Impact of GLOBE Program on Alaskan Students' STEM Knowledge & Interests

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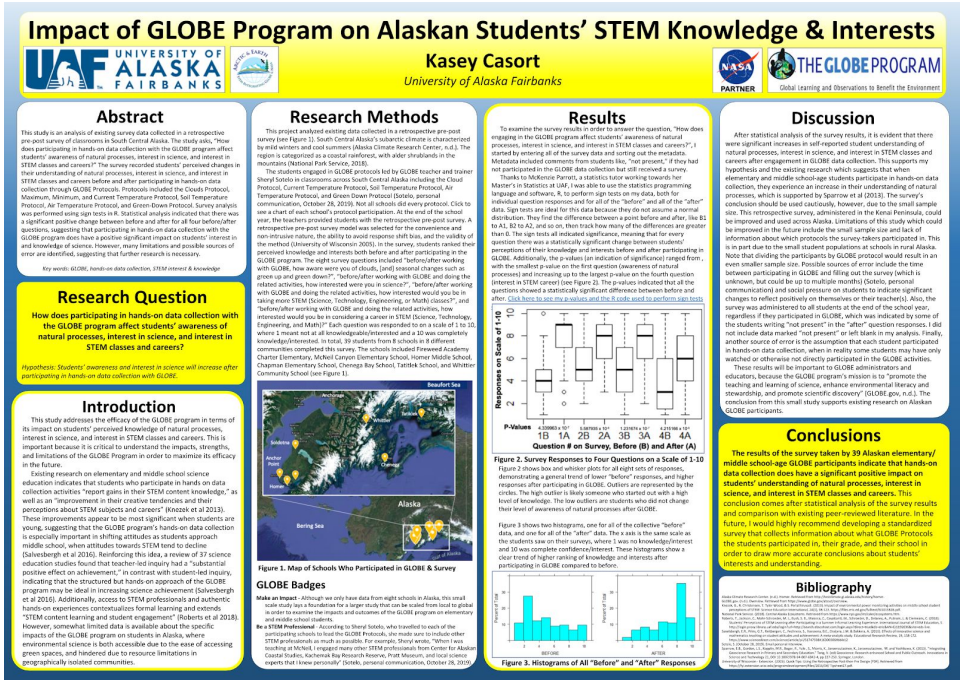
November 23, 2019



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Abstract

This study is an analysis of existing survey data collected in a retrospective pre-post survey of classrooms in South Central Alaska. The study asks, "How does participating in hands-on data collection with the GLOBE program affect students' awareness of natural processes, interest in science, and interest in STEM classes and careers?" The survey recorded students' perceived changes in their understanding of natural processes, interest in science, and interest in STEM classes and careers before and after participating in hands-on data collection through GLOBE Protocols. Protocols included the Clouds Protocol, Maximum, Minimum, and Current Temperature Protocol, Soil Temperature Protocol, Air Temperature Protocol, and Green-Down Protocol. Survey analysis was performed using sign tests in R. Statistical analysis indicated that there was a significant positive change between before and after for all four before/after questions, suggesting that participating in hands-on data collection with the GLOBE program does have a positive significant impact on students' interest in and knowledge of science. However, many limitations and possible sources of error are identified, suggesting that further research is necessary.

Key words: GLOBE, hands-on data collection, STEM interest & knowledge

Research Question

How does participating in hands-on data collection with the GLOBE program affect students' awareness of natural processes, interest in science, and interest in STEM classes and careers? This is an important question because educators, curriculum developers, and sponsors should understand how GLOBE impacts students, and where its strongest and weakest impacts are in order to improve it in the future. It is also important because no other data is available regarding the efficacy of the GLOBE program on students in Alaska.

My hypothesis was that students' awareness and interest in science would increase after participating in hands-on data collection with GLOBE.

Introduction

This study addresses the efficacy of the GLOBE program in terms of its impact on students' perceived knowledge of natural processes, interest in science, and interest in STEM classes and careers. This is important because it is critical to understand the impacts, strengths, and limitations of the GLOBE Program in order to maximize its efficacy in the future.

