability to learn science are strong indicators of students' persistence in science (Stake and Mares 2001, 2005). Moreover, research indicates that the level of accomplishment in sciences is more closely associated with the attitudes toward them than to the ability to study those (Stake and Mares 2001, 2005). Thus, for students to maintain their interest in science, their competence to learn scientific content is not as important as their motivation toward it and the confidence in their own abilities to learn science.

Measures of science attitudes, such as science motivation and confidence, represent the self-concept, which is formed and changed by comparing oneself to others and by the immediate social environment. Therefore, a science enrichment program allows students to compare themselves to other program participants and evaluate their own science ability (Stake and Mares 2001, 2005). In addition, after their participation in that kind of programs, it is possible that students could be able to recognize and incorporate program-related gains into their self-concept. Measures of the possible self also have been associated with future career goals and student's academic choices.

Aiming to accomplish the necessary attitudes for student development in science, many programs include scientific inquiry, participative learning and practical activities (fieldwork) as part of their educational offer. In this same manner, the GLOBE Costa Rica project develops scientific inquiry processes and encourages fieldwork and the collective construction of learning among students.

In GLOBE Costa Rica project, teachers and students collect local environmental data for use by scientists around the world. In return, scientists provide mentoring to the teachers and students about how to apply scientific concepts in analyzing real environmental problems. Thus, the GLOBE Program depends on students to help monitor the environment while educating them about it (Roschelle et al. 2000).

GLOBE Costa Rica develops scientific inquiry process through the experience of being a scientist, as they:

- take valid scientific measurements of water, air, soil, etc.;
- share data via the GLOBE Web site;
- publish research according to GLOBE protocol;
- analyze data through the creation of maps, charts and graphs on the GLOBE Web site, and;
- collaborate with scientists and students around the world (www.globe.gov).

As many authors have stated when students are engaged in actively constructing knowledge from a combination of experience, interpretation and structured interactions with peers and teachers, they are more likely to gain an expert understanding of science concepts and therefore understand better the Nature of Science. Moreover, reports from researchers and teachers suggest that students who participate in computer-connected learning networks show increased motivation, a deeper understanding of concepts and an increased willingness to tackle difficult questions (Roschelle et al. 2000; Penuel and Means 2004).

Therefore, the objective of this study was first to assess the learning environment of the project in Costa Rica, and second as GLOBE Costa Rica also look to develop interest in science (see overall objective), we also evaluated aspects related to interest and motivation in science such as science motivation, motivation for a career in science, science confidence, science knowledge and the possible self in science, as well as the confidence in learning scientific content. This assessment will provide the degree to which students recognized the positive effects of their participation in an enriched environment for science learning, such as the GLOBE Costa Rica project.

## Methodology

For the comparison of the groups, a quasi-experimental design was used which involved groups of students that participated in the GLOBE Costa Rica project and groups of students with similar features but who had not participated in the project. The objective was to observe the effect of the project in their learning and attitudes toward science.

The participating GLOBE groups were selected randomly by clusters. Each group participating of the project was considered as a cluster. The control groups were selected based on the matching of the school and grade level of the GLOBE participating groups. Therefore, in each selected school, the evaluation was performed on groups participating in the project (GLOBE group) and groups of the same grade level that did not participate in the project (non-GLOBE group). All measurement scales were applied to all groups under the same conditions.

### Participants

For the selection of the sample, the total 2013 GLOBE Costa Rica participants were considered the total reported of 14 schools throughout the country, and following a systematic random cluster selection process, 8 high schools were selected to build the evaluation sample. The total number of students in the control groups was higher than on the GLOBE project because the control groups were sections already formed and attending school regularly. Table 1 shows the study sample.

### General Strategy

Once the sample schools were identified, the teachers in charge of the GLOBE project were contacted in order to plan the data collection dates. In a visit to schools, the evaluation instruments were applied to both the participating GLOBE Costa Rica students and the Non-GLOBE students. A single evaluation session was performed with each group, which lasted approximately 2 h. The instruments were applied in the classrooms or in the computer laboratories for the GLOBE Costa Rica students. In all cases, the instruments were applied in a group manner and in a control environment while a project representative remained available in case the students had any doubts.

### Instruments

#### Socio-demographic Variables and General Information

The following data were requested from the students: gender, age, school center, school level, previous participation in the GLOBE Costa Rica project, access to magazines, TV shows and Web sites with scientific content and the highest academic degree of their parents.

