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Impact of STEM Professionals as Teachers on Student Perception

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Abstract The goal of our work is to assess student perception to STEM careers skills when in the presence of scientists in the classroom. Our school has several doctorate level scientists who have become full time teachers and who design content based on their careers as scientists. We are interested in measuring the impact of these teachers who infuse their curriculum with genuine experience and content relevance.

Keywords: *STEM, perception, action research*

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1. Introduction

In this work there is interest in gauging the impact of having doctoral level STEM professionals as educators in science classrooms. The continuous decline of students choosing to pursue STEM career fields has resulted in a pursuit by both educators and private sector companies to take measures to recruit the scientists of tomorrow.

Our student demographic represents an area of interest for that targeted pursuit. The network of schools in Houston are thirteen charter schools, wherein the vast majority of our student body is more than 1 year behind in science in math. Additionally, 85% of our student body has a family income of less than $30,000/year, having very few ties to scientific role models in their families. With several participating teachers from seventh to eleventh grade, we are able to collect data from over 600 students.

As a result, it is the goal of this project to compare the perception of students in classrooms lead by scientists-turned-teachers to identify practices capable of addressing this aversion to science. This is explored via the following question: If I have classroom lead by an educator with alternative career experience in STEM, students' will indicate greater interest in science as a field. This will be demonstrated by increased favorable response to science activities and in consideration of future careers in science.

2. Literature Review

Even a cursory glance at the literature leads to a strong reminder: the issue of reforming practices in science education is certainly not a novel one. A tremendous amount of effort is being exerted into identifying practices and professional development opportunities by schools, companies, and the government. Reports that serve to frame the problem on a topical level assist in quantifying the problem at hand, such as those released by the Bureau of Labor Statistics [1] and The White House Office of Science and Technology [2].

Delving into the source of this dilemma, we turn to the superb work of Archer et al [3]. This research digs deep into student attitudinal data with several years and thousands of students surveyed, discussing the student perspectives and their aversions to science. A critical takeaway relevant to the interest of this work is how the presence of a STEM role model vastly outweighed the impact of classroom resources; a strong divergence from the notion that STEM classrooms are in need of financial support first and foremost. While certainly there is shared correlation between STEM role models present in familial situations and economic availabilities in schools and homes, for this work having the educator as the STEM role model offers an actionable solution.

Focus of the work attempted to focus on structural themes, such as how to promote high level scientific thinking and the importance of relationships in shaping the interest in STEM. As such, work detailing general guidelines for inquiry-based classroom [4], were beneficial for novice teachers. While these are helpful tools for standardizing classroom practice across participating teachers, this work more heavily relied on reports, such as those by Daggett [5] and Schwartz [6]. These reports offer a very concise prescription for how to avoid common pitfalls in scientific instruction (such as use of language that perpetuates scientific misunderstanding) as well as assessment and categorization methods which will be critical for my project once underway. These works not only allowed non-career scientists teachers to familiarize themselves with content specifics, but allowed the participating scientists-turned-teachers to invoke their previous experience into an educational setting.

Considerable research focused on relationships between teachers and students as well as the relationships between teachers and scientists. Articles that employed emphasized the former [7], which were pertinent to the availability of the STEM role model component in the charter school we operate in, much like discussed above. Most exciting was reviewing similar efforts in collaboration between scientists and educators, which was undoubtedly helpful for this project. For example, those that detail research between teachers and scientists [8,9]. However, their focus differed from our aims in that the mode of action is teacher development, wherein scientists are present for professional development with existing teachers. My concern about a strategy like this is that this does not necessarily propagate science to curriculum to students. It may shore up teacher's comfort with current scientific practices, but how does this translate to students? In fact, a previous action research project [10] found exactly this; seminars delivered by scientists to teachers during a summer training were overly technical and had no understanding of how their expertise could be reflected in the classroom.

As a result, the differentiating factor of this work from the plethora of partnership research is how the expertise in both science and education is shared. That is to say, the current model relies upon two skillsets with little overlap: science in research and science in the classroom. The teacher will never fully grasp the technical expertise of the scientist and the scientist has no understanding of how align their expertise to the curricular standards and audience of a classroom. However we have a set of 'bilingual' professionals at hand, capable of bridging the two fields. This should allow for a positive and lasting impact on a key student demographic and allow for sharing of lessons learned to both scientists and educators alike.

Furthermore, because of the array of ethnicities and backgrounds of our educators, this is an excellent opportunity to explore hope-building and alliances [11] between minority students and representative teachers who have come from similar upbringings to find careers in science.