Existing research on elementary and middle school science education indicates that students who participate in hands on data collection activities "report gains in their STEM content knowledge," as well as an "improvement in their creative tendencies and their perceptions about STEM subjects and careers" (Knezek et al 2013). These improvements appear to be most significant when students are young, suggesting that the GLOBE program's hands-on data collection is especially important in shifting attitudes as students approach middle school, when attitudes towards STEM tend to decline (Salvesbergh et al 2016). Reinforcing this idea, a review of 37 science education studies found that teacher-led inquiry had a "substantial positive effect on achievement," in contrast with student-led inquiry, indicating that the structured but hands-on approach of the GLOBE program may be ideal in increasing science achievement (Salvesbergh et al 2016). Additionally, access to STEM professionals and authentic hands-on experiences contextualizes formal learning and extends "STEM content learning and student engagement" (Roberts et al 2018). However, somewhat limited data is available about the specific impacts of the GLOBE program on students in Alaska, where environmental science is both accessible due to the ease of accessing green spaces, and hindered due to resource limitations in geographically isolated communities.

Research Methods

This project analyzed existing data collected in a retrospective pre-post survey (see Figure 1). South Central Alaska's subarctic climate is characterized by mild winters and cool summers (Alaska Climate Research Center, n.d.). The region is categorized as a coastal rainforest, with alder shrublands in the mountains (National Park Service, 2018).

The students engaged in GLOBE protocols led by GLOBE teacher and trainer Sheryl Sotelo in classrooms across South Central Alaska including the Cloud Protocol, Current Temperature Protocol, Soil Temperature Protocol, Air Temperature Protocol, and Green Down Protocol (Sotelo, personal communication, October 28, 2019). Not all schools did every protocol, as shown in Table 1.

Table 1: Schools & GLOBE Protocol Participation

School	Atmosphere Daily Min/Max	Air Temp	Soil Temp	Green Down	Cloud
Fireweed Academy Charter Elementary	x	x	x	x	x
McNeil Canyon Elementary School	x	x	x	x	
Homer Middle School	x				x
Chapman Elementary School	x	x	x		
Chenega Bay School	x	x	x		
Tatitlek School	x	x	x		
Whittier Community School	x	x	x		

Note: this is based on personal communication with GLOBE educator Sheryl Sotelo (Sotelo, personal communication, October 28, 2019)