**Table 1** Detail of study sample of GLOBE and non-GLOBE participants

| School | Location | Total of GLOBE students | Total of non-GLOBE students |
|---|---|---|---|
| Gregorio José Ramirez High School | Alajuela | 10 | 17 |
| Alfaro Ruiz High School | Alajuela | 13 | 18 |
| Paraíso High School | Cartago | 6 | 17 |
| Engineer Alejandro Quesada High School | Cartago | 10 | 21 |
| Colorado High School | Guanacaste | 18 | 20 |
| Nicolás Aguilar Murillo High School | Alajuela (San Carlos) | 12 | 17 |
| Gastón Peralta High School | Alajuela (San Carlos) | 10 | 19 |
| San Antonio de Pejibaye High School | San José (Perez Zeledón) | 8 | 16 |
| Total | | 87 | 145 |

During the measurements, the total of participating students was 232, of which 95 (40.9 %) were males and 137 (59.1 %) were females, with an overall average age of 14.65 years old SD = 1.40

### Science Learning Environment

The complete NCLES (New Constructivist Learning Environment Scales) instrument was used. It contains 34 items that create 4 scales: attitudes related to (1) instruction in science, (2) interaction during science learning activities, (3) scientific inquiry and (4) understanding. The items are presented as prepositions with a five-point answer scale: (1) Never, (2) Seldom, (3) Sometimes, (4) Most of the time and (5) Always. The negative items were scored in reverse direction. The answer time was 15–20 min. Cronbach's alpha was .91.

### Confidence in Science Learning and Motivation

The variables related to the students' perception of their own change in attitude toward science were evaluated with a scale that has four subscales developed to assess students' perception in relation to the degree in which learning projects affect positive changes in their motivation, confidence and knowledge (Stake and Mares 2001). For the total scale, Cronbach's alpha was .86. The whole scale of 21 items was used because each subscale separately reports low Cronbach's alpha.

### Possible Self (Vocational Interest in Science)

Vocational interest in science was assessed with a scale based in the theoretical presuppositions of the self-schema theory by Markus and Nurius (1986). More specifically, the possible future self in science reference was used. This is an aspect of the self-schema that represents what the self can become in the future, concerning science.

The scale used is named professional future self (Stake and Mares 2001), in which students were asked to imagine the possibility of pursuing a career in the field of science, mathematics or engineering, and think of a series of situations that could occur and choose what would be most likely to happen. For each affirmation, they were requested to indicate how certain they were it would happen. The instrument has eight items with an answer scale that goes from not certain at all, to completely certain (see Annex 4). For this scale, Cronbach's alpha was .92.

## Data Analysis Procedures

Data were processed with the statistical pack SPSS 19.0 to perform the following analyses:

- Psychometric analysis for all the measurements that required it: internal consistency analysis Cronbach's Alpha and item-total correlations.
- Basic descriptive analysis for the sample's characterization and the description of the variables in univariate level (measurements of central tendency, dispersion).
- Comparison analysis of measurements to determine whether there are significant statistical differences in the answers from the GLOBE and non-GLOBE groups. When the variables were under the condition of a normal distribution (verified through the normality test Kolmogorov–Smirnov), parametric analysis was made, and when the normal distribution principal did not apply, nonparametric analysis took place.
- Matrix of bivariate correlations between all the measurements and scales to identify meaningful associations.
- Multiple regression analyses with variables: science learning environment, confidence in science learning, motivation and vocational interest in science as dependent variables, and project participation, school grade, parents' academic level and previous project participation as independent variables.

## Results

### Participants

The total participating students in the measurements was 232 including GLOBE and non-GLOBE students, of which 95 (40.9 %) were male and 137 (59.1 %) female, with an average age of 14.65 years old SD = 1.40. Of the total participants 72 students (31 %) were enrolled in eighth grade, 67 (28.9 %) were seventh grade students, 54 (23.3 %) were tenth grade students, 37 (15.9 %) were enrolled in ninth grade and only 1 (.4 %) was an eleventh grade student.

Of the total of students, 222 (95.7 %) had not previously participated in the GLOBE project and 10 (4.3 %) reported participating in previous years, 9 of them in 2011 and one student in 2008.

### *Access to Resources Associated with Science*

Since experiences and participation in sociocultural environment shape both current and possible self, it is important to know the kind of science resources that students have access to; because the quantity and quality of those resources influences the motivation and interest of students on science. Table 2 shows the access to resources associated with science such as magazines, TV and Web sites, among the studied population.

TV shows associated with science is the most used resource by students. In regard to magazines, the students mentioned National Geographic and Nature most frequently. The TV shows mentioned were Animal Planet, Toyota Fauna, National Geographic and Discovery Channel. In terms of Web sites, the GLOBE Web site was mentioned the most, other Web sites mentioned were Discovery Channel, NatGeo and Planet.org. About the frequency with which they access these resources, they mentioned "Once a week" was the most frequent response for magazines, "Everyday" for TV shows and "Once a week" for Web sites. The table shows that students have limited access to social cultural products related to science. Most of the students do not access those kinds of resources. There could be many reasons for these results, for example, the internet service or access could be a key factor in these findings, since many of the GLOBE Costa Rica project high schools are located in rural areas of the country were the internet service has several limitations. The present study did not assess the internet conditions in the GLOBE project communities. Either way, these findings lead us to think that the students have limited opportunities to be exposed to an enrichment sociocultural environment that could enhance the interest and motivation to learn science, as well as having academic choices related to science.