3. Methods

The survey shown in Appendix 1 is focused on collecting data to address our perception data. The survey relied on several question types, namely a single-response scale, multiple-response ranking, and an open field response, similar to that shown previously [3]. Taken both at the beginning and of the year, 600 students participated from 7^{th}-11^{th} grade. This should allow for tracking changes in critical areas, such as interest in STEM careers or recognition of relationships between science and the world. This comparison is done both over the course of the year and between teacher-types. Attention is given to our diverse teacher participants when it comes to impact of acting as a STEM role model to our culturally and linguistically diverse students. That is to say, our participating teachers consist of:

1. A bachelor's level (education) White fifth year teacher,
2. A Masters level (education) White first year teacher,
3. A doctoral level (science) White second year teacher,
4. A doctoral level (science) Latino first year teacher, and
5. A bachelor's level (science) Asian-American second year teacher.

This participating staff provided a unique opportunity to gauge the influence of not just scientists in the classroom, but minority scientists.

We also scheduled interviews with students who indicate interest in careers that will require STEM college workloads, yet who may have not indicated interest in science (for example, any student who doesn't see the disconnect in wanting to be a veterinarian while indicating they don't like science class).

Ideally, this will serve as a foundation for future work also be coupled with performance tracking. This should provide a measure of how STEM trained educators impart critical thinking methodology as a focus of their curricula, such as has been highlighted before [5,7]. The assessment component is not meant to serve as a conclusive connection, but instead as a starting point for further, more rigorous research projects in which we are able to better track the contributions of both scientist and educator practices.

The most crucial aspect of the project timeline was acquiring teacher buy-in prior to school beginning. This allowed for communication between both parties to ensure that we are all working on the same team, and the focus is not "are scientists better teachers", but "can the experience of scientists, especially minority scientists, be brought into the curriculum to the benefit of students". Cooperation and commitment at the onset was essential, such as found by work previously discussed [8,10].

Data workup was compiled using Tableau Server, for ease of graphical interpretation and analysis, allowing us to easily track trends in gender, age, and ethnicity. This allowed for interesting findings as to when interest drops off and where, as well as how our scientists-teachers affect that drop off by year end.

4. Initial Perception Data

Upon tabulation of our surveys, several key messages were identified. Perception, as defined by favorable ratings of science course activities (ex. Labs) and consideration of future careers in science, was measured via the survey in Appendix 1. First, we were pleased to find that students indicate a high degree of enjoyment for their science classes (ranging from an average by grade of between 3 and 4 out of possible 5 overall in all grades polled). Not surprisingly, students indicated highest enjoyment for middle school and biological sciences, with physics and chemistry being less favored. However, we were surprised to find that when split by gender, responses to questions around enjoyment of science and interest in careers in STEM did not favor one gender over another. This indicates that our school is successfully reaching both male and female students in terms of engaging content and delivery. Breaking this down by grade level, we are able to dig deeper and track male and female interest in STEM careers, in which we see that in eighth grade in particular, female students actually outnumber male students when it comes to career aspirations in science-related fields.