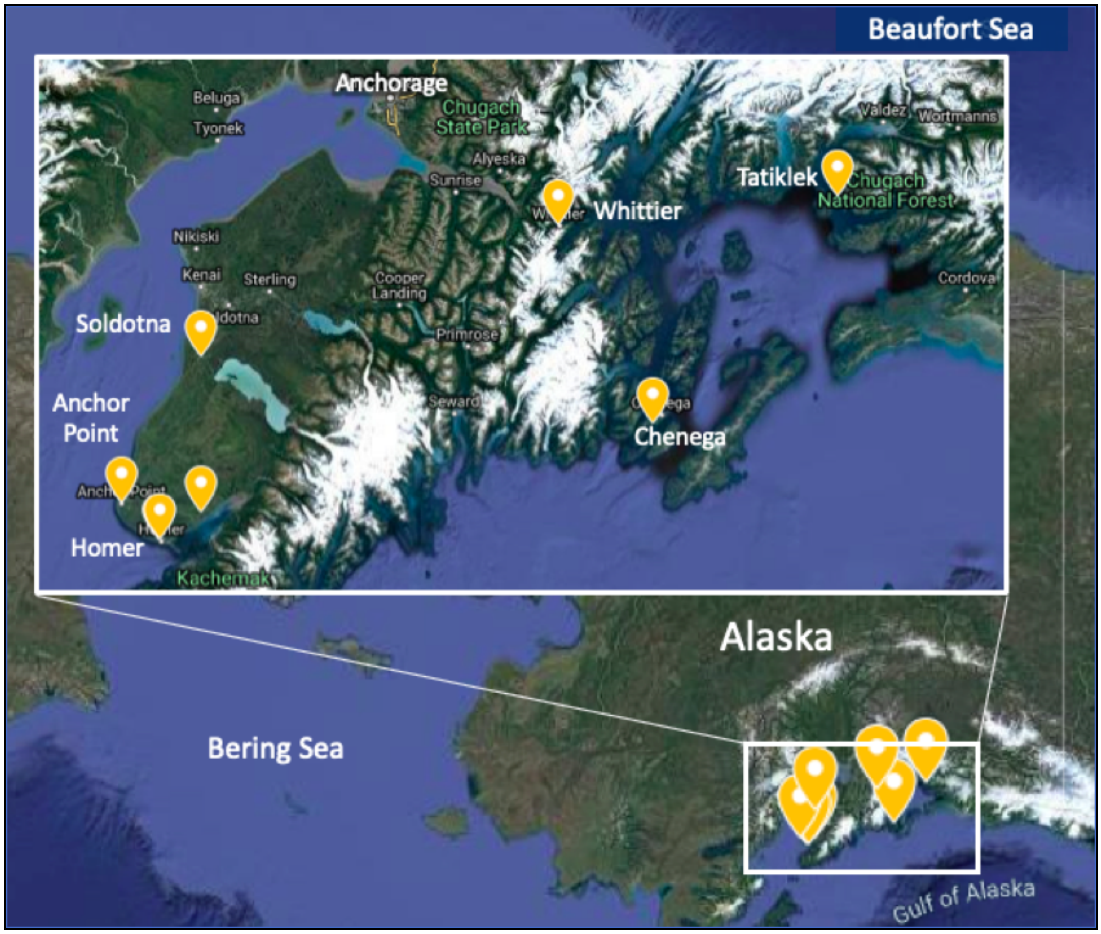

Figure 1. Map of Schools Who Participated in GLOBE & Survey

At the end of the school year, the teachers provided students with the retrospective pre-post survey. A retrospective pre-post survey model was selected for the convenience and non-intrusive nature, the ability to avoid response shift bias, and the validity of the method (University of Wisconsin 2005). In the survey, students ranked their perceived knowledge and interests both before and after participating in the GLOBE program. The eight survey questions included

1. Before/after working with GLOBE, how aware were you of clouds, [and] seasonal changes such as green up and green down?
2. Before/after working with GLOBE and doing the related activities, how interested were you in science?
3. Before/after working with GLOBE and doing the related activities, how interested would you be in taking more STEM (Science, Technology, Engineering, or Math) classes?
4. Before/after working with GLOBE and doing the related activities, how interested would you be in considering a career in STEM (Science, Technology, Engineering, and Math)?"

Each question was responded to on a scale of 1 to 10, where 1 meant not at all knowledgeable/ interested and a 10 was completely knowledgeable/interested. In total, 39 students from 8 schools in 8 different communities completed this survey. The schools included Fireweed Academy Charter Elementary, McNeil Canyon Elementary School, Homer Middle School, Chapman Elementary School, Chenega Bay School, Tatitlek School, and Whittier Community School (see Figure 1).

Globe Badges

Make an Impact - Although we only have data from eight schools in Alaska, this small scale study lays a foundation for a larger study that can be scaled from local to global in order to examine the impacts and outcomes of the GLOBE program on elementary and middle school students.

Be a STEM Professional - According to Sheryl Sotelo, who travelled to each of the participating schools to lead the GLOBE Protocols, she made sure to include other STEM professionals as much as possible. For example, Sheryl wrote, "When I was teaching at McNeil, I engaged many other STEM professionals from Center for Alaskan Coastal Studies, Kachemak Bay Research Reserve, Pratt Museum, and local science experts that I knew personally" (Sotelo, personal communication, October 28, 2019).

Results

To examine the survey results in order to answer the question, "How does engaging in the GLOBE program affect students' awareness of natural processes, interest in science, and interest in STEM classes and careers?", I started by entering all of the survey data and sorting out the metadata. Metadata included comments from students like, "not present," if they had not participated in the GLOBE data collection but still received a survey.

Thanks to McKenzie Parrott, a statistics tutor working towards her Master's in Statistics at UAF, I was able to use the statistics programming language and software, R, to perform sign tests on my data, both for individual question responses and for all of the "before" and all of the "after" data. Sign tests are ideal for this data because they do not assume a normal distribution. They find the difference between a point before and after, like B1 to A1, B2 to A2, and so on, then track how many of the differences are greater than 0. The sign tests all indicated significance, meaning that for every question there was a statistically significant change between students' perceptions of their knowledge and interests before and after participating in GLOBE. Additionally, the p-values (an indication of significance) ranged from 5.587935E-08 to 4.215166E-06, with the smallest p-value on the second question (awareness of natural processes) and the largest p-value on the fourth question (interest in STEM careers) (see Figure 2). The p-values indicated that all the questions showed a statistically significant difference between before and after.

