Building science knowledge, identity, and interest using place-based learning to engage diverse urban undergraduate and high school students

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Introduction

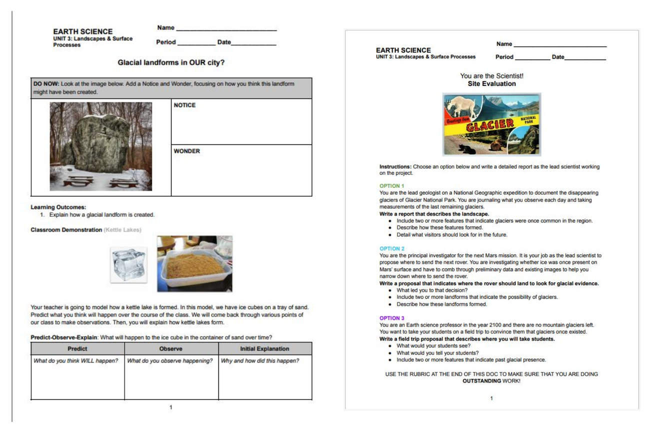
- New York's glacial history and landforms were used to engage a diverse, urban population of undergraduate and high school students heavily impacted by remote learning. These classes all had:
  - High ethnic and racial diversity
  - High proportion of English Language Learners (ELLs)
  - Populations underrepresented in STEM fields
  - Limited science literacy
  - In the case of the two-year college (2YC), first generation college students
- The goals of this work was to increase students' science content knowledge, science identity, and science interest.

Who we are:
- MAT professors in science education and science
- Former MAT students, now NYC public high school teachers

Who our students are:
- **Deep Valley High School:** 54% Latinx, 10% Black, 8% Asian, 26% White; 49% Female, 51% Male; 6% ELL; 18% Students with disabilities; 54% Economically disadvantaged
- **Douglass High School** 36% Latinx, 10% Black, 36% Asian, 16% White; 41% Female, 59% Male; 28% ELL; 15% Students with disabilities; 82% Economically disadvantaged
- **Garnet Community College:** 29% Latinx, 28% Black, 28% Asian, 14% White; 53% Female, 47% Male; 54% receive financial aid

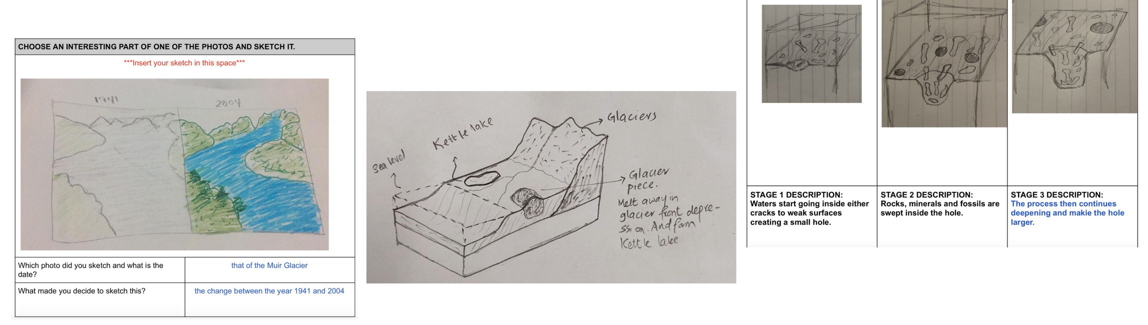
What we did:
- We co-developed a 5E lesson sequence, with pre- and post-surveys that measured the development of content understanding (Keeley & Tucker, 2016), student science identity (Pugh et al., 2009), and interest in science (Lamb et al., 2012).
- The mini-unit took 2 weeks to 1 month to teach (6 hours total).

Examples of Classroom Materials



Adaptations included:
- Formatting to match each teacher's teaching style
- Use of graphic organizers
- Translated materials for ELLs
- Simplification of lessons to fit pacing needs and remote learning setting
- Conversion of short answer questions to multiple choice

Examples of Student Work



Theoretical Framework

We used pedagogical strategies that provided equitable ways of learning and demonstrating knowledge to validate and reflect the diversity, identities, and experiences of all students, and communicate to students that they are valued and their varied experiences are an asset in learning (Moll et al., 1992).
These strategies included:
- **Place-based learning** (Semken et al., 2017). We focused on local glaciation history to increase student connections to the lesson content.
- **Active learning** opportunities applying the 5E instructional model (Bybee et al., 2006).
- Incorporating **fun in lessons** to elicit positive emotional responses, thereby increasing effective processing of information and the transfer to long-term memory storage (Willis, 2007; NRC, 2000).
- Providing **multiple ways to demonstrate skills and understanding** such as sketching (Ainsworth et al., 2011) and developing analogies (Rivet & Kastens, 2012).
- **Building scientific skills** such as observing, measuring, interpreting data, sketching, and map reading during virtual field trips (NRC, 2012).