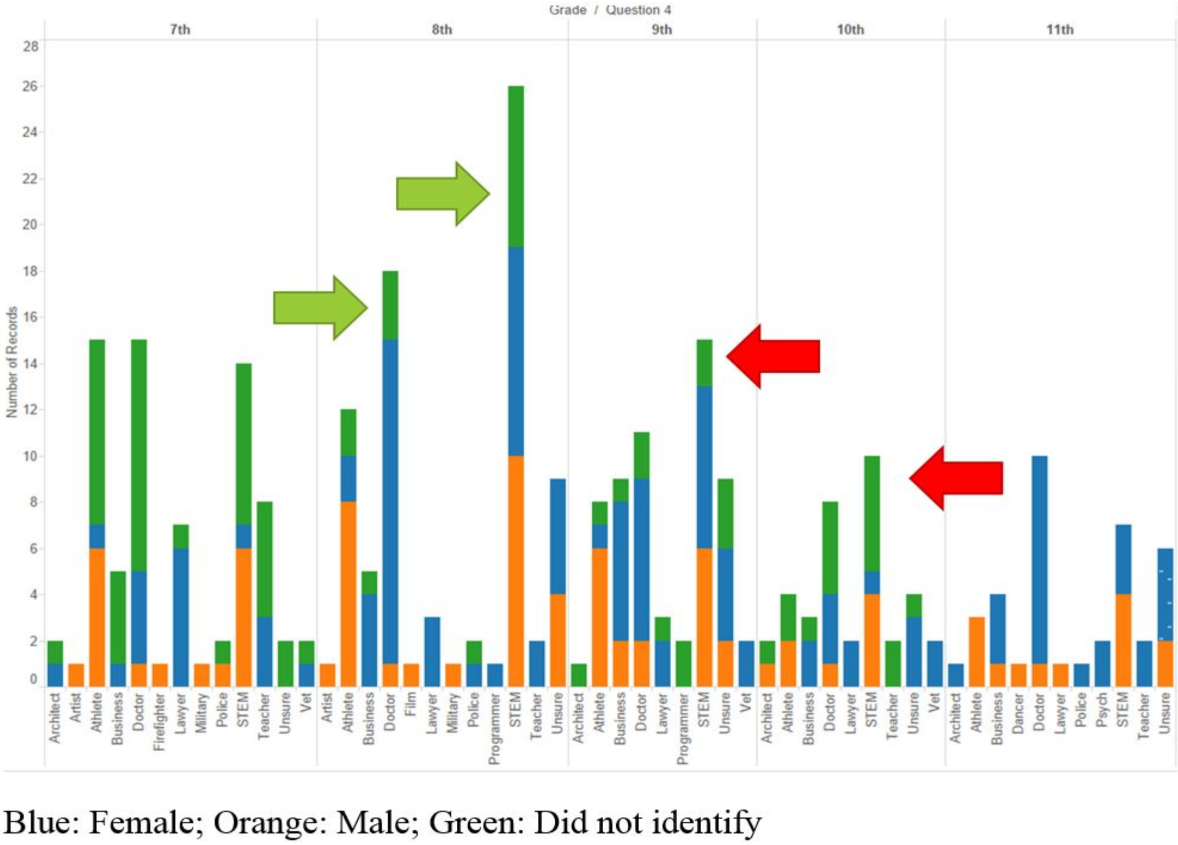

Figure 1. Career Goals by Gender

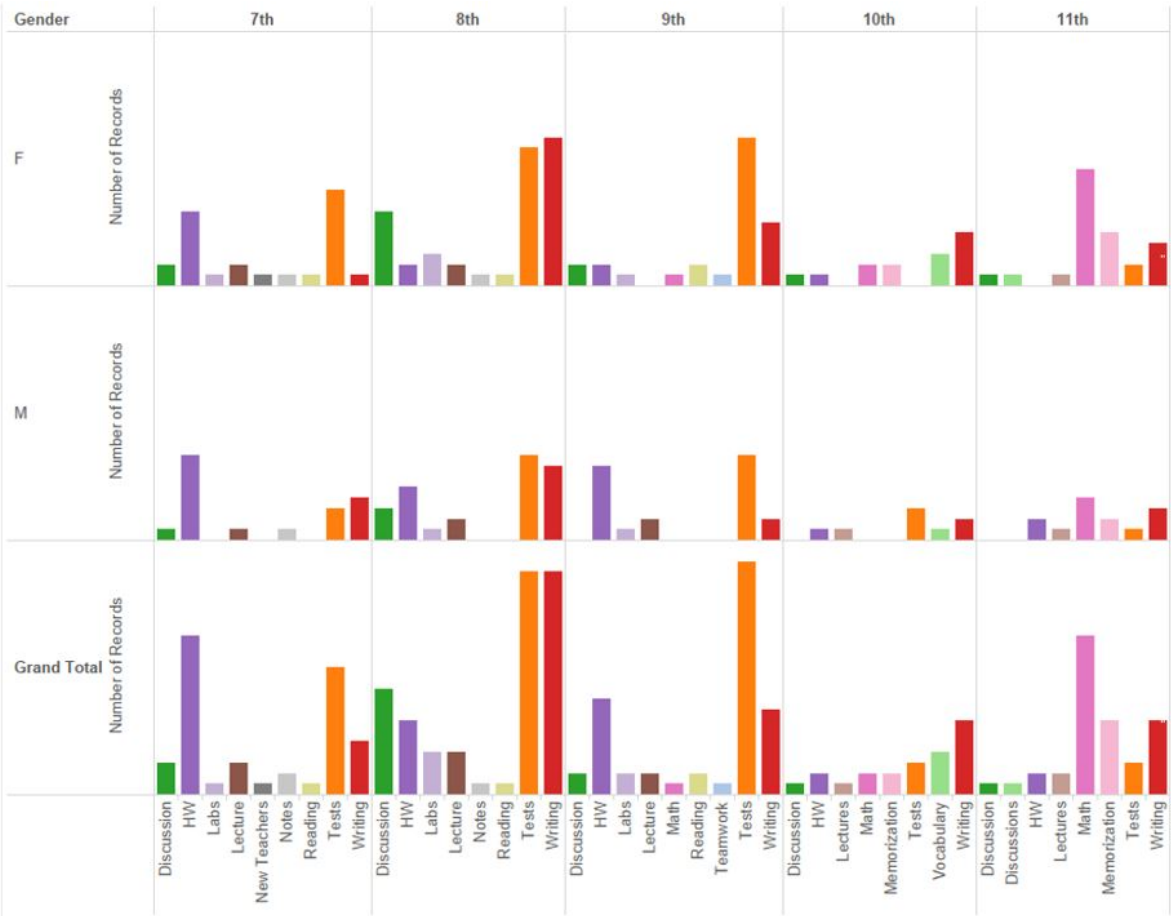

Figure 2. Dislikes in Science Courses by Gender

As a deeper dive, whenever students indicated that they disliked their science course, yet at the same time indicated they were interested in a STEM related field, that student was selected for a follow up interview. This included several questions around why they chose their career plans and general knowledge on what was required to get there. Their responses were generally indicative of a lack of understanding of what educational course loads would be required to reach that career. For example, a tenth-grade student who indicated she wanted to be a doctor replied she chose the career because she liked working with kids. When asked what college courses she thought that would require, she indicated she didn't know, and was very upset to hear it meant numerous chemistry and biology courses. In general, we were typically given the responses akin to "maybe I don't want that career after all".

Despite high rankings for enjoying science, after eighth grade student plans for STEM careers drop offs in very pronounced fashion. As shown in Figure 1, we can see that responses indicating an interest in being a doctor or scientist drop off by roughly 50% in one year, with students making a switch to law and business fields. In response, we were interested in determining what caused this drop off. Thus, the inclusion of the question shown in Figure 2, which asked students what about their science class deterred them from further pursuits. At the 8th grade, many students indicated a dislike for tests and writing. However, this is almost entirely removed by 10th and 11th grades. Instead, student responses around math and memorization increased by nearly twenty-fold. Interestingly, female students were twice as likely to indicate disliking math and memorization than male students. Luckily, female retention in science appears to be stable, as per above, but this does present some considerations to be made in our curriculum moving forward.

