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The Relationship Between STEM Identity in Marginalized Groups and Engagement Strategies in 5th Grade Science Students

Leigh C. Danner

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Leigh C. Danner

Saint Catherine University

St. Paul, Minnesota

Advisor _____ Date _____

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Abstract

This investigation focused on improving STEM identity and agency in students from populations historically marginalized from STEM participation. The investigation took place over six weeks in a 5th-grade science classroom in the upper Midwest and was bookended by a STEM identity survey. During the six-week process, the teacher focused heavily on increasing the visibility of marginalized groups in the forms of role models and images represented in content. Additionally, there was increased access to materials at all levels, hands-on experiments, opportunities for choice, and real-world applications of content. Students were frequently polled on their understanding of the lesson and its usefulness in daily life. Results suggest that students' sense of agency increased across the intervention. Approximately the same amounts of white and non-white students made a positive change in their STEM identities. Additionally, a large percentage of students with the lowest confidence in their abilities made positive changes throughout the study. The findings indicate educators can improve students' outcomes by providing resources that support students' identities and implement choice and hands-on applications of lessons for meeting the needs of diverse learners.

Introduction

To ensure all students recognize the opportunity and possibility of future success in a STEM field, teachers need to actively represent the racial, gender, and cultural backgrounds of students in the curriculum. Often, historically marginalized students-girls, racial and ethnic minorities-do not see themselves as represented in their classrooms' curriculum nor feel they have much say in what they are learning (Gushue & Whitson, 2006). This underrepresentation can cause students to feel less connected and committed to their education.

Student agency refers to students being the 'agent of their own learning' and interacting and monitoring their own education. This process can be nebulous and hard to achieve (Rickard, 2015). Practices such as personalized learning, collaborative problem solving, identity visibility, and engagement have been shown to help students improve student agency (SciGirls, 2020).

Typically, at the school identified in this research study, students of color perform at lower levels than white students on state standardized assessments. For example, in the Minnesota Comprehensive Assessments (MCA) reading test in 2019, 80% of white students met or exceeded state standards, compared with 45% of Latinx students. This gap is a consistent problem, one that is made even more obvious when parsing out specific subgroups such as English Language Learners (ELL). Sixty-seven percent of non-ELL students met or exceeded state standards on the MCA reading, compared with 11% of ELL students. Minority students make up half of the school population, yet according to the data, they are not being serviced adequately and are struggling to meet state academic standards in comparison to white students.

Based on past experiences, I recognized that my school's academic achievement was not equitable. Our school set an academic and equity goal to improve the achievement of marginalized groups. Because of these lower outcomes, I decided to identify a research basis for making changes that would reduce the disparities of outcomes based on race or gender in my own classroom.

Student engagement is a major component of academic success (Jackson, 2003). When students do not see a purpose or meaning behind their learning, they suffer academically (Krishnamurthi, Ballard, & Noamet, 2014). STEM education—science, technology, engineering, and math—promotes student agency (Honey, Pearson, & Schweingruber, 2014). STEM education, when made relevant to the interests of individual students, has been found to be crucial in developing students' sense of agency and academic success (Krishnamurthi et al., 2014). Additionally, research shows that teacher curriculum and instructional practices can impact students' learning outcomes, with strong learning outcomes comes a greater sense of self and identity within their education (Ring, Crotty, & Roehrig, 2017).

Students in historically marginalized communities may not see the potential for a career in a STEM field, due to not knowing anyone from their own background with a STEM career (SciGirls, 2020). There is a need to gather and present information about the instructional strategies that can help to increase STEM identity in these specific populations, which will ultimately support all students.

Theoretical Framework

Self-efficacy theory states that people's perceived beliefs about their capabilities have an extraordinary influence on their lives (Bandura, 1997). A strong sense of efficacy

can enhance accomplishment and personal well-being. Bandura (1997) shows that people can develop and improve their efficacy through four significant sources: mastery experiences, social models, social persuasion, and the altering of negative emotional proclivities.

Personal efficacy can shape the interests, careers, and social development of the individual through the avoidance of activities and situations that exceed perceived abilities (Bandura, 1997; Joët, Usher, & Bressoux, 2011). Students with low self-efficacy may not challenge themselves to a STEM career or may believe they are incapable of being successful in a STEM field. As Bandura (1997) has shown, task mastery, social role models, persuasion, and positive experiences can help an individual increase their self-efficacy. Intentional STEM education can support students' STEM identity and efficacy. Through the use of role models, multiple paths to mastery, and scaffolded support, education can help support students as they develop their self-efficacy.

Review of Literature:

Student engagement is a crucial predictor of success for students (Jackson, 2003). Engagement in the classroom enhances the levels of "skills and mindsets that students have for increasing agency" (Fergusun et al., 2015, p. 16). Student agency is generally referred to as students being the "agent" of their learning and taking on a more active role in their education (Wagner, 2019). Students of color report lower levels of self-efficacy and agency in their education (Gushue & Whitson, 2006). Across the United States, African American and Latinx students continue to achieve at rates far behind their white peers (Westchester Institute for Human Services Research, 2000). Agency can be nebulous and hard to change (Rickard, 2015).

However, STEM education—referring to: science, technology, engineering, and math—fosters student agency (Honey, Pearson, & Schweingruber, 2014). Teachers from Inclusive STEM high schools have found that STEM lessons increase student agency in their learning (Lynch et al., 2017). This literature review will define STEM education as it relates to student agency and explore the connections between using a STEM curriculum to foster student agency in science education for all groups of students, but in particular, students identifying in a minority group.

