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STUDENT ATTITUDE TOWARDS ENVIRONMENTAL ISSUES FOLLOWING EXTRACURRICULAR SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) ACTIVITIES: EVIDENCE FROM A STUDENT SURVEY

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ABSTRACT: *Educational interventions based in Science, Technology, Engineering, and Mathematics (STEM) positively affect student performance in school while also nurturing student interest in related fields. The impacts of STEM-based educational interventions have been widely studied, but there are few studies exploring the impact of extracurricular STEM-related activities on adolescent perceptions of environmental issues. Furthermore, little is known about the factors that impact a student's perception of environmental problems in historically excluded groups. To address this research gap, we surveyed students (n = 37) who participated in a field trip to Stokes State Forest in New Jersey as part of a STEM-based summer camp. Participants in the study were largely from urban areas that are predominantly Hispanic. The main objective of the study was to investigate the factors that impacted the change in participant perception towards environmental issues using a pre-post survey methodology. After the field trip, students from higher grades were more likely to believe that environmental threats were a concern. They also indicated in post survey assessment that they believed that environmental problems could be solved without making large scale changes in their life. Intrinsic factors, such as parents' education and occupation, also played a crucial role in shaping their environmental awareness. We found that the field trip had an overall positive influence on students' attitudes towards the environment, especially older respondents, who reporter higher willingness to make small changes and improved belief that solving environmental issues could be done on the individual level. In this study, we propose that exposing students to such out of class activities such as field trips can be a useful medium of environmental education, particularly for students from historically excluded communities.*

Keywords*: educational intervention, STEM education, environmental perception, underrepresented groups in STEM, stepwise regression*

INTRODUCTION

STEM education is critical in the overall economic success of the country (Bybee, 2010). There is particular emphasis on improving STEM retention in underrepresented, historically excluded communities including those from African American, Hispanic or Latino/Latina, American Indian, and Alaskan Native backgrounds (Estrada et al., 2016). The need for Science, Technology, Engineering, and Mathematics (STEM) education in the United States is crucial, with the country ranking below other nations in producing trained professionals capable of addressing the continued demand for technological advancements (Jackson, 2003). According to the Program for International

Student Assessment, the United States ranked 19th in science and 31st in mathematics out of 35 Organization for Economic Co-operation and Development (OECD) countries (OECD, 2015). To remain competitive in the growing global economy, various initiatives, such as out-of-school interventions, have been suggested to engage students in STEM education (Estrada et al., 2016).

Out-of-school educational interventions are programs that are implemented to help "offset impacts of poverty and inadequate learning environments on child development and school success" (Barnett, 2011). They generally are not included in the basic curriculum of schools but provide significant experiences that cannot be taught in a classroom. These activities are varied and can include science clubs, field trips to museums, zoos, planetariums, national parks, and summer camps (Sahin et al., 2014; Mohr-Schroeder et al., 2014).

These initiatives have been helpful in boosting student grades but also have improved behaviors (Fredricks and Eccles, 2008). The positive effects of extracurricular activities on other aspects of education such as grades, academic achievements, high school dropout rates, college enrollment, attitudes toward society, and drug and substance abuse have been widely studied (Feldman and Matjasko, 2005). Extracurricular activities like outdoors field trips can also improve environmental awareness and STEM capacity in adolescents, especially for children from historically excluded groups (Sprague et al., 2020). Field trips can be particularly useful towards building environmental awareness and connection to the environment (Nadelson and Jordan, 2012). Encouraging children to be in nature, even in the short-term of less than one full day, leads to noted mental, social, and physical benefits like increased self-image, better stress management, decreased stress and fatigue (Mygind et al., 2019; Connelly, 2012; Hohashi and Kobayashi, 2013).

With urban sprawl continuing to grow, natural spaces for children to explore become increasingly rare—a major concern, considering a significant amount of children demonstrate a preference for indoors and screen-based activities, leading to a disconnect between children and nature (Karsten and Vliet, 2006; Larson et al., 2018; Lovelock et al., 2016). Mending this disconnect could help improve the urgency of preservation and conservation efforts, emphasized in the 15th objective of the United Nations Sustainable Development Goals (Woods, 2018; UNICEF, 2022).

The effect of educational interventions such as field trips on environmental awareness in children—especially of children from historically excluded communities—has been explored, but these studies do not often include precise, pre-study experiences of their respondents.