Other variable that shapes social cultural environment is the academic level of parents, and support and encouragement from significant others for students' science interest (Stake and Mares 2005). Students who enjoy support and encouragement develop more confidence in their science abilities and enhance their interest and motivation in science learning. The details for parents' academic level are shown in Table 3.

The most common academic level among the parents is complete elementary, followed by incomplete high school and incomplete elementary in third place. These items add up to 75.1 % in the case of mothers, and 67.8 % in the case of fathers. Moreover, mothers show the largest percentage of complete college degrees, while fathers show the highest percentage of postgraduate degrees. Most parents are beneath the complete high school degree, which is an indicator of a low academic level in the figures supporting the sample youth's education process. Parents' low academic level is other indicator of limited sociocultural environment in which students develop their interest in science learning.

Taken together, these findings about access to sociocultural resources related to science and parents' academic level lead us to think that the participating students do not have an enrich family environment for learning science in their daily life. Those limitations can act on their interest and motivation to learn science and on their current and

**Table 2** Access to resources associated with science

| Resources | Use | Do not use | Total |
|---|---|---|---|
| Magazines | 19 | 213 | 232 |
| TV show | 118 | 114 | 232 |
| Web sites | 34 | 198 | 232 |

**Table 3** Academic level of the sample of students' parents

| Grade | % of mothers | % of fathers |
|---|---|---|
| None | 3.1 | 7.4 |
| Incomplete elementary | 17.5 | 19.4 |
| Complete elementary | 32.3 | 28.6 |
| Incomplete high school | 25.3 | 19.8 |
| Technical career | .4 | 3.2 |
| Complete high school | 9.2 | 8.8 |
| Incomplete college | 4.4 | 6.0 |
| Bachelor's degree | 3.5 | 2.3 |
| Licentiate degree | 3.5 | 2.3 |
| Postgraduate degree | .9 | 2.3 |
| Total | 100 | 100 |

future self-representations associated with science, and finally with future career goals and academic choices.

## Evaluation of the Science Learning Environment

The complete NCLES is made up of four subscales: (1) attitude toward science instruction, (2) interaction between participants, (3) scientific inquiry and (4) understanding of scientific concepts. The results for the complete instrument for each group in each of the NCLES subscales are shown in Table 4.

The attitude toward science dimension evaluates feelings about the science curriculum and the extent to which they enjoy learning science. GLOBE Costa Rica students have positive feelings and attitudes toward learning science ($M = 3.49$ and $SD = 1.18$), as measurements were above value 3, which leads to an intermediate positive attitude tendency. While the non-GLOBE group shows lower positive feelings toward learning science ($M = 2.89$, $SD = 2.83$). The difference between groups is significant $t_{(216)} = 3.52$, $p = .001$. This result indicates that the GLOBE Costa Rica project lets to the students develop better attitudes toward science learning than regular science class do.

The subscale interaction among participants evaluates the relationships between students, and students and educators. In this aspect, there were also significant differences between GLOBE Costa Rica students ($M = 3.22$, $SD = .94$) and non-GLOBE group ($M = 2.59$, $SD = .87$), $t_{(219)} = 5.02$, $p < .001$. We can think that GLOBE Costa Rica environment lets students have more interaction through the collaboration for teamwork and completing tasks.

The participants recognize the importance of collaborative work; nevertheless, we may think that this collaborative work is not dedicated to performance of research activities or previous research discussion, because those items present a lower frequency of positive answers. In this point is important to notice that, although Scientific Inquiry shows significant differences between GLOBE ($M = 3.06$, $SD = .97$) and non-GLOBE group ($M = 2.66$, $SD = 1.03$), $t_{(221)} = 2.83$, $p < .005$; Scientific Inquiry is the dimension that shows lower means. It is possible to think that students in both groups are no enough involved in activities that allow them to use epistemic approximations to develop and evaluate research and experiments, evidence, hypothesis, explanations, models and arguments.

In both groups, there are few positive responses associated with the design of research proposals, which leads to the conclusion that the science learning spaces have a low level of accomplishment in getting students to design and conduct research processes. Other indicators with low percentages of positive response refer to metacognitive processes of awareness of their own learning, which points to a scarce student reflection of the evolution of the acquisition of knowledge and the learning process. This is a critic finding for the GLOBE Costa Rica project because one goal of the project is develop in the students formal skills of scientific research. The project offers student a better environment to learn and to research than science traditional class, but scientific research is the weakest aspect into the GLOBE Costa Rica learning environment. It is necessary to think in pedagogical strategies to enhance research opportunities into the GLOBE Costa Rica project.

Finally, there also were significant differences in the understanding dimension, GLOBE Costa Rica students ($M = 3.83$, $SD = 1$) and non-GLOBE group ($M = 3.13$, $SD = 1.5$), $t_{(223)} = 4.60$, $p < .001$. It indicates that students participate in meaningful learning activities of concepts and conceptual understanding of science. Teachers from the GLOBE learning environment assessed implement strategies to relate new content with previous knowledge. The items related to the planning and design of research obtained the lowest average of the components, which is consistent with results previously explained.