What is STEM Education?

STEM education has its origins in the 1990s through the National Science Foundation (NSF). While STEM education has been around since the 1990s, there is still confusion as to what it encompasses (Breiner et al., 2012). STEM has been used as a generic label for any "event, policy, program or practice that involves one or several of the STEM disciplines" (Bybee, 2010, p. 30). When surveyed, many educators interpreted the STEM acronym as meaning science or math exclusively. Bybee (2010) hypothesized that this confusion in educators could have occurred with the implementation of the No Child Left Behind Act and the diminishing focus of science in contemporary education. Educators and schools that have successfully integrated STEM into their curriculum have shifted from a traditional lecture-based classroom to the implementation of pedagogy that involves more inquiry and problem-based learning approaches (Breiner et al., 2012). STEM education includes an integrated curricular approach to studying grand challenges of our era, such as energy efficiency, resource use, environmental quality (Bybee, 2010). Additionally, Bybee posits that competencies that citizens need to understand and address social issues are related to STEM disciplines (2010).

Goals of integrated STEM education include STEM literacy and 21st-century competencies: a "blend of cognitive, interpersonal and intrapersonal characteristics that support deeper learning and knowledge transfer" (Honey et al., 2014, p. 35). According to Bybee and the National Science Teachers Association (NSTA), STEM literacy refers to a student's ability to gain:

- "knowledge, attitudes, and skills to identify questions and problems in life; situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues;
- understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;
- awareness of how STEM disciplines shape our material, intellectual, and cultural environments
- willingness to engage in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as a constructive, concerned, and reflective citizen" (2013, p. 10-11).

Lack of clarity on the specific meaning of the acronym makes implementing STEM practices in contemporary schools challenging. Researchers and educators need to develop a universal educational definition of STEM and "recognize technology and engineering as full members of the STEM quartet of disciplines" (Bybee, 2013, p. 7).

Attributes of Student Agency

Several perspectives on student agency exist. Student agency refers to students being the director of their own learning (Rickard, 2015). This control of learning refers to the quality of students' "self-reflective and intentional action and interaction with their environment" (Klemenčič, 2015, p 2). Since the agency of students can be based on their

experience and knowledge of the conventions of a particular context, it is intrinsically relational, social, and situated in structural, cultural, and socio-economic-political contexts of action (Deed et al., 2014; Klemenčič, 2015). Deed (2014) refers to the indicators of agency as the perceived level of investment in learning, teaching, and autonomous problem-solving. Approaches to increasing student agency include, but are not limited to, choice, multi-leveled text, and hands-on experiments, as well as an intentional emphasis on culturally relevant representation (Jackson, 2003). Others have found that agency can be promoted by loosening the task structure, such as by using personalized learning, project-based learning (PBL), performance assessments, mastery learning systems, or research internships (Lynch et al., 2017). Increasingly, it is necessary for students to focus on developing collaborative knowledge and problem-solving in order to be agents of their education (Deed et al., 2014).

Life circumstances such as family background, past experiences, and projections of the future all shape how individual students exercise their agency (Klemenčič, 2015). Teachers should not ignore the ways student agency is influenced by broader socio-structural constraints, which also shape students' long-term educational trajectories and life (Klemenčič, 2015).

How are student agency and STEM education linked?

Student agency is buried beneath layers of well-meaning complications since there are many factors that can contribute to it (Jackson, 2013). It can be difficult to distill what is meaningful and essential to individual students in the modern era. According to the ASPIRES project, young people hold relatively high career aspirations. Yet only 15% of students aspired to be scientists (ASPIRES Project, 2014). Jackson (2003) shows that

when students see themselves and their society represented in their curriculum, they tend to find success. In the ASPIRES Project, students "liked science" but "imagined a scientist to be mostly white, middle-class, male, and brainy and not something they could see in their own lives" (2014). Thus, non-white males and all-female students had trouble seeing themselves represented in the field of STEM. Even if students of color are academically successful in a STEM-based program, many still do not "identify with STEM fields, nor are they recognized for their contributions" (Kang, Barton, Tan, Simpkins, Rhee & Turner, 2019, p. 4). Using integration models, such as a culturally responsive curriculum, as a guide, students can begin to see themselves represented in their curriculum and education (Gay, 2018).

A STEM-focused curriculum uses student-centered pedagogies to develop problem-solving skills (Ring et al., 2017). STEM schools create learning environments where students can build academic and social capital, and dispositions, knowledge, skills, and networks to be successful in STEM majors and careers (Lynch et al., 2017). Groups typically underrepresented in STEM, such as female, African American, and Latinx students, perform better in STEM-labeled schools (Wiswall et al., 2014; Lynch et al., 2017). Additionally, as STEM schools are often programs where students opt-in, school selection itself provides students with experience making decisions about academic opportunities, including out-of-school learning opportunities (Lynch et al., 2017). STEM curriculum, particularly technology and engineering disciplines, has been shown to increase all student's learning and interest (Moore et al., 2014; National Academy of Engineering & National Research Council, 2009). Krishnamurthi et al. (2014) describe schools and teachers in STEM education as part of a broader "learning ecosystem" where

students are at the center of the system, creating investment and engagement in their learning.