With large scale changes to the environment observed throughout the world, the changing perceptions of students towards environmental awareness are of increasing interest (Wals et al., 2014). Early exposure to environmental issues helps students become aware of imminent dangers to the environment, but furthermore, understanding environmental perceptions has been noted to be of importance not just in in actual food and water availability, but in land management, policy creation, and resource management (Bodzin, 2012; Roeschel et al., 2016).

Nordstrom and Mitteager (2001), for example, surveyed over 800 New Jersey high school students to assess their perceptions of natural and restored dunes, concluding that education—or intervention—efforts to residents beyond the shore would be necessary to help obtain support for policy for dune restoration. These studies, however, did not investigate the factors that impact students' perceptions of the environment. Moreover, we are unaware of studies that examine the impact of educational intervention on environmental awareness of middle school students in a population from historically excluded groups, using an assessment of STEM-based experiences to determine significant factors in positive perceptions of the environment. Studies have shown that participation of students from historically excluded communities in STEM-based activities is low and still a cause of concern (Estrada et al., 2016). Furthermore, parent education (Özden 2008) and involvement are shown to have positive influences on education (Anderson and Minke, 2007), particularly in urban areas (Jeynes 2005). Therefore, socio-demographic factors can be significant factors to consider when assessing environmental perceptions.

Because of low participation from historically excluded groups in extracurricular STEM-enrichment programs, we know little about factors that impact their perceptions towards the environment. To address this research gap, we arranged a field trip to study students' perception change before and after an educational intervention. In this study, we use a field trip to the New Jersey School of Conservation located in Stokes State Forest as the intervention to gauge differences in participant perception of environmental issues. The students included in this study were a part of a STEM-learning summer camp largely directed towards students from school districts with high percentages of low-income households. The main objective of the project was to study the factors that affected changes in perception towards environmental awareness amongst students before and after a field trip. The field trip introduced the students to concepts of terrestrial and aquatic ecology, and the issues surrounding them.

METHODS

Camp Activities

The study's participants were part of a STEM-based summer camp organized at Montclair State University in New Jersey, under the Assimilating Computational and Mathematical Thinking into Earth and Environmental Science (ACMES) STEM + Computing (STEM+C) program, which was offered to students attending schools in the nearby district of Kearny. The New Jersey Board of Education (NJBOE) classifies school districts using a District Factor Group (DFG) method, which compares districts of similar socioeconomic structures. Classification is based on a scale from "A" to "I", with "A" indicating lowest socioeconomic status and "I" indicating the highest; Kearny is classified as a level "B" district by the NJBOE (New Jersey Board of Education, 2004). Additionally, 50% of Kearny's population identifies as of Hispanic or Latino descent, which are historically excluded in the STEM fields (United States Census, 2019). Therefore, Kearny provided a unique opportunity to study historically excluded students' perceptions of environmental issues.

The participants for the summer camp were selected on a "first come, first served" basis by the Kearny Board of Education. Student participation was capped at 24 participants for each week-long session, with three sessions available through July 2018. All survey participants were from grades 6-8 in the age group of 11-14 years. All necessary Institutional Review Board regulations were followed during the recruitment and execution of the program.

After four days of participating in the STEM summer camp held on campus, students were requested to complete a pre-field trip survey to gauge their preexisting experiences and perceptions pertaining to the environment. Pre- and post-surveys were administered exclusively by camp leaders, who were with the students throughout the duration of the camp.

Once the surveys were completed, the participants were taken on the field trip accompanied by a lead instructor to the School of Conservation (NJSOC), located in Stokes State Forest in New Jersey. The field trip comprised of two major activities: a two-mile hike led by a terrestrial ecologist, and a stream-health activity led by an aquatic ecologist (Figure 1). Ecologists were affiliated with the School of Conservation and were not involved with the study, preventing extraneous influence on camper response to questions in the surveys. During the two-mile hike, the terrestrial ecologist gave a brief lesson on terrestrial ecology, including environmental issues that plague ecosystems, such as deforestation and invasive species, and identifying plant and animal species. Campers were given instructions on how to properly follow trail paths and were also shown how to identify bear tracks by looking at scratches on poles and trees as well as their hibernating grounds. Participants were also able to engage in hands-on activities during the hike, touching and smelling plants with different properties; many students enjoyed plants with pleasant smells like the pineapple weed *(Matricaria discoidea)*, while others were taken aback by malodorous plants, like the skunk cabbage *(Symplocarpus foetidus)*.

Figure 1. Campers learning about different New Jersey woodland species from the terrestrial ecologist (left), and how to identify indicator species found in the stream activity (right).