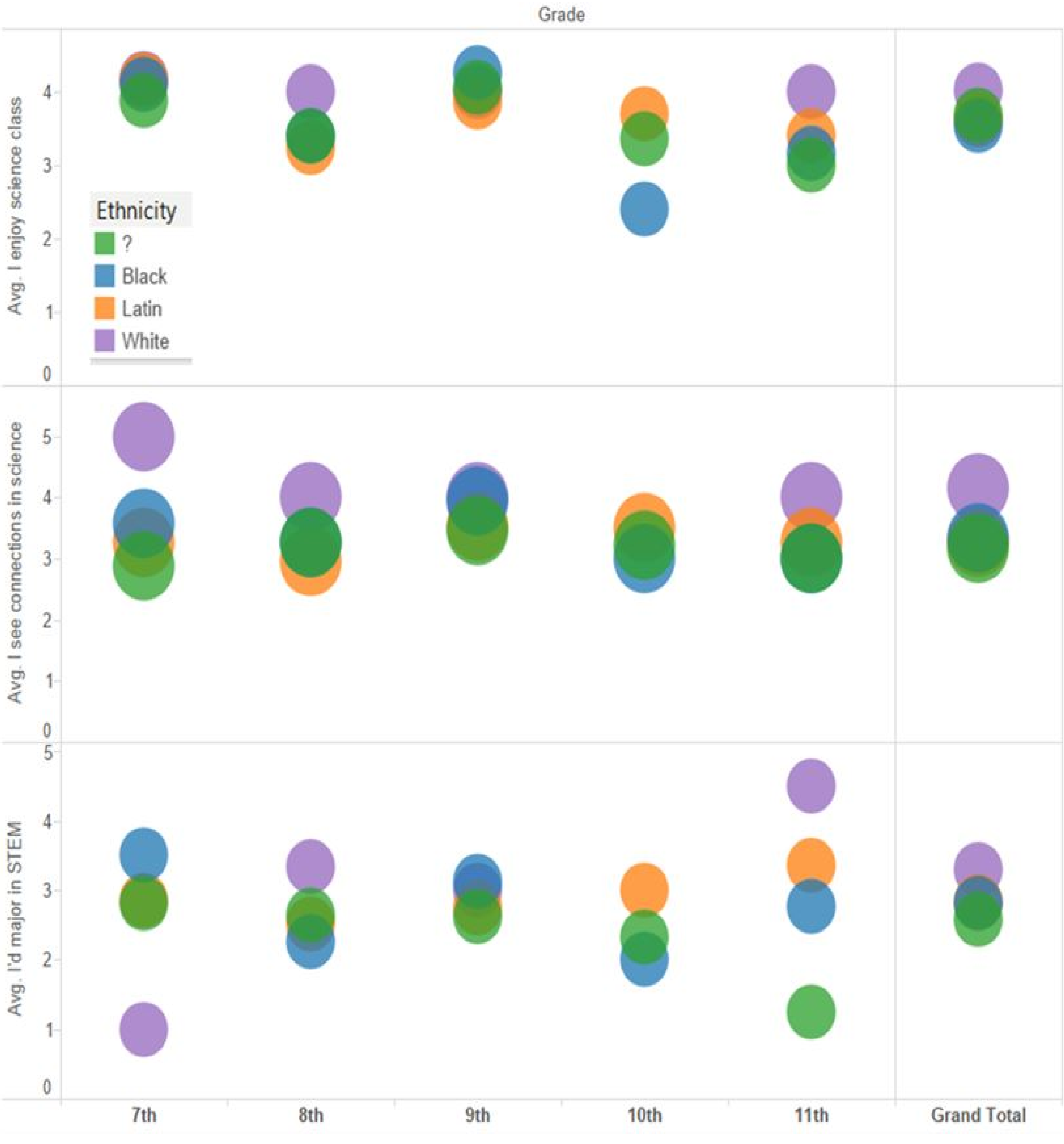

Figure 3. Initial STEM Perception by Ethnicity

Lastly, we also broke down our student STEM perception data by gender. As shown in Figure 3, we see that while we may see gender perseverance across science courses and grade levels, the same cannot be said for ethnicity. As we move from seventh to eleventh grade, we find white students dramatically increase their willingness to major in STEM disciplines in college. Of course, statistical strength of this trend warrants warning, as our number of Caucasian students is too low for conclusive data. Our Latin students show mild increase over the same time frame. However, conversely, our African American (and unidentified) students drop off, with a notable exception being during ninth grade. Note that despite the drop off, students, regardless of ethnicity showed a strong unity in indicating the value of science and its connections with the world they live in.

5. Year-End Perception Data

At the end of school year, the same survey was administered and data was compared both to the in-year responses, as well as the year-over-year data in order to best measure the effect of teachers new to their content. Here too, we are probing favorable perceptions of science both in their enjoyment of in-class activities as well as any resultant changes in consideration of STEM careers. That is to say that an increase in students considering careers in science at year end versus the beginning of the school year would constitute a successful science program. Here, we consider year-over-year data, for example, to be the year-start data from tenth graders compared to the year-end data of ninth graders to measure the impact of different teachers, while the in-year data could be used to analyze the impact of individual teachers.

Upon analysis of our results, we did not observe marked differences between the desire to major in STEM fields versus perception of science. As in the beginning of the year, students seemed to have a generally strong awareness that career fields they were interested in would include a very science-heavy course load come college. That is to say, in no year, initial or final, was there significant student indication that students who wanted a career in science (question 3) did not enjoy their science class (question 1), which would indicate potential confusion about future coursework. As detailed above, several students were chosen for interviews where these disconnects showed up. This included two students from ninth and tenth grade who indicated the desire to be a veterinarian, yet rated strong dislike for their science classes. Their reasons for pursuing this career was motivated by a like for animals, but showed very little knowledge of the requirements of the career or the highly-competitive nature of today's veterinary programs. In general, outside of these immediate disconnects the initial qualitative data did not yield fruitful data until compared with the year-end data, discussed further.