Conclusion

While student self-efficacy and agency are linked to academic achievement, it can be hard to know how and where to address their development. STEM education—with its emphasis on collaboration, focus on "real-world" issues, and engaging learning opportunities—is a great place to start. Groups that are not well represented in STEM careers, such as male minority students or females, require particular emphasis on the development of agency through visibility, representation, and identity scaffolding, to help them envision academic success (Ladson-Billings, 2008; Sci Girls, 2020). Developing student agency should be first on educators' minds when creating a curriculum, as developing these skills has been shown to increase success for students outside of the academic classroom as well (Ferguson, Phillips, Rowley & Friedlander, 2015). Though developing agency in students can be challenging, the use of STEM strategies and intentional planning can make progress toward the goal of each student seeing potential and success for themselves in STEM futures. The purpose of this action research study is to explore if using common STEM instructional strategies such as choice, hands-on experimentation, real-world experiences, and creating a highly engaging representative curriculum will affect students' STEM identity and academic agency.

Methodology

This study uses an action research methodology. Action research is defined as a process of self-study to improve an educational practice (Hendricks, 2013). The purpose

of this study is to investigate if specific classroom instructional practices (such as choice, multi-leveled text, and hands-on experiments, as well as an intentional emphasis on culturally relevant representation) would influence students' STEM identity and sense of agency in a science class. Before beginning this study, a letter was sent out to all families, informing them of this study and providing an opportunity to have their students' data removed from the study (Appendix A). All families opted to keep their students' data in the study. At the beginning of this study, baseline data was collected about interest and confidence in STEM courses. Classroom observations, teacher reflection, and analysis of materials used occurred in conjunction with student questionnaires or exit tickets.

The subjects for this action research study were middle school students in a 5th-grade science classroom in the outskirts of a large city in the Midwestern United States. A total of four classes were surveyed on the first day of the study during the 2019-20 school year. A total of 101 out of 105 students responded to the survey. Fifty-five students were female, and 50 were male. Additionally, this study focused on students in historically marginalized groups, 59 of those students identified as non-white on the federal race/ethnicity form.

Pre- and post-assessments were used in the form of a STEM Identity survey developed by the National Center for STEM Elementary Education (2012), which included opinion questions that gathered information on students' level of interest and confidence within each STEM discipline (Appendix B). The survey asked students to rate themselves on a scale between strongly agreeing with the statement or strongly disagreeing. Exit slips were given at the end of each new lesson, asking students to rate their understanding of the lesson objectives, as well as to note how relevant the lesson

seemed to their real-life (Appendix C). At the conclusion of the study, students' responses were sorted using grounded theory by both teaching strategy and understanding of the lesson. Grounded theory is when the analysis and development of theories happen after the data collection (Glaser & Strauss, 1967). Additionally, the teacher engaged in a rubric-guided self-reflection of gender and culturally relevant teacher strategies (Anderson, Billington, Britsch, Santiago, 2018) before and after the intervention time-frame. Finally, the number and type of materials found to scaffold to student levels were recorded. All introductory text was provided in both English and Spanish, and options given for video learning,

Using Google Forms for the pre- and post-assessments, the teacher read the questions to students in order to provide all levels of students equal access to the questions. Students marked their answers to each statement. Once all of the questions were answered, students submitted their survey from their iPad. After each lesson, students logged onto their iPad to complete a 'Daily Exit Ticket," consisting of the same four questions. Students reflected on their learning and the learning target before answering and submitting their responses. At the conclusion of the study, the teacher reviewed the student pre- and post-assessment data as well as the students' daily exit tickets to find themes of successful instruction and if students felt the same way about STEM in their life both before and after the study. Students' responses were compared, and any change was noted.

Data Analysis

The purpose of this study was to examine the use of common STEM and curriculum strategies identified to improve the outcomes of students from marginalized backgrounds. By creating engaging and representative instructional materials and lessons, I hoped to improve students' STEM identity and academic agency. Students were given a pre- and post-assessment survey to measure their STEM identity and self-reported their engagement on a daily basis.

The raw data measuring student STEM identity was given in the form of a survey and collected using a coded system of one to five. Each statement on the survey was compared both pre- and post-intervention. Positive and negative changes were recorded. Additionally, the students were observed pre-intervention, during the intervention and post-intervention, any significant change in behaviors or academics was noted in the teacher reflection journal (Table 1). Exit ticket data quantified on a scale of one to five were used to identify trends and patterns amongst groups of students so I could adapt my teaching strategies.

STEM Strategies

Table 1: STEM strategies used and Teacher Reflection

Identified Strategy from Literature Review	Strategy/Resource	Purpose	Thoughts/ Reactions
Scaffolding	Video Notes Modified Notes	Students could progress through the notes at their own pace. They can pause my video, and rewind if necessary.	Students really loved these video notes. Students who needed more time, felt supported and students who could move more quickly through the notes could move

			on to other enrichment activities without waiting.
Visibility	**Visiting Scientist** Wolves at Our Door Dodge Nature Center	Expose students to other scientific careers.	Students were very engaged with the naturalist- as she comes weekly. Mostly engaged with Wolves at our Door visitor- was a long presentation and very conceptual.
	STEM Career Assignment	Expose students to the many types of STEM careers.	Students particularly liked this assignment, and many chose to research more about their chosen career. In the future I would have them add an additional research piece and research a person in that field.
	I am a Scientist Activity Introduction Video Example Drawing	Attempt to show students that students are not the stereotype white, old man. (Challenge stereotypes)	After watching the video students recorded their reaction on LMS. Generally they were shocked at the video but agreed that the stereotype exists. We hung up their drawings for conferences, and the kids were very proud.
Project-based Learning	Hands on experiment	Allow students time to practice the skills they learned reading and taking notes.	Always a favorite for kids. Group work can be challenging for some, but overall they have a greater understanding of the topic once they are able to touch things.
	Field Trip	At the end of the unit, a trip to use the scientific concepts in real life.	Students were well prepared and impressed the staff at the nature center with their knowledge and vocabulary.
Personalized Learning	Introduction activity in English and Spanish	Provide access to the curriculum in many different ways and support language	50/50 split on if students chose to watch a video or read a text. Almost every spanish speaking student