**Table 4** Differences between GLOBE students and non-GLOBE students in the NCLES subscales

| Subscales | Students | *M* | SD | *t* | *p* | 95 % CI of the difference |
|---|---|---|---|---|---|---|
| Attitude | GLOBE | 3.49 | 1.18 | 3.52** | .001 | .26–.93 |
| | Non-GLOBE | 2.89 | 1.23 | | | |
| Interaction | GLOBE | 3.22 | .94 | 5.02** | <.001 | .38–.87 |
| | Non-GLOBE | 2.59 | .87 | | | |
| Scientific inquiry | GLOBE | 3.06 | .97 | 2.83* | .005 | .12–.67 |
| | Non-GLOBE | 2.66 | 1.03 | | | |
| Scientific understanding | GLOBE | 3.83 | 1.00 | 4.60** | <.001 | .39–.99 |
| | Non-GLOBE | 3.13 | 1.15 | | | |

Sample for GLOBE students = 83, sample for non-GLOBE students = 140

* Significant differences at $p < .05$ level

** Significant differences at $p < .001$ level

Altogether, these findings lead to think that even if both learning environments promote science learning and implement strategies for this accomplishment, their strength is not the learning to design and implement experimental procedures and scientific research.

In general, GLOBE Costa Rica students have a better perception of the science learning environment than the students that do not participate of this project. The *t* test results show that all differences are statistically significant. Nonetheless, the strongest differences are observed in the Interaction and Scientific understanding subscales ($p < .001$). That is to say the students participating in the project perceive more positively the opportunities of interacting with each other and teaching staff than their peers in regular science class. In addition, GLOBE students perceive more meaningful learning opportunities than their peers do.

This is an important finding taken into consideration that research indicates that the level of accomplishment in science is more closely associated with the attitudes toward it than to the ability to study it (Stake and Mares 2001, 2005). In this sense, GLOBE Costa Rica project offers an enriched science learning environment that allows students to develop positive attitudes toward science learning.

According to the individual item analysis, the lowest averages, in which the participants' perception is less positive, correspond to the Interaction and Scientific inquiry subscales, although students perceive a better interaction environment than at the regular classes. The Scientific inquiry component that responds to planning, design and implementation of experimental and research processes, presents the second lowest average, suggesting that even though students sense a better atmosphere within the project class, this aspect needs to be improves in both groups.

## Interest and Science Motivation

Even though GLOBE Costa Rica students present higher averages in each of the subscales assessing interest and science motivation, most of these differences were not statistically significant. Table 5 shows the comparison between GLOBE and non-GLOBE students for all the subscales.

Even though GLOBE students present higher averages $M = 3.23$, $SD = 1.19$ than the non-GLOBE group $M = 2.92$, $SD = 1.48$ in each of the items assessing an increase in science motivation, these differences were not statistically significant $U = 4{,}456.0$, $p = .123$. The aspects that both groups valued more positively were that the interventions in which they participate make science more interesting and funnier. Both aspects show the results of changes in the students' attitudes that would facilitate science learning in appropriate educational contexts. In general terms, the GLOBE students acknowledge being more motivated by science after participation in this project.

Another relevant aspect is although student reports an increased science motivation, this does not seem to influence directly upon their motivation to pursue a career in science. Once again, the GLOBE students' measurements are higher than those that are not participating in the project. However, the differences are not statistically significant. The averages for the motivation to pursue a career in science dimension are lower in comparison with the averages for the science motivation dimension, which seems to confirm that there is no direct relationship between the motivation to have a career in science and the possibility to choose one. There are many others aspects to consider as access to science resources and social encouragement for science (Stake and Mares 2001)

In the case of increased science confidence, there were no differences statistically significant. However, the items scored highest by the GLOBE students were those about feeling confident and secure as science students and professional. This may indicate that in the short term, the project contributes to students feeling comfortable, secure and at ease during science activities, even if this does not necessarily indicate their future decisions.

Related to increased science knowledge, it is important to note that both learning environments, GLOBE Costa Rica and regular science class, comply with the science learning aim. However, GLOBE students show higher averages, $M = 3.82$, $SD = .88$ than those not participating in the project, $M = 3.35$, $SD = 1.18$. In this subscale, differences are statistically significant $U = 3973.0$, $p = .007$. In this sense, unlike students who do not participate in the project, GLOBE students assess that the intervention allows them to learn more about science, better understand scientific work and knowledge, and increase their knowledge about science. It is important to highlight that this is the only subscale in which statistically significant differences were found between both groups of students. That is to say, GLOBE participants value positively the access to new knowledge, while the non-participants do not equally perceive the knowledge increase in association with science class.

## Possible Self in Science

The results for this scale are shown in Table 6. This subscale gives an account of the individual vision of the self-potential to become something, in this case in the professional area. More specifically, imagining the self becoming a scientist if the student decides to pursue a career in science.