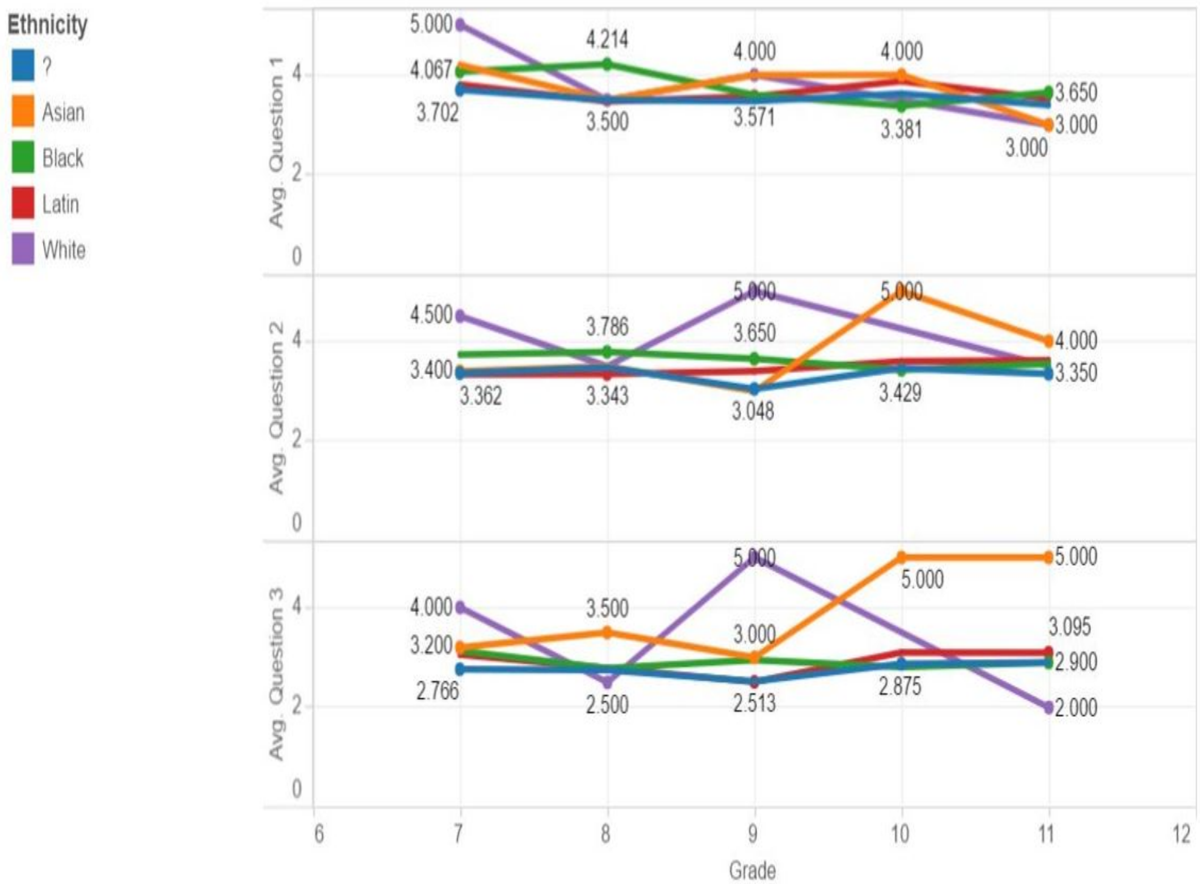

Figure 4. Year-end STEM Perception by Ethnicity

Figure 5. Comparison of STEM Perception Data by Gender

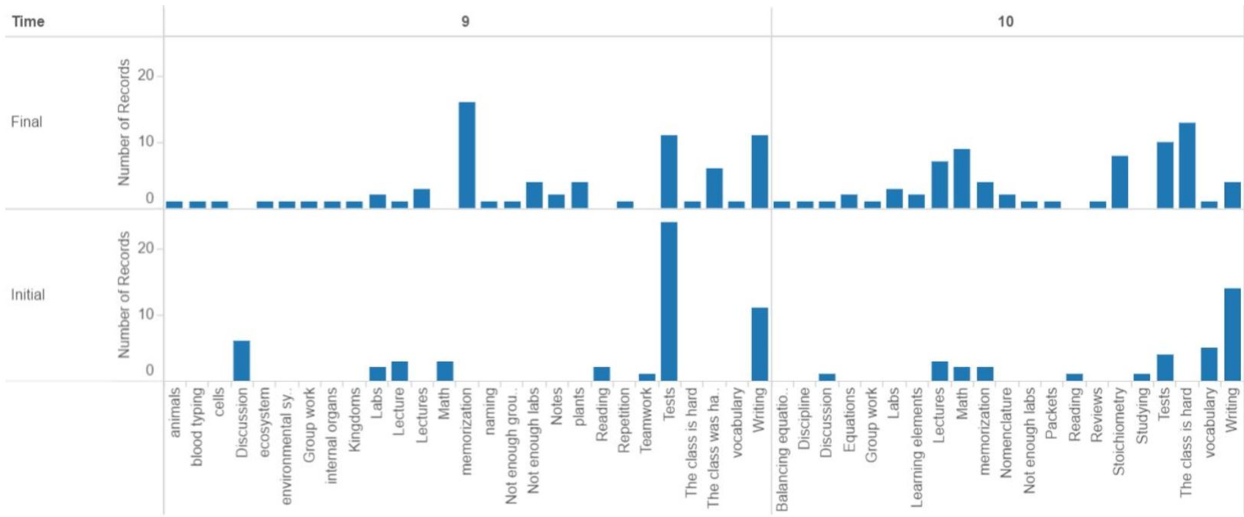

Figure 6. Indicated likes/dislikes in initial and year end survey

Generally, strong increases to responses to questions about enjoying science class, seeing connections, and desire to major in science were indicated by year end. This was most pronounced by the seventh-grade science teacher's students (5th year teacher, education major) and the tenth-grade chemistry teacher (1st year teacher, chemistry Ph.D.), both of whom found double digit increases in student responses in each category. In fact, the chemistry students had a 21% increase in interest in a STEM major from year start to year end. Again, this in-year increase is used to measure increased willingness to enjoy and explore science in the future, although it does not necessarily reflect any changes in academic performance. When further analyzing this increase by changes by specific ethnicity, this led to an observance not only of general increase, but tighter distribution of ethnicities indicating greater perception of science. As shown in Figure 4, the year-end data shows a more favorable average for Latino and Black students when compared to Figure 3 in questions 1-3. Most noticeable is the increase in question 3, pertaining to the interest in a STEM major, which increases of 30% among Black students during the tenth grade, as well as a 20% increase from female students over that same timeframe. It is worth noting, however, that because of the low number of White and Asian students, statistical strength warrants caution when making this comparison to these demographics. Instead, a far stronger claim can be made when comparing the same responses as indicated by gender. As can be readily seen in Figure 5, the increase in STEM perception responses is not only generally much higher, regardless of grade, reaching highest increases in the later grades. Recall that this is a demographic that saw dramatic falloff at the beginning of this study, as highlighted previously in Figure 1. This exciting finding shows that the presence of teachers with scientific backgrounds, even as novice teachers, are communicating in meaningful ways to our most vulnerable and underrepresented students. It may even be such that female students are demonstrating resilience in the face of difficult coursework, when looking at the data in Figure 5 from questions 1, 2 and 3. In grades 7 and 9, female students saw a decrease in enjoyment of their science class, although minor. While the decrease is not very significant in question 1, it does not follow the marked increase indicated in questions 2 (I see the connections between science and my life) and question 3 (I am considering a STEM major). The fact that questions 2 and 3 see increase regardless may indicate a growing