	Video- English Video- Spanish Article- English Article-Spanish	learners.	chose the english video or article.
	Choice Board	Provide choice and independence for students working through small learning challenges.	Initially received a lot of push back from these, and students found it hard to self-start. In the end, students loved these days, expressing gratitude that they can work at their own pace.

STEM Identity

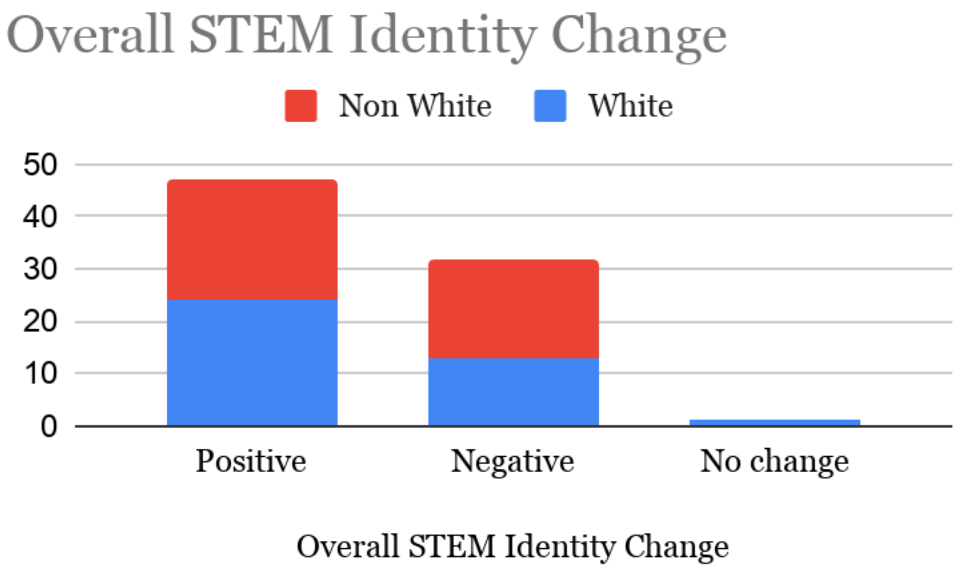

Figure 1. The average change of students' rating of STEM identity questions.

On a scale of 1 to 5 on the STEM identity survey (Appendix A), 1 being they strongly disagreed with the given statement, and 5 being that they strongly agree with the statement, students' change in responses was recorded among all questions. Overall,

white and non-white students experienced similar levels of change. 24 white students experienced positive change, and 23 non-white students experienced positive change. Additionally, 13 white students experienced negative change and 19 non-white. Although there was a negative change, it is worth noting that the average amount of change was twice as high for positive change at 0.3769 when compared with the average negative change of -0.186. Notably, in terms of the focus on student self-efficacy, on the five questions that focused on growth mindset specifically, 91% of the students who marked a 1 on the pre-assessment, increased by at least one point in the post-assessment, some quite significantly.