The activity at the flowing stream incorporated lessons about the aquatic ecosystem and explored problems faced by aquatic ecosystems, including eutrophication and pollution. The lesson included a tactile, team building activity of catching water indicator organisms from the flowing streams with other campers. These organisms are benthic macroinvertebrates generally present at the bottom of the water body attached to rocks, vegetation, logs, and sticks or burrowed into the bottom sand and sediments. The presence or absence of such indicator organisms helps distinguish levels of pollution in streams and rivers to help students understand how pollution can affect stream ecosystems. Once the activities ended, we again administered the same survey and recorded the responses. The pre- and post- surveys allowed us to study the factors that impacted students' changes in environmental awareness after having participated in the field trip.

Survey Design

Our survey was designed to assess how respondent perception of nature might change after the field trip to Stokes State Forest. The survey instrument was created after a thorough literature review to determine the number of questions (Bell, 2007; Bixler et al., 2002). Some questions regarding perceptions of nature were partially modeled using Bixler et al. (1997) study, where urban respondents identified different ways they felt about nature. However, our survey was modified to fit the age group of our respondents and tailored to fit our study objectives. Surveys underwent peer review, focus group discussions, and a pilot test before distribution to respondents. Surveys included questions to collect sociodemographic information as well as Likert-scale questions regarding level of agreement concerning feelings and perceptions about nature and environmental protection, and experience with nature prior to the field trip (see Table 1).

Table 1. Subset of survey questions to respondents.

	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
Threats to the environment are not my business					
I am willing to have environmental problems solved even if it means sacrificing many goods.					
Environmental problems can be solved without big changes to our way of life.					
I think each of us can make a significant contribution to environmental protection.					
I am optimistic about the future.					
Nature is uncomfortable because of heat, bugs etc.					
Nature is inspiring because of the colors, peace, and bird songs					
I am not interested in spending any time in nature					
It is too expensive for me and my family to participate in nature activities					
There is too much risk of getting hurt in natural areas (I could fall, get lost, be attacked by animals, etc.)					

DATA ANALYSIS

In our survey, 15 Likert-scale questions related to environmental attributes were our dependent response variables. Participant age, school grade, gender, ethnicity, parent education, and occupation were the explanatory variables. To study the effect of intrinsic factors (explanatory variables) on the change in participant perception towards the environment, we subtracted the pre-survey from the post-survey. This is different from a cross-sectional analysis, which would assess differences in attitude among different groups without evaluating the impact of the intervention designed to affect those attitudes. Subtracting pre-survey data from that of the post-survey gave us a

matrix table that represented the changes in the respondent's perception. To select the most representative response variables from the list of 15 questions, we ran a Principal Component Analysis (PCA) followed by cluster analysis. The purpose of the PCA/clustering analysis is to select fewer number of questions that statistically represent the longer set of questions. Using the cluster analysis, we picked the responses that explained the maximum variance in the data. We then ran a stepwise regression on the selected principal component responses as our dependent variables and the demographic information as independent variables. The stepwise function aided in helping explore all possibilities for significant relationships (JMP, 2018).

RESULTS

We had 37 complete responses from 62 campers for both pre- and post-trip surveys. Responses that were partially or incorrectly filled were removed from the dataset. The age of the respondents varied from 10 to 13 years. While we had one participant with an age of 10 years old, the distribution of ages 11, 12, and 13 years varied between 24 - 38%. We had the highest responses from grade 8 students (46%), with responses from grades 6 and 7 at 16% and 38%, respectively. We had a higher number of responses from females (62%) than males (38%). 68% of respondents identified as Hispanic. We included parents' education as an independent factor and found that 68% were educated outside of the US, suggesting that the majority of survey participants were first-generation students. 59% of the participants' parents worked in a non-STEM related field.

The clustering analyses shows that here were five clusters, whose variation in turn was captured by the following five variables: "I think each of us can make a significant contribution to environmental protection," "Threats to the environment are not my concern," "I am willing to have environmental problems solved even if this means sacrificing many goods," "I am optimistic about the future," and "Environmental problems can be solved without big changes to our way of life" (see Table 1). These five opinions captured over 56% of the variance in data. Tables 2 and 3 show the variance of the representative opinions from the cluster and response, respectively.

Table 2. Principal component analysis of change in student's perception toward environmental issues.