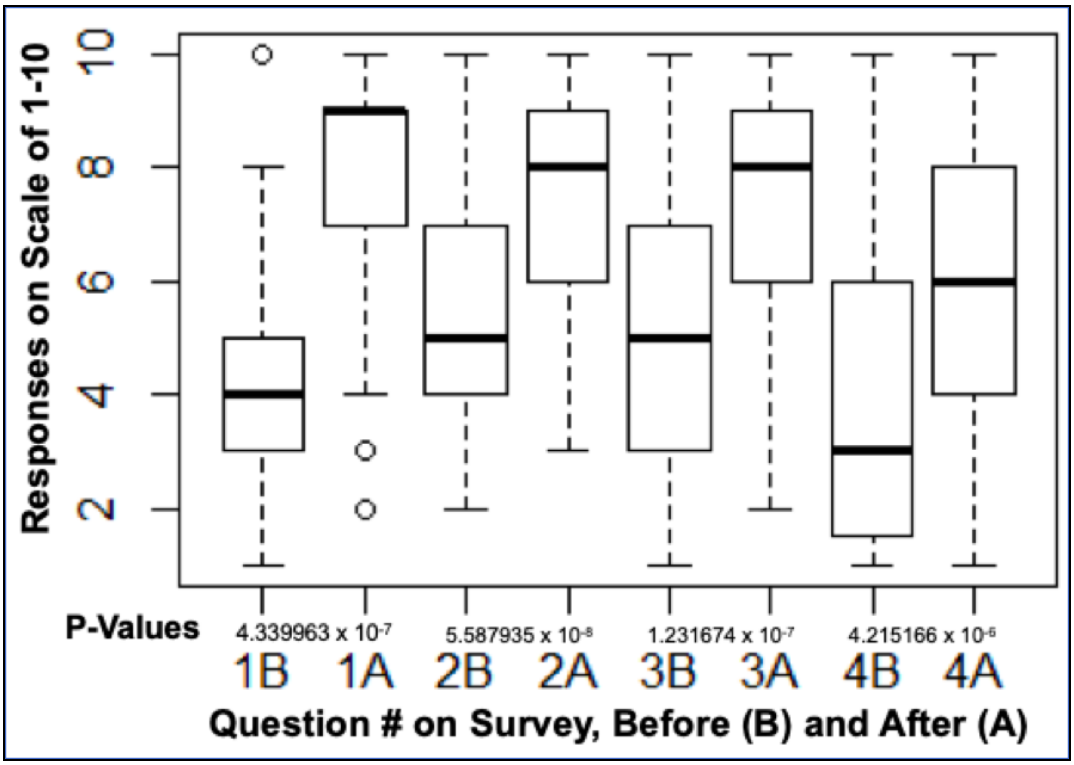

Figure 2. Survey Responses to Four Questions on a Scale of 1-10

Figure 2 shows box and whisker plots for all eight sets of responses, demonstrating a general trend of lower "before" responses, and higher responses after participating in GLOBE. Outliers are represented by the circles. The high outlier is likely someone who started out with a high level of knowledge. The low outliers are students who did not change their level of awareness of natural processes after GLOBE. For clarity, the questions and their respective p-values are listed in Table 2.

Table 2: P-Values from Sign Tests on Survey Questions Before (B) and After (A)

Question #/Topic	P-Value
1 - Awareness of Natural Processes	4.339963E-07
2 - Interest in Science	5.587935E-08
3 - Interest in Future STEM Classes	1.231674E-07
4 - Interest in STEM Career	4.215166E-06
All Before --> All After	< 2.2E-16

Note: these p-values were generated in R from the code linked below

Click here to read the R code used to perform the sign tests, generate the box plots and histograms, and generate the P values.