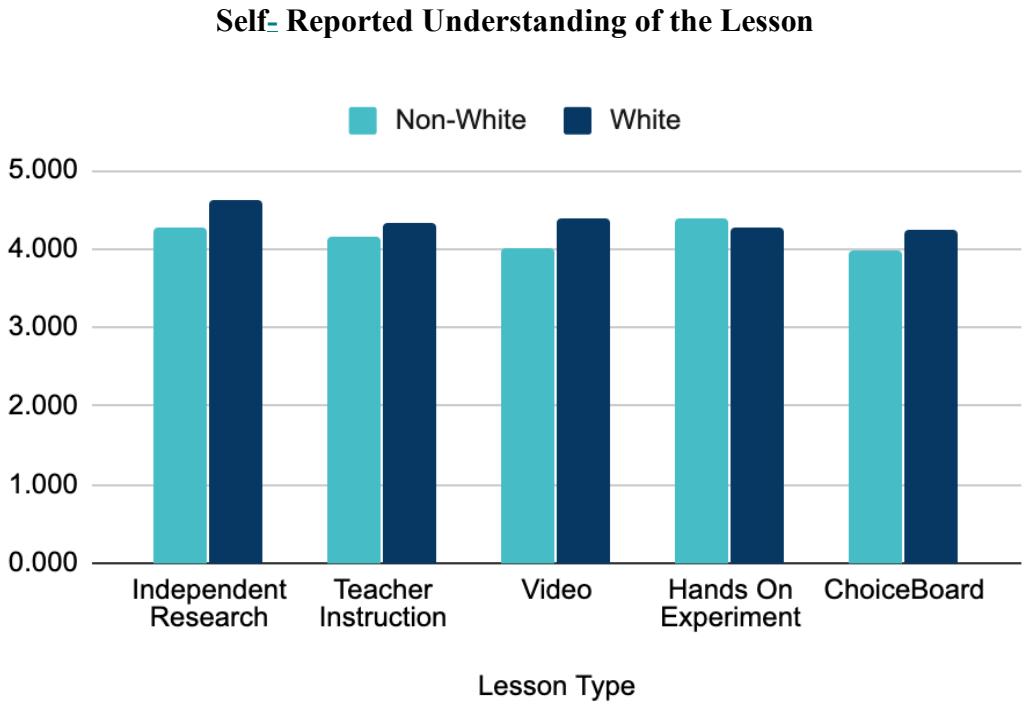

Figure 2: Student self-reported understanding of each lesson by teaching strategy.

On a scale of 1 to 5 on the Daily Exit Ticket (Appendix B), 1 indicating a low level of understanding, 5 indicating mastery, white students had, on average, the highest self-reported understanding of the lesson when utilizing independent research (4.619). Non-white students, on average, had the highest self-reported understanding of the lesson when participating in hands-on experiments (4.391). The average understanding of all lessons of white students was 4.371, for non-white students, it was 4.163 on a scale of 1 to 5.

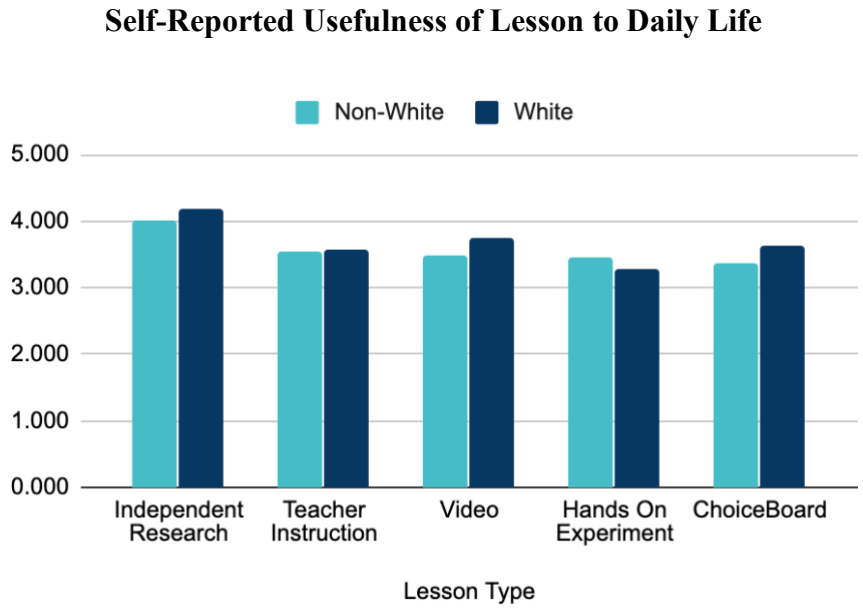

Figure 3: Student self-reported rating of a lesson's usefulness in their daily life.

On a scale of 1 to 5 on the Daily Exit Ticket (Appendix B), with 1 indicating a low level of usefulness and 5 indicating an extremely applicable lesson, both white and non-white students rated "Independent Research" as the most useful. For non-white students, the "hands-on experiments," was the only category in which they perceived the activity as more useful to their daily living than any of the activities did for white students. This is

interesting because previous research identifies this as a strategy that is more inclusive of diverse students (SciGirls, 2020), but that strategy is still rated lower than the efficacy of other strategies overall. In general, students rated all lessons above a 3 on the scale.

Agency

Students were given a Choice Board' at the beginning of each unit with nine activities to complete. They could complete the activities in any order and in any way, as long as they followed a few instructions. Initially, students were saying, "Just tell me what to do!" or would spend the greater part of an hour asking the teacher questions or for their work to be checked. At the conclusion of the study, students were more self-sufficient and asked fewer questions. The questions changed from, "Am I doing this right?" to "The fulcrum is the pivot point (referencing the large human-sized lever in the classroom)" as they assisted their peers. Their questions clarified specific concepts and connected tasks to prior learning. Students self-reported being more comfortable with this independent learning. One student said on their exit ticket, "I like when we get to learn on our own, and (at) my own pace."

Conclusion

The purpose of this action research study was to examine the use of STEM strategies and to see if highly engaging and representative instruction would affect students' STEM identity and academic agency. The research focused on answering the question, "Will the self-reported STEM identity of students historically marginalized from STEM populations in a 5th-grade science classroom increase through the use of identity congruence and academic scaffolding?"

In general, all students made growth in the area of agency, and a majority of students' STEM identities remained the same or increased. Approximately the same amount of students, both white and non-white experienced growth in their perceived STEM identity. The positive change was twice as high as the negative change among all students.

Agency

Qualitative data, in particular, leads me to conclude that students did develop a stronger sense of agency through the use of the recommended instructional techniques (SciGirls, 2020). Through classroom observations and feedback forms, students showed a gradual improvement in their ability to direct their own learning. Initially, there was a lot of pushback from many students who seemed to want more teacher-directed learning. However, as students progressed through the year, there was a shift in the majority of students who became more confident and engaged in self-directed choice activities. There was no particular strategy that was influential to this development. Rather, consistent messaging and exposure to a wide variety of learning techniques appeared to be the most helpful.