Cluster number	Number of members in each cluster	Representative variable	Variance explained of the cluster	Total variance of the cluster
1	3	L	0.68	0.13
2	4	A	0.47	0.12
3	4	E	0.46	0.12
4	2	N	0.67	0.08
5	2	I	0.63	0.08

Table 3. Important variables from the cluster analysis.

Representative Variable	Variable
L	I think each of us can make a significant contribution to environmental protection
A	Threats to the environment are not my concern
E	I am willing to have environmental problems solved even if this means sacrificing many goods
N	I am optimistic about the future
I	Environmental problems can be solved without big changes to our way of life

We ran five stepwise regressions with the representative variables as responses and the demographic data (age, school grade, gender, ethnicity, parents' education, parents working in STEM) of the respondents as explanatory variables. The stepwise regression model for "L - I think each of us can make a significant contribution to environmental protection" was significant ($f = 3.28$, $p = 0.032$). The model explained 23% of the variation ($R^2 = 0.23$)

associated with the data. We found that that parents' occupation was the significant factor in the model (Table 4). Respondents whose parents worked in a STEM-related field were 44% more likely to believe that they could make significant ($p = 0.026$) contribution towards environmental protection. School grade ($p = 0.106$) or gender ($p = 0.246$) did not have any significant effect.

Table 4. Stepwise regression with "L - I think each of us can make a significant contribution to environmental protection" as the response variable.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.21	0.19	1.09	0.284
School Grade	-0.30	0.18	-1.66	0.106
Gender	0.22	0.19	1.18	0.246
Parents occupation	0.44	0.19	-2.32	0.026*

The stepwise regression for the response variable "A - Threats to the environment are not my concern" was also found to be significant ($f = 3.14$, $p = 0.038$). The model explained 22% of the variance associated with the data ($R^2 = 0.22$). We did not find any significant effect of parents' occupation ($p = 0.235$) or ethnicity ($p = 0.215$) on our response. However, we found that grade had a significant effect ($p = 0.030$) on the response. In other words, students from grade 8 were 36% more like to believe that threats to the environment were their concern (Table 5).

Our third stepwise regression with "E - I am willing to have environmental problems solved even if this means sacrificing many goods" as the response was also significant ($f = 7.17$, $p = 0.002$). The model explained over 29% of the variance associated with the data ($R^2 = 0.29$). School grade did not have any significant ($p = 0.154$) effect on the response (Table 6). We found that parents' education had a significant ($p = 0.003$) on the response. The results show that students who reported that both of their parents had an education in the United States were 46% more likely to feel like they would be willing to make sacrifices to solve environmental problems. The stepwise regression model labeled "N - I am optimistic about the future" as a response was not significant ($f = 0.71$, $p = 0.588$).

Table 5. Stepwise regression with "A -Threats to the environment are not my concern" as the response variable.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.56	0.60	0.93	0.356
School Grade	0.36	0.16	-2.26	0.030*
Ethnicity	-0.63	0.50	-1.26	0.215
Parents occupation	0.43	0.35	-1.21	0.235

Table 6: Stepwise regression with "E - I am willing to have environmental problems solved even if this means sacrificing many goods" as the response variable.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.43	0.16	-2.61	0.013
School Grade	-0.21	0.15	-1.46	0.154
Parents Education	0.46	0.15	-3.12	0.003*

Our last stepwise regression with "I - Environmental problems can be solved without big changes to our way of life" as the response was significant ($f = 3.60$, $p = 0.021$). The model explained more than 25% of the variation in data ($R^2 = 0.25$) (see Table 7). School grade was significant ($p = 0.013$) in explaining the variation of the data. In other words, students from grade 8 were more likely to believe that environmental problems can be solved without making significant changes to their lifestyle. In this regression, ethnicity was marginally significant, but applied to respondents who declined to indicate their ethnicities. This group was compared to the rest of the respondents, irrespective of their ethnicities; therefore, neither historic exclusion nor or parents' education t significantly affected our model.

Table 7: Stepwise regression with "I - Environmental problems can be solved without big changes to our way of life" as the response variable.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1.11	0.45	-2.44	0.020
School Grade	0.54	0.20	-2.60	0.013*
Ethnicity	-0.92	0.46	-2.01	0.053
Parents Education	-0.32	0.21	-1.51	0.141

DISCUSSION

With this research, our focus was to study the factors that affected the students' change of perception towards environmental awareness in a low income, diverse, underrepresented demographic population. Kearny, a low-income district in New Jersey, provided us with an opportunity to accomplish our objective. With a response of 68% identifying as of Hispanic descent and 62% as females, we were able to study underrepresented groups in STEM fields. Our nuanced statistical approach helped us capture crucial information from our data that helped us explore participants' perceptions of the environment.