As with the science motivation scales, the GLOBE Costa Rica participant averages are higher than those not

**Table 5** Differences between GLOBE students and non-GLOBE students in the attitude toward science subscales

| Subscales | Students | *M* | SD | *U* | *p* |
|---|---|---|---|---|---|
| Increased science motivation | GLOBE | 3.23 | 1.19 | 4,456.0 | .123 |
| | Non-GLOBE | 2.92 | 1.48 | | |
| Motivation for a career in science | GLOBE | 3.10 | 1.47 | 4,480.0 | .137 |
| | Non-GLOBE | 2.75 | 1.59 | | |
| Increased science confidence | GLOBE | 3.56 | 1.07 | 4,366.5 | .079 |
| | Non-GLOBE | 3.20 | 1.32 | | |
| Increased science knowledge | GLOBE | 3.82 | .88 | 3,973.0* | .007 |
| | Non-GLOBE | 3.35 | 1.18 | | |

* Difference statistically significant at $p < .05$

**Table 6** Possible self in science scale for GLOBE and non-GLOBE students

| Item | | Completely certain | Very certain | Not certain or uncertain | Not very certain | Not certain at all | *M* | SD |
|---|---|---|---|---|---|---|---|---|
| If I choose a career in science, I will | | | | | | | | |
| Go to a good university in the specific scientific area | GLOBE | 27 | 23 | 17 | 13 | 5 | 3.64 | 1.24 |
| | Non-GLOBE | 42 | 29 | 31 | 27 | 15 | 3.39 | 1.35 |
| Obtain a graduate degree in that career | GLOBE | 26 | 23 | 25 | 5 | 6 | 3.68 | 1.17 |
| | Non-GLOBE | 35 | 38 | 33 | 20 | 18 | 3.36 | 1.32 |
| Pursue postgraduate studies | GLOBE | 23 | 26 | 20 | 9 | 6 | 3.61 | 1.20 |
| | Non-GLOBE | 25 | 35 | 44 | 20 | 19 | 3.19 | 1.26 |
| Complete the postgraduate studies | GLOBE | 26 | 22 | 20 | 10 | 7 | 3.59 | 1.26 |
| | Non-GLOBE | 28 | 33 | 43 | 23 | 17 | 3.22 | 1.26 |
| Find a good job in the field | GLOBE | 33 | 20 | 18 | 10 | 4 | 3.80 | 1.21 |
| | Non-GLOBE | 48 | 35 | 32 | 12 | 15 | 3.63 | 1.31 |
| Continue working in the field and perform a good job | GLOBE | 31 | 35 | 9 | 6 | 4 | 3.98 | 1.09 |
| | Non-GLOBE | 58 | 32 | 24 | 15 | 14 | 3.73 | 1.34 |
| Have a great career and make important contributions to science | GLOBE | 57 | 27 | 18 | 6 | 7 | 3.72 | 1.22 |
| | Non-GLOBE | 51 | 31 | 32 | 12 | 16 | 3.63 | 1.34 |
| Be one of the most important scientists in the field and one of the best in the country | GLOBE | 27 | 17 | 23 | 12 | 6 | 3.55 | 1.26 |
| | Non-GLOBE | 29 | 26 | 48 | 20 | 21 | 3.15 | 1.30 |

participating in the project, and these differences are not statistically significant, however. The highest averages correspond to the following items: continue working in the field and perform a good job ($M = 3.98$, $SD = 1.22$), find a good job in the field ($M = 3.80$, $SD = 1.21$) and have a great career and make important contributions to science ($M = 3.72$, $SD = 1.22$). That is, in some way, GLOBE students can imagine themselves studying and working in science-related fields.

In regard to the overall scale, there are not statistically significant differences between both groups ($U = 4{,}467.0$, $p = .130$). Even though the students are motivated and interested in science, there is not necessarily a direct connection with a possible career choice.

It is possible to analyze the results in the way that GLOBE Costa Rica Project is a unique scientific learning experience for students in rural areas. The project helps to participant to increase their interest, motivation and knowledge in Science, but it is not enough for the development of scientific vocational interest. The project need working in more integral interventions in order to enrich the daily context to the students and giving them access to different scientific resources, promoting science and scientific careers in their communities and encouraging social support to their scientific interest.

Finally, multiple regression analyses were made in order to assess the impact of control variables on the dependent variables that account for the motivation for science and interest in science careers. The control variables included as predictors were as follows: sex, age, school, prior participation in the GLOBE Costa Rica project, participation in the GLOBE Costa Rica project (at the time of assessment), access to scientific journals, access to science television programs, access to Web pages with scientific content and highest academic degree of parents. Each of subscales (science motivation, motivation for a career in

**Table 7** Multiple regression analysis of the change of attitude toward science

| | β Age | 95 % CI | β previous years | 95 % CI | β TV shows | 95 % CI |
|---|---|---|---|---|---|---|
| Science motivation | −.298* | −.505 to −.082 | −.168* | −2.162 to −.223 | −.353** | −1.360 to −.612 |
| Motivation for a career in science | −.279* | −.552 to −.069 | −.151* | −2.351 to −.088 | −.306** | −1.402 to −.530 |
| Science confidence | −.275* | −.436 to −.053 | | | −.298** | −1.074 to −.392 |
| Science knowledge | −.273* | −.390 to −.051 | −.136* | −1.583 to .000 | −.249** | −.872 to −.264 |
| Possible self in science | | | −.191* | −2.167 to −.298 | −.262** | −1.012 to −.299 |

* $p < .05$

** $p < .01$

science, science confidence, science knowledge and the possible self in science) was included as dependent variables.