As an educator, I anticipated that the Choice Board would help students to develop a stronger sense of agency. For non-white students, this was the strategy they identified as providing the least amount of understanding. Further study is needed as students were becoming used to the idea of choice as this study was being conducted. Since the conclusion of the study, students have been far more comfortable, and they might rate their understanding of learning during these activities higher than they did at the conclusion of this research period.

Interestingly, students were offered Spanish and English versions of texts and videos that provided introductory learning. Every native Spanish speaker chose the English versions of the text or video, often beginning with the Spanish, but switching to the English after beginning the learning. More investigation would be necessary to determine why this choice was made.

STEM Identity

Non-white students, when surveyed on each STEM component, rated themselves on average lower than their white peers before the study began. This is in alignment with the literature, which states that non-white students' ratings of self-efficacy are lower than their white peers (Gushue & Whitson, 2006). Their rating was generally very neutral. Often rating themselves as a 3, between "strongly agree" and "strongly disagree" for each statement. White students were more confident in their STEM identity, on average, rating themselves at a 4.

Overall, all students rated themselves as neutral or with high confidence in their STEM identity and ability. No single ethnicity group averaged below a 3 on any identity question. Qualitatively, at the conclusion of this study, students developed more confidence in their ability to do science. As this study was conducted specifically in a traditional science classroom, student confidence and belief in their own ability and potential have grown significantly from September to March. Fifth graders often come into science believing science to be "explosions and chemistry" but are exposed to many types of science in their 5th-grade general science class, which has shown to be beneficial to their sense of self and their STEM identity through qualitative observation.

This data supports my observations throughout the year. Though this study only measured a small portion of time, students made remarkable positive changes in the area of growth mindset among all observable STEM disciplines. This is often the first major exposure of science to 5th graders, and it can be quite scary and overwhelming for them. I witnessed a large change in how students perceived their own ability when confronted with a new topic ranging from as dramatic as a student completely shutting down when things would get challenging, to that same student seeking me out to research a topic on their own.

Anecdotally, students particularly appreciated the time devoted to STEM careers. Time devoted to the discussion that not all scientists look like white, old men, and an emphasis on the many varieties of STEM careers, not just scientists in lab-coats, seemed worthwhile. Frequent role models were brought in or experienced virtually as examples of this. At the conclusion of this study, students chose a STEM career for themselves to research, and many of them became quite passionate about that career.

Recommendations

Based on the findings and conclusions of this study the following conclusions were drawn.

Agency

Supporting student agency is not a simple task; it requires a consistent and frequent emphasis on the students' ability to drive their own learning. Making content relevant, providing choice, and supporting students with difficult concepts is crucial. Using a variety of instructional strategies is necessary to support all learners. Dedicated

educators, who encourage their students' passions, and take time to speak with the students rather than just at them, while finding more growth in student ownership are essential. At the beginning of middle school, students are at their most helpless and require nurturing and exposure to help them to develop a sense of self. When leaving middle school, particularly in science, they are much more comfortable in their own beliefs and an understanding of how they prefer to learn. Next school year, having completed this research, I will continue to provide opportunities for students to develop their agency and would like to follow a cohort of students through their science classes at a STEM school and to measure how their sense of agency changes as they age through middle school.

STEM Identity

It is crucial for STEM education to be representative of the entire population. Today, the STEM career field is not representative of the nation's population. Therefore, for students, highlighting women and underrepresented groups working in STEM is essential. Simple changes to the classroom environment can make a big impact, like posters and images that represent racial and gender diversity in STEM roles. Science educators can be thoughtful when sharing scientific history, talking about the lack of representation, and highlighting the discoveries and impact of non-white scientists. Exploring STEM careers can be very impactful for students. Most 5th graders have a very limited world view and usually want to grow up to be what they see glamorized in the media or what their parents do for careers. Exposing all students to the potential in STEM careers—vocationally, financially, and otherwise—helps students to envision themselves with different narratives and can help to inspire a passion for the STEM field.

Limitations

This study had a few limitations that prevented the data from being helpful in completely illustrating the research questions. This study lasted six weeks, in which the pre-assessment was taken in the middle of the year. Students ideally should take the pre-assessment at the beginning of the year. Many changes and modifications were made prior to the beginning of the study, though new interventions were also introduced and measured during this time. For example, role models and visibility are significant influencers of student identity in STEM. While role models did visit the school and were representative of underrepresented groups during the study, the classroom has been filled since September with physical indicators of diversity in STEM with posters of diverse women in STEM careers. In short, there had been a conscious effort to represent the STEM field as diverse in terms of race and gender since the beginning of the year, not just during the time measured.

Additionally, during this study, the cold and flu season hit the school district hard. There were a number of significant absences of a week or greater that could have influenced a students' understanding of the material, making them feel less confident and generally not setting them up for academic success.

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Appendix A
Passive Consent Form English and Spanish

Dear 5th grade Families,

In addition to being your child's 5th-grade science teacher, I am a St. Catherine University student pursuing a Masters of Education. As a capstone to my program, I need to complete an Action Research project. I am going to study strategies to improve students' STEM identity because I believe it to be important that students at (school removed for data privacy), feel that they have a purpose and future in STEM if they so choose.