Results Science Interest

- The Science Interest Survey of Lamb et al., (2012) includes 21 questions that are broken into five subscales: F (Family Encouragement), P (Peer Attitudes toward Science), T (Teacher Influence), I (Informal Learning Experiences), and S (Science Classroom Experiences).
- Highest values were recorded for Teacher Influence followed by Science Classroom Experiences (Fig. 1).
- For all three schools, Family Encouragement and Informal Learning Experiences increased from pre- to post- survey.
- For averaged data, we see:
  - Family encouragement, Informal learning experiences, and Science classroom experiences increase
  - No change for Peer attitudes
  - A slight decrease in Teacher Influence
  - A t-test determined only the change in family encouragement was statistically significant (Table 1)

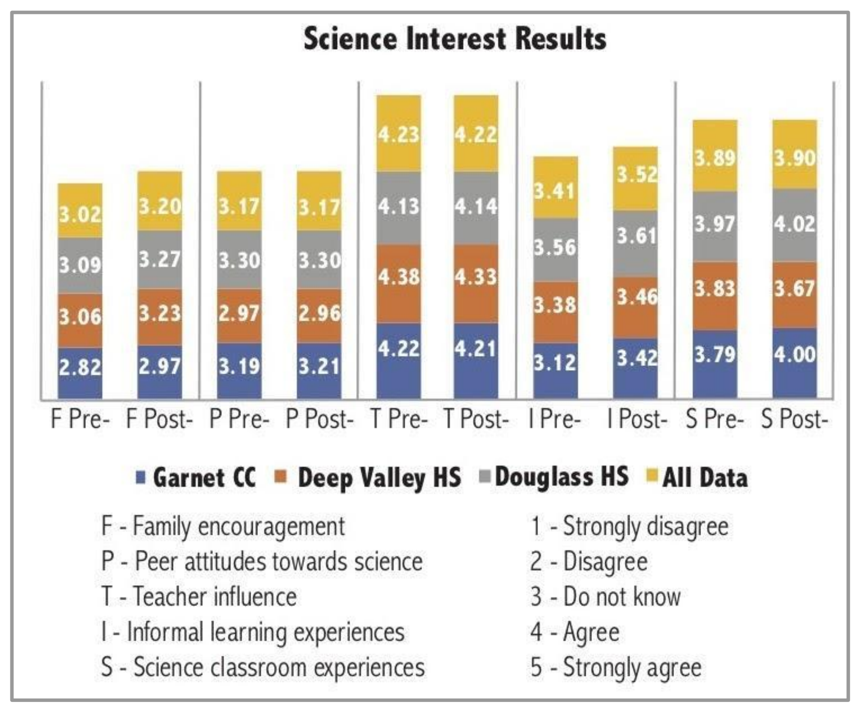


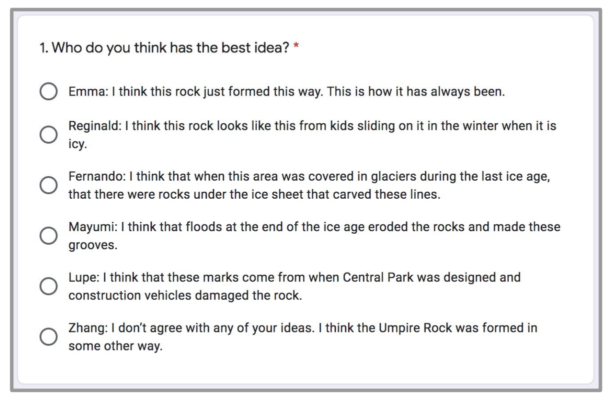
Figure 1. Comparison of all pre- and post-science interest survey results grouped by subscale.

	F	P	T	I	S
Sig. (2 tailed) P value for all data	0.006	0.961	0.806	0.137	0.179

Table 1. Paired t-test results for Family encouragement.

Results Science Content Learning

- 92 students completed both the pre- and post-surveys.
- 44 students were from Douglass HS, 30 were from Deep Valley HS, and 18 were from Garnet 2YC.
- Each group recorded a similar increase in content knowledge of ~ 41%.
- Overall, all groups moved toward "more correct" by selecting the correct answer or second closest choice (Fernando & Mayumi):
  - 70% chose one of the two most correct answers in the pre-survey.
  - 85% chose one of the two most correct answers in the post-survey.
- 8.7% of students chose one of the two least correct answers in the pre-survey (Reginald & Lupe). This was lowered to 5.4% in the post survey (Fig. 2 & 3).