Table 7 shows a summary of the control variables that are related to the dependent variables accounting for the motivation and interest in science.

The variables accounting for the greater variance degree in each model are age, prior participation in the GLOBE project and access to scientific TV shows, and the most important coefficients are the ones shown in Table 7.

For the science motivation, the model including all predictors gives an account of 22 % of the variance degree ($R^2 = .224$, $F_{(11,188)} = 6.32$, $p < .001$). Once we identify these predictor, we also included interaction effects analysis of age *X* previous year ($p = .208$), age *X* TV shows ($p = .739$) and previous years *X* TV shows ($p = .086$), and none of the interactions were significant.

For motivation for a career in science scale, the model with all the variables accounts for 21 % of the variance ($R^2 = .218$, $F_{(11,190)} = 4.81$, $p < .001$). Interaction effects between Age *X* previous year ($p = .960$), age *X* TV shows ($p = .268$) and previous years *X* TV shows ($p = .213$) were not significant.

The complete model accounts for 25 % of variance explained for the Science confidence subscale ($R^2 = .258$, $F_{(11,189)} = 5.98$, $p < .001$), in which the variables associated the most with the dependent variable are age and access to TV programs with scientific content. Interaction effects between Age *X* TV shows ($p = .625$) were not significant.

The model for the Science knowledge subscale accounts for 27 % of the variance ($R^2 = .270$, $F_{(11,190)} = 6.38$, $p < .001$). The variables that contribute most to the model are age, participation in previous years and access to TV programs with scientific content. Interaction effects between age *X* previous year ($p = .061$), age *X* TV shows ($p = .125$) and previous years *X* TV shows ($p = .180$) were not significant.

For the possible self in science scale, the full model accounted just for 14 % ($R^2 = .145$, $F_{(11,195)} = 3.00$, $p = .001$). The variables that contribute most to the model are participation in previous years and access to TV programs with scientific content. There was not significant interaction effect between previous years *X* TV shows ($p = .180$).

The variables age, participation in previous years and access to TV shows help predict the values in each of the subscales used to assess motivation and interest in science. These findings should be considered in the design of educational interventions of the GLOBE project, because according to the existing literature, access to scientific resources, specifically TV programs, helps to predict studenťs interest in science. Also, participation in previous year's variable can lead to consider the possibility of extended interventions in time for those students showing particular interest in science. In other words, the most significant predictors are variables related to the context of the GLOBE Costa Rica students, confirming the need to widen the focus of the program to the social context of students.

## Discussion of Results

### Science Learning Environment

GLOBE Costa Rica students had significant better scores on the four dimensions proposed by Wang and Lin (2009) to develop environments that promote the achievement of learning goals in science. Thus, GLOBE Costa Rica students perceive that the learning environment fostered by the project is suitable for learning science. It should be reminded that modern learning theories propose that different learning goals require different approaches to instruction and changes in learning environments to optimally achieve desired learning outcomes (Wang and Lin 2009).

The environment promoted by GLOBE Costa Rica project allows students to develop positive attitudes toward the instruction or learning of science. Students also expressed enjoying their participation in the activities proposed by the project. This is an encouraging result considering that developing and strengthening positive attitudes toward science is one of the main goals of science education (Keeves and Alagumalai 1998; Simpson et al. 1995, cited by Wang and Lin 2009). People interested in developing learning environment for science education could consider implementing experiences such as GLOBE international project offer, take valid scientific measurements of water, air, soil, etc., share data with scientist around the world, publish research, analyze data through the creation of maps, charts, and graphs and collaborate with scientists and students around the world (www.globe.gov).

Regarding the interaction dimension, GLOBE students perceive that they are largely involved in collaborative learning environments. The project activities empower students to share learning experiences, build knowledge together and associate that knowledge with their project peers. Also, students perceive the relationship with teachers as relationships that enhance the joint construction of knowledge.

While in all evaluated dimensions, significant differences were observed, in both groups scientific inquiry was the dimension that obtained the lowest scores. In both teaching–learning modalities, students perceive that they are little involved in activities that allow them to collect and use their prior knowledge, develop and evaluate experiments or research, evidence, hypothesis, explanations, models and arguments. This result is striking considering that one of the purposes of GLOBE Costa Rica project is to develop scientific inquiry skills in the participants. The results suggest that, although the students perceive more opportunities for scientific inquiry than in traditional learning environments, this is a dimension that must be strengthened to better achieve the project objectives. One possible explanation for this result is that GLOBE teachers and students are focused on data collection using protocols of the hydrology section, but they are not working enough in designing complete research processes. The program needs to review the strategies to teach the scientific research process, which includes pedagogical strategies, activities in the classroom, field trips and teacherś training on scientific research. There is important to take into consideration these issues in order to redesign the future applications of the project in Costa Rica, but also in further applications abroad. People interested in developing the GLOBE project or similar initiatives must consider the issues of designing and conducting scientific research projects and developing strategies to overcome those issues maintaining the focus on scientific inquiry.