In the coming weeks, I will be adapting lessons and providing access to additional learning opportunities as a regular part of my teaching. All students will participate as members of the class. In order to understand the outcomes, I plan to analyze the data obtained from the results of this change such as a student survey to determine if there was any change in how students feel about STEM currently, as well as in their future plans. All strategies implemented and assessments given are part of normal educational practice.

The purpose of this letter is to notify you of this research and to allow you the opportunity to exclude your child's data from my study.

If you decide you want your child's data to be in my study, you don't need to do anything at this point.

If you decide you do NOT want your child's data included in my study, please note that on this form below and return it by February 18th. Note that your child will still participate in the lessons but his/her data will not be included in my analysis.

In order to help you make an informed decision, please note the following:

- I am working with a faculty member at St. Kate's and an advisor to complete this particular project.

- The results of this research can help support students as they select (school removed for data privacy) and give them space where they feel empowered.

- I will be writing about the results that I get from this research. However, none of the writing that I do will include the name of this school, the names of any students, or any references that would make it possible to identify

outcomes connected to a particular student. Other people will not know if your child is in my study.

· ● The final report of my study will be electronically available online at the St. Catherine University library. The goal of sharing my research study is to help other teachers who are also trying to improve their teaching.

· ● There is no penalty for not having your child's data involved in the study, I will simply delete his or her responses from my data set.

If you have any questions, please feel free to contact me, Leigh Danner. You may ask questions now, or if you have any questions later, you can ask me, or my advisor Siri Anderson, ssanderson2@stkate.edu, who will be happy to answer them. If you have questions or concerns regarding the study and would like to talk to someone other than the researcher(s), you may also contact Dr. John Schmitt, Chair of the St. Catherine University Institutional Review Board, at (651) 690-7739.

You may keep a copy of this form for your records.

_____

Leigh Danner

OPT-OUT: Parents, in order to exclude your child's data from the study, please sign and return by 02/18

I do NOT want my child's data to be included in this study.

_____ _____ _____

Student Name Signature of Guardian Date

Estimadas familias de 5to grado,,

Además de ser la maestra de ciencias de quinto grado de su hijo/a , soy un estudiante de la Universidad de St. Catherine que cursa una Maestría en Educación. Como punto culminante de mi programa, necesito completar un proyecto de investigación de acción. Voy a estudiar estrategias para mejorar la identidad de STEM de los estudiantes porque creo que es importante que los estudiantes de (school removed for data privacy) sientan que tienen un propósito y un futuro en STEM si así lo eligen.

En las próximas semanas, adaptaré las lecciones y daré acceso a oportunidades de aprendizaje adicionales como parte regular de mi enseñanza. Todos los estudiantes participarán como miembros de la clase. Con el fin de comprender los resultados, planeo analizar los datos obtenidos de los resultados de este cambio, como una encuesta estudiantil para determinar si hubo algún cambio en cómo se sienten los estudiantes sobre STEM actualmente, así como en sus planes futuros. Todas las estrategias implementadas y las evaluaciones realizadas son parte de la práctica educativa normal.

El propósito de esta carta es notificarle sobre esta investigación y permitirle la oportunidad de excluir los datos de su hijo/a de mi estudio.

Si decide que desea que los datos de su hijo/a estén en mi estudio, no necesita hacer nada en este momento.

Si decide que NO desea que se incluyan los datos de su hijo/a en mi estudio, tenga en cuenta que en este formulario a continuación y devuélva antes del 18 de febrero. Tenga en cuenta que su hijo todavía participará en las lecciones, pero sus datos no se incluirán en mi análisis.

Para ayudarlo a tomar una decisión informada, tenga en cuenta lo siguiente:

- Estoy trabajando con un miembro de la facultad en St. Kate y un asesor para completar este proyecto en particular.

- Los resultados de esta investigación pueden ayudar a apoyar a los estudiantes a medida que seleccionan (school removed for data privacy) y les dan espacio donde se sienten empoderados.

- Escribiré sobre los resultados que obtengo de esta investigación. Sin embargo, ninguno de los escritos que haga incluirá el nombre de esta escuela, los nombres de los estudiantes o cualquier referencia que permita identificar resultados relacionados con un estudiante en particular. Otras personas no sabrán si su hijo está en mi estudio.

· El informe final de mi estudio estará disponible electrónicamente en línea en la biblioteca de la Universidad de St. Catherine. El objetivo de compartir mi estudio de investigación es ayudar a otros maestros que también están tratando de mejorar su enseñanza.

· No hay penalización por no tener los datos de su hijo involucrados en el estudio, simplemente eliminaré sus respuestas de mi conjunto de datos.

Si tiene alguna pregunta, no dude en ponerse en contacto conmigo, Leigh Danner. Puede hacer preguntas ahora, o si tiene alguna pregunta más tarde, puede preguntarme a mí, o a mi asesor Siri Anderson, ssanderson2@stkate.edu, que estará encantado de responderlas. Si tiene preguntas o inquietudes con respecto al estudio y desea hablar con alguien que no sea el investigador (es), también puede comunicarse con el Dr. John Schmitt, Presidente de la Junta de Revisión Institucional de la Universidad de St. Catherine, al (651) 690-7739.

Puede conservar una copia de este formulario para sus registros.

_____

Leigh Danner

Optar por NO: Padres, para excluir los datos de su hijo/a del estudio, firme y regrese antes del 18 de febrero

NO deseo que se incluyan los datos de mi hijo/a en este estudio.