commitment to science in the long term, even if the particular course did not wholly appeal to them. For our purposes specifically, namely the impact in questions 1-3 in trained scientists versus traditional teachers, we see that the former saw largest gains in questions 2 and 3 among students, regardless of gender or ethnicity. Arguably, the teachers with science research experience were more capable of communicating connections between the content and science in the students' lives, resulting in greater growth in favorability indicated. It worth noting that regardless of background training, all teachers observed an increase during the year in terms of enjoying their science course, with the exception of the freshman Biology teacher (doctoral science background).

Another interesting discovery was observed in responses pertaining to what students liked and disliked about their science classes. Analyzing the qualitative data and later survey questions from the beginning of the year, student responses were not very creative, such as indicating they "liked labs" and "hated tests". Recall in Figure 2, tests and memorization made the bulk of all student dislikes. While no statistically relevant trends were observed in the year-end data for gender or ethnicity, students exclusively in the ninth and tenth grade classes, led by the science-background teachers, had a 20% and 33% rate of response to content-related issues, respectively. That is to say, that students in these classes and only these classes, abandoned unavoidable class practices (such as taking tests) as likes/dislikes in favor of scientifically specific responses, such as "disliking stoichiometry" or "enjoying blood typing". As detailed in Figure 6, dramatic decreases were observed for responses disliking writing or tests by year end, with diverse, content related factors taking their place. A telling example is how students at the beginning of the year indicated a dislike for "memorization" were now indicating a dislike for "nomenclature". This use of academic language and voicing of content-related features in their discussion of science was an unexpected indicator of the impact of scientist-led classrooms. Indication of exams being the least favorite part of the class saw a 50% decrease over the course of the year, while content-specific indicators, such as 'balancing-equations' or 'ecosystems' constituted almost 30% of student responses at year-end. In a similar vein, the most prominent response at year-end in these classes was a form of student's biggest complaint being simply that "the class was very challenging"; a statement not indicated at all in any class at the beginning of the study. Again, when combined with earlier survey questions regarding student enjoyment and plans of STEM careers, we considered the indication of the class being difficult while maintaining enjoyment of said class to be a measure of success.