In this point is also important to notice the need to widen scientific resources that GLOBE Costa Rica project offers to students, promoting the use of the web page of GLOBE Costa Rica and designing didactical resources in alternatives formats such as videos, for example. It is necessary to analyze the quality of internet services in the students' communities in order to plan the kind of materials more adequate for student's daily context.

Also, GLOBE students perceive that this learning environment allows them to be further involved in meaningful learning activities of scientific concepts, also allowing them a greater conceptual understanding of science. That is from the students' perspective the project meets the commitment to promote the learning of scientific knowledge through the mediation of educators, GLOBE protocols and proposed activities.

Notably, the interaction and understanding dimensions showed the greatest differences with respect to students who only received traditional science classes. That is, these aspects are the major contributors to the students' positive perception of the GLOBE learning environment.

### Interest and Motivation in Science

While GLOBE students had better scores on the subscales assessing interest and motivation in science, compared to students attending traditional science classes, these differences are not statistically significant, except for the increase in the scientific knowledge assessing scale.

In this regard, it should be considered that the variables accounting for the interest and motivation in science indicate results in medium- and long-term the vocational and professional interests of students of the GLOBE Costa Rica project, in contrast to the variables assessing the learning environment, which account for the short term. To achieve the long-term effects, a greater time frame of student participation in the project may be necessary to enable them to consolidate their interest in science. Note that at the time of the evaluations, students had on average 5 months of participation in the project and had about 3 more months of intervention. Longer exposure would allow participants to consolidate the changes in attitudes that can be attributed to the project, or consolidate what Stake and Mares (2005) called splashdown effect, which refers to the effect of science learning programs and their intensity in the change in attitudes toward science in time. In the case of GLOBE, it would be advisable to take another measurement at the end of student participation and establish follow-up periods, because some of the changes in attitude related to participation in scientific projects may be more noticeable to students in the period following completion of these programs (Stake and Mares 2005).

It is also necessary to consider other variables that help to develop and maintain positive attitudes toward science. These are strongly influenced by the support and encouragement of important social agents for students such as family, peers, teachers (Stake and Mares 2001, 2005). In this regard, changes in attitudes toward science may be affected by the support provided by these social networks during the time of participation in the project and during the following period.

Another variable related to change in attitudes after participating in a project of scientific learning is academic performance; since it has been shown that students with low academic performance prior to the project obtained more pronounced and lasting effects. Some variables that contribute to the consolidation of interest and motivation in science were not addressed by this study, but it is important to take account of them in future studies.

Also the GLOBE Costa Rica proposal lacks content or specific activities to strengthen the identified mediating variables. It would be meaningful to review the international GLOBE goal of improving student achievement in science and mathematics, in order to know the project's impact on these two academics areas.

It is also important to consider the geographical location of the GLOBE project participating high schools; most are located in rural areas where the prospect of a scientific career is not common. It should be reminded that in most of the cases the highest academic degree of the participant's parents is complete Elementary School or incomplete High School, in this sense the educational level of the parents could affect the support and motivation that their offer to the participants to pursue scientific careers.

Because of the lack of a scientific background in their communities and families, GLOBE Costa Rica is the most significant opportunity to students to be in contact with scientific experiences and the project is one stimulus that let them thinking themselves as involved in scientific fields in the future. However, the results show that it is necessary to widen the action of GLOBE Costa Rica in order to promote a stronger social support system to the students with scientific interest. It is also important make more efforts to closer the science to a daily life of studentś communities in order to promote science fields as possible options in the future.

The only subscale presenting significant differences between the two groups was Science knowledge; GLOBE students perceive their science knowledge increase better than their counterparts, because of their participation in the project. This result agrees with the assessment outlined in learning environments section, in which one of the best dimensions evaluated by GLOBE students was the understanding of scientific concepts. From the perspective of students, the project meets the objective of increasing their understanding of science and the acquisition of scientific knowledge.

Finally, in the regression model, the control variables showing stronger connection with the change of attitudes toward science were as follows: age, participation in GLOBE in previous years and access to TV programs with scientific content. The access to TV programs variable may indicate the need for alternative formats in the production of educational materials while also warning about the need to evaluate possible strategies to improve the use of online resources in the project. This is an opportunity to GLOBE Costa Rica project to think about the formats and strategies used to bring educational material to the students. It is also necessary to take into account the quality of the internet service in the participant's communities in order to design appropriate strategies to the studentś context.