_____ _____ _____

Hijo firma fecho

Appendix B
STEM Identity Survey

Student Attitudes Towards STEM and Computer Science (Actitud de Estudiante hacia STEM y la Computadora)

DIRECTIONS: There are lists of statements on the following pages. Please read each statement and think about your life and how you feel. Do you agree or disagree with the statement? How strongly do you agree or disagree? For each statement, select a single radio button for each statement that is the best answer. There are no "right" or "wrong" answers!

INSTRUCCIONES: Hay listas de declaraciones en las siguientes páginas. Lea cada declaración y piense en su vida y en cómo se siente. ¿Está de acuerdo o en desacuerdo con la declaración? ¿Qué tan de acuerdo o en desacuerdo estás? Para cada declaración, seleccione un solo botón de radio para cada declaración que sea la mejor respuesta. ¡No hay respuestas correctas o incorrectas!

* Required

Name (Nombre) Last Name, First Name *

What hour do you have science?

Math Section

Math has been my worst subject (La matemáticas han sido mi peor clase)

Strongly Disagree (fuertemente desacuerdo)1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

When I am older, I might choose a job that uses math (Cuando sea mayor, podría elegir un trabajo que use matemáticas)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

Math is hard for me. (La matemática es difícil para mí.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I am the type of student who does well in math. (Soy el tipo de estudiante que tiene buenos resultados en matemáticas.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I can understand most subjects easily, but math is difficult for me. (Puedo entender la mayoría de las materias fácilmente, pero las matemáticas son difíciles para mí.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

In the future, I could do harder math problems (En el futuro, podría resolver problemas matemáticos difíciles.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I can get good grades in math (Puedo sacar buenas grados en matemáticas.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I am good at math (Soy bueno en matemáticas.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (Fuertemente acuerdo)

Science Section (Sección de Ciencias)

Please remember! Select a single radio button for each statement that is the best answer for your life and how you feel.

Por favor recuerde! Seleccione un solo botón de radio para cada declaración que sea la mejor respuesta para su vida y cómo se siente.

I feel good about myself when I do science (Me siento bien conmigo mismo cuando hago ciencia.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I might choose a career in science (Podría elegir una carrera en ciencias.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

After I finish school, I will use science often (Después de terminar la escuela, usaré la ciencia frecuentemente)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

When I am older, knowing science will help me earn money (Cuando sea mayor, conocer la ciencia me ayudará a ganar dinero.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

When I am older, I will need to understand science for my job (Cuando sea mayor, tendré que entender la ciencia para mi trabajo.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I know I can do well in science (Sé que puedo hacerlo bien en ciencias.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

Science will be important to me in my future career (La ciencia será importante para mí en mi futura carrera.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I can understand most subjects easily, but science is hard for me to understand (Puedo entender la mayoría de las materias fácilmente, pero la ciencia es difícil de entender para mí.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

In the future, I could do harder science work (En el futuro, podría hacer un trabajo de ciencia más difícil.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

Engineering and Technology Section (Sección de Ingeniería y Tecnología)

Please remember! Select a single radio button for each statement that is the best answer for your life and how you feel.

Por favor recuerde! Seleccione un solo botón de radio para cada declaración que sea la mejor respuesta para su vida y cómo se siente.

I like to imagine making new products (Me gusta imaginar hacer nuevos productos.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

If I learn computer science, then I can improve things that people use every day (Si aprendo ciencias de la computación, entonces puedo mejorar las cosas que la gente usa todos los días.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I am good at building or fixing things (Soy bueno construyendo o arreglando cosas.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I am interested in what makes machines works (Estoy interesado en lo que hace que las máquinas funcionen)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

Designing products or computer programs will be important in my future jobs (El diseño de productos o programas de computadora será importante en mis futuros trabajos.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I am curious about how digital technology works (Tengo curiosidad acerca de cómo funciona la tecnología digital.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I want to be creative in my future jobs (Quiero ser creativo en mis futuros trabajos.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

Knowing how to use math and science together will help me to invent useful things (Saber utilizar las matemáticas y las ciencias juntos me ayudará a inventar cosas útiles.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

I believe I can be successful in computer science and engineering (Creo que puedo tener éxito en ciencias de la computacíon y ingeniería.)

Strongly Disagree (fuertemente desacuerdo) 1 2 3 4 5 Strongly Agree (fuertemente acuerdo)

References

Adapted by Leigh Danner, Graduate Student, St. Catherine University, in collaboration with the National Center for STEM Elementary Education. Developed from the upper elementary schools S-STEM Survey for the Friday Institute for Educational Innovation (2012).

Appendix C
Daily Exit Ticket

Before you leave class today, answer the following questions.

* Required

Name (Last Name, First Name) Nombre *

Your answer

Science Hour (Hora de la Ciencia) *

What classroom activity did you use the most today? (Que actividad de clase usaste mas hoy?) *

How would you rate your understanding of the lesson today? (Como clarifica su comprension de la leccion de hoy) *

I do not get it at all (No lo entendi) 1 2 3 4 5 I got it! (lo tengo)

How useful is today's lesson in your daily life? (Que tan util es la leccion de hoy en tu vida diaria?) *

I will never use this (Nunca usare esto) 1 2 3 4 5 The things I learned today will help me in the future (Las cosas que aprendi hoy me auyadaran en el futuro)

What would help make today's lesson more effective or better? (Que ayudaria a que la leccion de hoy sea mas efectiva o mejor?)