1. Who do you think has the best idea? *

- Emma: I think this rock just formed this way. This is how it has always been.
- Reginald: I think this rock looks like this from kids sliding on it in the winter when it is icy.
- Fernando: I think that when this area was covered in glaciers during the last ice age, that there were rocks under the ice sheet that carved these lines.
- Mayumi: I think that floods at the end of the ice age eroded the rocks and made these grooves.
- Lupe: I think that these marks come from when Central Park was designed and construction vehicles damaged the rock.
- Zhang: I don't agree with any of your ideas. I think the Umpire Rock was formed in some other way.

Figure 2. Answer options given to students for the content knowledge portion of the survey.

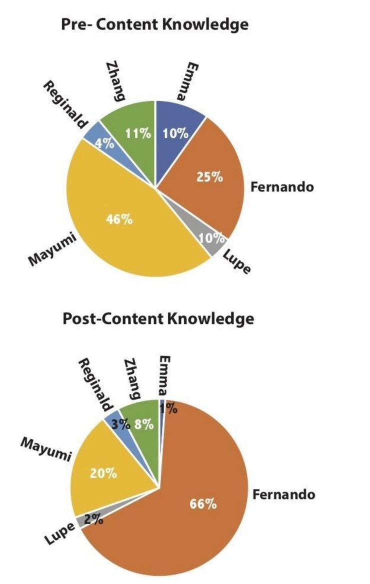


Figure 3. Charts showing percentages of answers selected by student from all three schools.

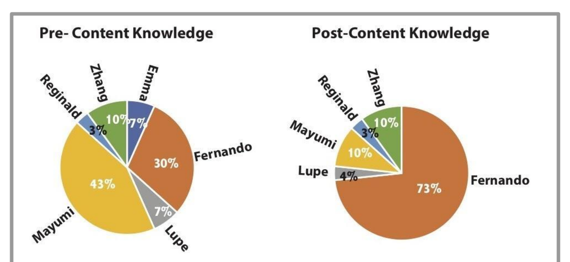


Figure 3. Answers selected by students at Deep Valley HS (n = 30).

Students from **Deep Valley HS** selected five out of six answers in the post-survey, deciding one option was not possible. The three least correct answers (Lupe, Reginald, Zhang) stayed almost the same in the post-survey.

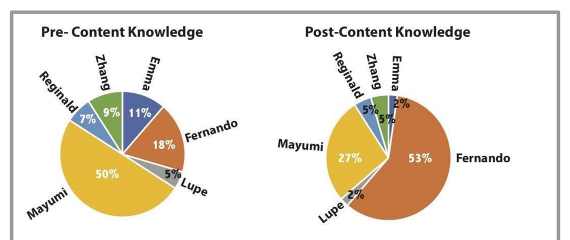


Figure 4. Answers selected by students at Douglass HS (n = 44).

In the pre-survey, 2YC students showed the highest content knowledge, while **Douglass HS** students, with the highest ELL population, scored the lowest.

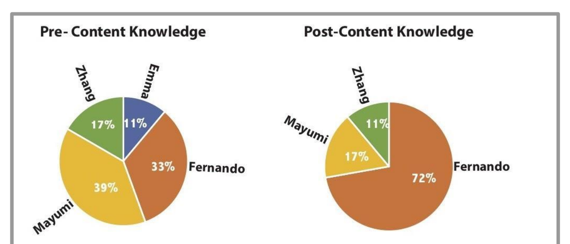


Figure 5. Answers selected by students at Garnet 2YC (n = 18).

Garnet 2YC students only selected four of the answers in pre-survey, deciding two were not possible. This was reduced to three options in the post survey.

Results Science Identity

- Student science identity was determined using four science identity statements (Pugh et al., 2010) to measure students' evolving perceptions of themselves as scientists in the present and in their futures as a part of the pre- and post-survey (Fig. 6).
- Averaged data shows an increase of 4.8% on the Likert scale for Douglass HS students and a 0.3% increase for Deep Valley HS and the Garnet CC.
- When averaged for all students, the increase in scores between the pre- and post-test is statistically significant (P value = 0.04).