We selected five important responses from a list of 15 questions. Our analysis suggests that the field trip changes students' perception of environmental threats. We found that students from grade 8 were more receptive to the idea that environmental threats were their concern. The result suggests that more academically developed students were either aware of ecological issues or more likely to be receptive to environmental complications. Students from higher grades tend to have better comprehension skills (Shell et al. 1995). Moreover, activities such as field trips also help them comprehend the enormity of environmental problems (Dori and Tal 2000). The results also show that a certain level of academic maturity may help students recognize environmental problems. Associations between grade level and students' reasoning have been observed (Means and Voss 1996). Moreover, Yilmaz and Alp (2006) have shown that the more a student is taught, the more likely they are to improve in subject matter comprehension. Therefore, continuing such educational intervention can help students understand complex environmental issues.

Recognizing environmental issues is the primary step towards environmental education. However, it is vital to study whether such awareness can lead to impactful actions. Therefore, we asked the participants whether they were willing to make sacrifices to mitigate environmental problems. We found that students were amenable to sacrificing many goods to improve environmental quality. Our analysis revealed that grade level did not have a significant effect on the participants' responses. The results suggest that students from all grades were equally willing to make sacrifices that can benefit the environment. We also found that the location of parental education was a significant factor in determining whether a student would be responsive to making sacrifices. Participants whose parents were educated in the United States were more likely to adopt changes in their environmental perceptions. Therefore, students with parents who had education in the US may be more likely to discuss environmental issues, which can potentially have a positive effect on students' understanding of environmental problems. As such, these participants would grasp the extent of environmental issues and may be more flexible in their willingness to sacrifice non-essential goods in their life.

Furthermore, we studied how much change in lifestyle is required to solve environmental problems. We asked the participants whether environmental problems can be solved without big changes to their way of life. Our analysis suggests that students from higher grades believed that large scale changes in life are not required to solve environmental issues. We also studied whether or not participants felt they were empowered towards making choices towards environmental protection. We found that the students assumed that everyone could collectively contribute to environmental protection. We found no significant difference in their opinion across grades, again suggesting students from all grades were equally like to believe that every individual can contribute towards the protection of the environment. However, students whose parents were involved in STEM-related jobs were more likely to think that individuals can collectively have an impact on environmental protection. Parental involvement affects students' ability to comprehend critical issues (Anderson and Minke, 2007). Damerell et al. (2013) found that parents who had a prior background on wetlands and its issues had a significant effect on students' awareness of a wetland. Parents who are working in a STEM-related field are likely to have more nuanced discussions involving environmental problems with their children. These discussions can contribute to students' awareness of an issue. Collectively, such interactions,

along with educational intervention, help students become more aware of environmental problems. Future studies are required to determine if these changes in attitude are persistent or if they are short-lived.

CONCLUSION AND RECOMMENDATIONS

This study focused on assessing the factors that impact environmental perception from underrepresented groups after participation in a STEM-based summer camp due to the urgent need to improve attendance and performance in STEM fields from those groups. Overall, we found there were changes in our respondents' perceptions towards the environment. Students believed that environmental issues were a big concern, and they could be solved without making significant changes in their lives. More importantly, they were willing to make small changes and believed every individual could play a key role in solving issues plaguing the environment. Students were even ready to make sacrifices to resolve the environmental problems. From our analysis, we found that while some of those changes were dependent on student's grades, others can be attributed to parents' education and occupation. The results suggest that the field trip did not significantly change the attitude towards environmental awareness of students from lower grades. Moreover, the field trip did not change participants' environmental awareness with parents who did not have a US-based education or STEM. Therefore, efforts are required so improvement in perceptions towards environmental awareness can be achieved independently of these intrinsic factors. For a holistic environmental education, the curriculum must be designed so that students who are at a disadvantage get appropriately involved.

We believe that educational intervention such as field trips provide an appropriate medium for information dissemination. This method of teaching is received favorably by students and contributes to the development of innovative environmental education programs. Our results also suggest that STEM-based educational intervention help change students' perceptions of environmental issues. Based on our results, there is a need to develop policies that benefit students, independent of their grades or parents' education and/or occupation. Future studies are required to determine if these changes in attitude are persistent or if they are short-lived.

Declarations

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