6. Conclusions

This research project has demonstrated two exciting successes for our teachers and for our students. The first is that our teachers who have come to a classroom from previous careers in science have given a voice to our students in describing their interests or even their disinterest in science using academic language. This is compounded by the results indicating significant increases in STEM perception across gender and ethnicity within the year of the study, most prominently in the seventh-grade teacher, our most longstanding teacher, and the doctoral chemist teaching tenth grade.

While these results are motivating, they are only the first step. Since this is purely a measure of perception regarding science, we must next link this to academic success. Despite seeing the greatest boons for interest in science in classes led by scientists, our student performance data is still tied proportionally to teacher experience in the classroom. As one would expect, our first-year teachers scored lowest on district-wide common assessment exams, with our longest tenured teachers scoring highest. Future work will identify practices between our traditional educators and scientists to bridge passion and performance in the classroom. Doing so will best capitalize on the willingness of students to explore careers in STEM in ways to best situate them for success at a university level.

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References

[1] The Bureau of Labor Statistics (2009). Retrieved from http://www.bls.gov/opub/mlr/2009/11/art5full.pdf.

[2] The White House Office of Science and Technology (2013, April 10). Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/2014_R&Dbudget_STEM.pdf.

[3] Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B., Willis, B. (2013, November 1) ASPIRES Young People's Science & Career Aspiration, Age 10-14. Retrieved from http://www.kcl.ac.uk/sspp/departments/education/research/aspires/ASPIRES-final-report-December-2013.pdf.

[4] Stohlmann, M., Moore, T. J., Roehrig, G. H. (2012). Considerations for Teaching Integrated STEM Education. Journal of Pre-College Engineering Education Research (J-PEER). 2(1), 28-34.

[5] Daggett, W. R. (2014). Rigor/Relevance Framework: A Guide to Focusing Resources to Increase Student Performance. International Center for Leadership in Education.

[6] Schwartz, R. (2007) What's in a Word? How Word Choice Can Develop (Mis)conceptions About the Nature of Science. Science Scope 31(2), 42-47.

[7] McNulty, R. J., Quaglia, R. J. (2012) Tips For Using Rigor, Relevance and Relationships to Improve Student Achievement. American Association of School Administrators. Retrieved from http://www.education.com/reference/article/Ref_Rigor_Relevance.

[8] Houseal, A. K., Abd-el-Khalick, F., Destefano, L. (2013) Impact of a Student–Teacher–Scientist Partnership on Students' and Teachers' Content Knowledge, Attitudes Toward Science, and Pedagogical Practices. Journal of Research in Science Teaching 51(1). p. 84-115.

[9] Merrill, C., Daugherty, J. (2010) STEM Education and Leadership: A Mathematics and Science Partnership Approach. Journal of Technology Education 21(2).

[10] Wilcutts, M. H. (2009) Scientist-Teacher Partnerships as Professional Development: An Action Research Study. Richland, WA: Pacific Northwest National Laboratory.

[11] Hammond, Z. L., (2014) Culturally Responsive Teaching & the Brain. London, United Kingdom. SAGE Publications.

Appendix

1. I enjoy my science classes
Strongly Disagree(1) (2) (3) (4) (5) Strongly Agree
2. I see the connection between science and my life
Strongly Disagree(1) (2) (3) (4) (5) Strongly Agree
3. I am considering a major in science in college
Strongly Disagree(1) (2) (3) (4) (5) Strongly Agree
4. When I finish college I want to be a:
Teacher Businessperson Professor Scientist/Engineer
Athlete Doctor Other _____
5. From lowest (1) to highest (5), my favorite part of the class was:
___Lecture ___Discussion___Labs ___Field trips/Guest speakers
___Other___________________
6. From lowest (1) to highest (5), I am good at:
___Tests/Quizzes ___Homework ___Labs
___Writing reports ___Discussion
7. What best helped you understand science?
8. What did you enjoy the least about the class? How would you fix it?