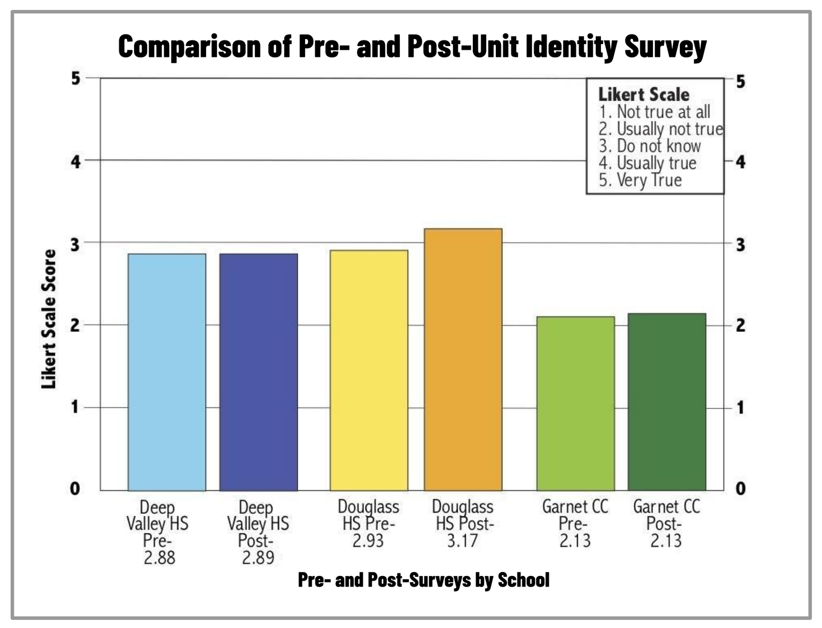


Figure 6. Comparison of science identity portion of pre- and post-surveys.

- Science identity statements can be broken into two categories: present and future (Table 2).
  - **Present:**
    (1) I see myself as a science person;
    (2) Being involved in science is a key part of who I am.
  - **Future**:
    (3) I can see myself doing science in the future;
    (4) I can imagine myself being involved in a science-related career.
- Grouping students' responses by present and future shows students' evolving senses of themselves as scientists.
  - For statements about the present, there is upward and downward movement.
    - Deep Valley HS: -1.8%
    - Douglass HS : +6.6%
    - Garnet CC: -3.0%
  - For statements about the future, all scores increased.
    - Deep Valley HS: +2.6%
    - Douglass HS : +3.0%
    - Garnet CC +3.6%

	DEEP VALLEY HS		DOUGLASS HS		GARNET 2YC		All Pre/Post Mean	All Pre/Post Standard Deviation
	Mean	SD	Mean	SD	Mean	SD		
Present Pre	2.78	1.16	3.08	0.91	2.18	0.77	2.68	0.95
Present Post	2.69	1.12	3.41	0.99	2.03	0.92	2.71	1.01
Future Pre	2.97	1.17	2.78	0.93	2.08	0.76	2.61	0.96
Future Post	3.1	1.18	2.93	0.8	2.26	0.87	2.76	0.95

Table 2. Comparison of present and future categories of science identity statements in the surveys at the three schools.

Discussion

Science Content Learning

- All student groups showed a similar increase in content knowledge.
- 5% of students were not engaged as indicated by little change in selections for the least right answers between pre- and post-survey.
- Garnet 2YC students showed the highest content knowledge. This may be because some of these students took high school Earth science and have greater prior knowledge.
- The student group consisting of many ELLs showed the lowest prior content knowledge. Equal learning gains suggests our use of equitable pedagogical methods was successful.

Science Identity

- High school students had higher science identity scores than 2YC students.
- Science identities increased for questions related to a career path (future category) in science.
- A possible explanation for some decreases from pre- to post-survey may be that students felt burned out after a year of remote learning.

Science Interest

- The highest science interest scores are in the subscales of Teacher Influence and Science Classroom Experiences, indicating the importance of teachers and classroom environments.
- For the pre- and post-test, the Family subscale was the only category that was statistically significant. We speculate remote learning from home may have facilitated discussion about science with family members.
- Despite having a lower science identity average, 2YC students have a similar post-survey science interest score (2YC: 3.54, HS: 3.61). This may reflect 2YC students having decided on a non-STEM related career path, while high school students are unlikely to have made this choice.
- Conducting the pre- and post-test in the space of as little as two weeks may explain the small variation in values.

Conclusion

- The place-based 5E mini-unit conducted for a diverse group of urban 2YC and high school students showed an increase in content knowledge, and an increase in some aspects of science identity and science interest.
- High school students in this study to have a moderate science interest and science identity, while the 2YC students have a moderate science interest, but lower science identity.
- We developed a rich resource that uses equitable pedagogical methodologies for high school and college educators.
- The collaboration and professional interaction between high school and college educators and scientists was a beneficial professional development experience.

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