The variable participation in previous years could help more accurately measure the sustained effect of the project and evaluate the hypothesis that the higher the exposure, the higher the intensity of the expected results. Age has a negative correlation, indicating that the younger the student, the better the opportunity to improve outcomes. This is an opportunity to think about early interventions with scientific learning experience and to plan a GLOBE Costa Rica sequential educational process with different levels of complexity that let to develop abilities related to the whole scientific research process. These changes also involved professional development procedures like formal teacher training.

## Conclusions

GLOBE Costa Rica learning environment is appropriate for science learning. The project's participants expressed enjoying the didactic activities for science learning and perceiving an increased involvement in activities, leading to collaborative learning and greater opportunities to design and implement activities of scientific inquiry.

All the dimensions that involved an adequate learning environment for science instruction in science, interaction during science learning activities, scientific inquiry and understanding of scientific concepts (Wang and Lin 2009) showed significant differences with respect to students who only received traditional science classes. The most marked difference is that students perceived the GLOBE environment allowing them to acquire more knowledge and understanding of scientific concepts, as opposed to students who do not participate in the project.

Even though the dimensions of the GLOBE learning environment were positively assessed, in both groups the scientific inquiry dimension obtained the lowest scores, students perceive little opportunity to design and execute scientific research processes. This is a relevant result since one of the international aims of the project is to enhance students' scientific inquiry skills and in Costa Rica that goal is evidenced in the development of formal scientific research skills.

This would represent an area for improvement through the design of educational activities that promote the integral development of formal research processes that address different stages of this course and that suit the students' characteristics. Note that this would involve the training of teachers in charge of the project in the assigned high schools, as it has been evidenced that teachers are not fully acquainted with the content and as a result do not develop it properly with the students(Wang and Lin 2009).

However, taken into account the social context and familiar background of the GLOBE Costa Rica participants, the project represents a valuable opportunity to be in contact with scientific experiences and the project is one stimulus that let them thinking themselves as involved in scientific fields in the future.

In the measurement of interest and motivation in science, it was noted that GLOBE Costa Rica has a positive effect on its participating students. However, this effect is not statistically significant, except for the scientific knowledge dimension in which students perceive the increase in their scientific knowledge in relation to their peers who do not participate in the project.

In relation to the previous point is necessary to take into account that the time of participation in the project could be a variable affecting the intensity of the results; therefore, it would be necessary to consider a longer period of participation or an extended follow-up frame. However, it is a fact that the learning environment of the GLOBE Costa Rica project helps to develop positive attitudes toward science. This finding is important taking into consideration that the emotional aspect of science education is just as important as the cognitive and psychomotor components (Wang and Lin 2009). On the other hand, developing a positive attitude toward science is a fundamental aspect of any program introduced in science education (Abd-El-Khalick et al. 2001; Allchin 2011; Wang and Lin, Wang and Lin 2009). These results are significant if we consider that research indicates that the level of accomplishment in sciences is more closely associated with the attitudes toward them than with the ability to study those (Stake and Mares 2001, 2005).

About the possible self in science, the GLOBE Costa Rica participant averages are higher than those not participating in the project; these differences are not statistically significant. Since experiences and participation in sociocultural environment shape both current and possible self (Markus and Wurf 1987), GLOBE Costa Rica project offers to the students and enrichment-learning environment that promote that they can imagine themselves related to scientific fields that in other way they cannot have due to their daily context. It should also be considered that the relationship between interest in science and scientific career orientation also involves other variables such as the family, peer and faculty support systems that were not considered in this study.

Participation in the GLOBE project promotes youth's interest, motivation and confidence in science, more so than the traditional high school environments. This could be valuable information for people deciding on educational politics, for curriculum specialists, researchers and teachers, in order to adapt the traditional learning environments with proposed science aims in the country.

Furthermore, it was noted that participation in the project in previous years is related to the variables that assess interest and motivation in science. Also, at younger ages, it is more likely to increase the interest in science. Both results represent an opportunity to think about early interventions with scientific learning experience and to plan a GLOBE Costa Rica sequential educational process.

Other variables that help explain the increased interest and motivation are age and access to programs TV with scientific content. Although students were questioned on access to web pages with scientific content as one of the resources offered by the project, they were not questioned on Internet service access, which could be a variable that affects the access to such resources. The possibility of diversifying the support materials for the development of educational activities should be contemplated, to figure out audiovisual or multimedia resources for students that do not depend entirely on internet access.

Scientific inquiry was the weakest aspect in the Globe Costa Rica learning environment; therefore, it is suggested to reformulate the content and activities aimed at developing scientific research skills, in order to a better achieve the scientific skills proposed by the program. Based on these changes, teacher training processes must also be adjusted. It is also important to design a proposal that can be sustained over time, enabling the progressive development of student skills. Students may pursue progressive levels, not necessarily involving a linear order. Moreover, there should be a roll for students who have participated for several years in the program to play and a particular follow-up design for them.

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical standards** All persons gave their informed consent prior to their inclusion in the study. The manuscript does not contain clinical studies or patient data.

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