Figure 3. Histograms of all "Before" and "After" Responses

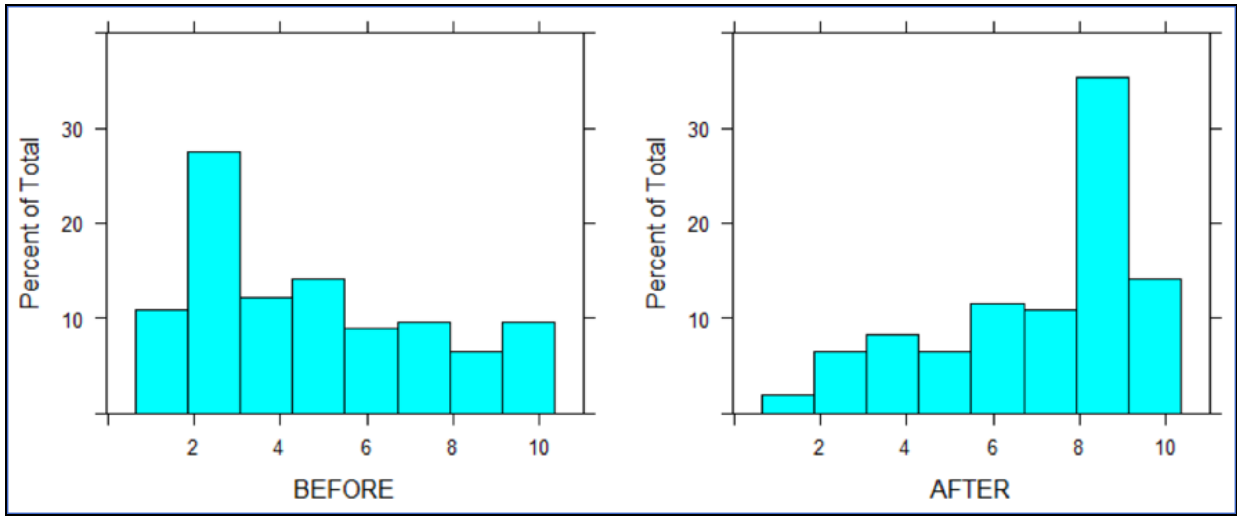

Figure 3 shows two histograms, one for all of the collective "before" data, and one for all of the "after" data. The x axis is the same scale as the students saw on their surveys, where 1 was no knowledge/interest and 10 was complete confidence/interest. The y axis represents how many students responded with that respective value. These histograms show a clear trend of higher ranking of knowledge and interests after participating in GLOBE compared to before.

Discussion

After statistical analysis of the survey results, it is evident that there were significant increases in self-reported student understanding of natural processes, interest in science, and interest in STEM classes and careers after engagement in GLOBE data collection. This supports my hypothesis and the existing research which suggests that when elementary and middle school-age students participate in hands-on data collection, they experience an increase in their understanding of natural processes, which is supported by Sparrow et al (2013). The survey's conclusion should be used cautiously, however, due to the small sample size. This retrospective survey, administered in the Kenai Peninsula, could be improved and used across Alaska. Limitations of this study which could be improved in the future include the small sample size and lack of information about which protocols the survey-takers participated in. This is in part due to the small student populations at schools in rural Alaska. Note that dividing the participants by GLOBE protocol would result in an even smaller sample size. Possible sources of error include the time between participating in GLOBE and filling out the survey (which is unknown, but could be up to multiple months) (Sotelo, personal communication) and social pressure on students to indicate significant changes to reflect positively on themselves or their teacher(s). Also, the survey was administered to all students at the end of the school year, regardless if they participated in GLOBE, which was indicated by some of the students writing "not present" in the "after" question responses. I did not include data marked "not present" or left blank in my analysis. Finally, another source of error is the assumption that each student participated in hands-on data collection, when in

reality some students may have only watched or otherwise not directly participated in the GLOBE activities.

These results will be important to GLOBE administrators and educators, because the GLOBE program's mission is to "promote the teaching and learning of science, enhance environmental literacy and stewardship, and promote scientific discovery" (GLOBE.gov, n.d.). The conclusion from this small study supports existing research on Alaskan GLOBE participants.

Conclusion

The results of the survey taken by 39 Alaskan elementary/ middle school-age GLOBE participants indicate that hands-on data collection does have a significant positive impact on students' understanding of natural processes, interest in science, and interest in STEM classes and careers. This conclusion comes after statistical analysis of the survey results and comparison with existing peer-reviewed literature. In the future, I would highly recommend developing a standardized survey that collects information about what GLOBE Protocols the students participated in, their grade, and their school in order to draw more accurate conclusions about students' interests and understanding.

Acknowledgements

Thank you to all of the students and educators who participated in the survey, to GLOBE Educator Sheryl Sotelo for talking with me about the GLOBE program in South Central Alaska, to Mackenzie Parrott in the UAF Statistics Tutoring lab for assisting me with the statistical analysis in R, and to Dr. Christi Buffington and Dr. Elena Sparrow for editing my poster and advising me throughout the process.

Contact Information

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