

Leveraging Student Interest to Create a Meaningful and Engaging Science Curriculum

- Sarah Maestrales
- Emily Miller
- Kayla Bartz
- Rand Spiro



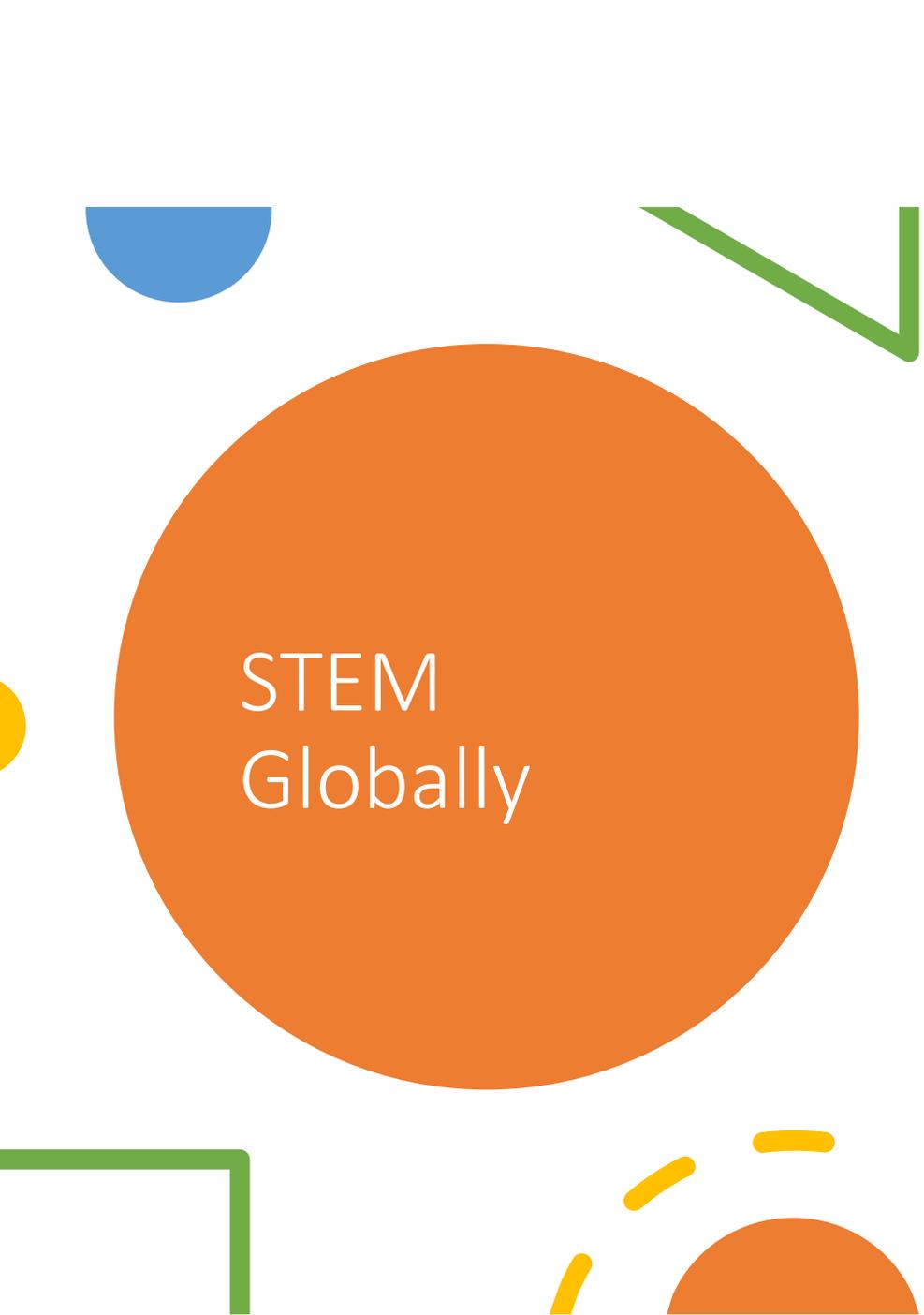


Santiago de Compostela



STEM Interest

A global concern



STEM Globally

Global efforts to expand STEM interest and opportunities for underrepresented groups with best practice are imperative (Dibner et al., 2020; Schleicher, 2019).

Diversity in STEM

(National Science Board 2016)

The STEM workforce must become more diverse—that it must be better positioned to draw on the minds and talents of underrepresented groups.

Underrepresented minority (URM) groups are simultaneously the fastest growing segment of the population and the least likely to pursue STEM degrees and careers.

Black males and females represent only 2.9 % of the nearly 5.75 million STEM professionals.



Promoting Diversity in STEM

- Career education and role modeling for black males through mentorship programs (Freeman Hrabowski III, 2014).
- Interest and identities of students in underrepresented groups (Carpi et al., 2017).
- Motivating racio-socio identity (Brown, & Edouard, 2017),
- Antiracist pedagogies (Alderman et al., 2019).
- Desettling science content (Bang et al., 2012).
- Culturally sustaining pedagogies (Paris & Alim, 2017).

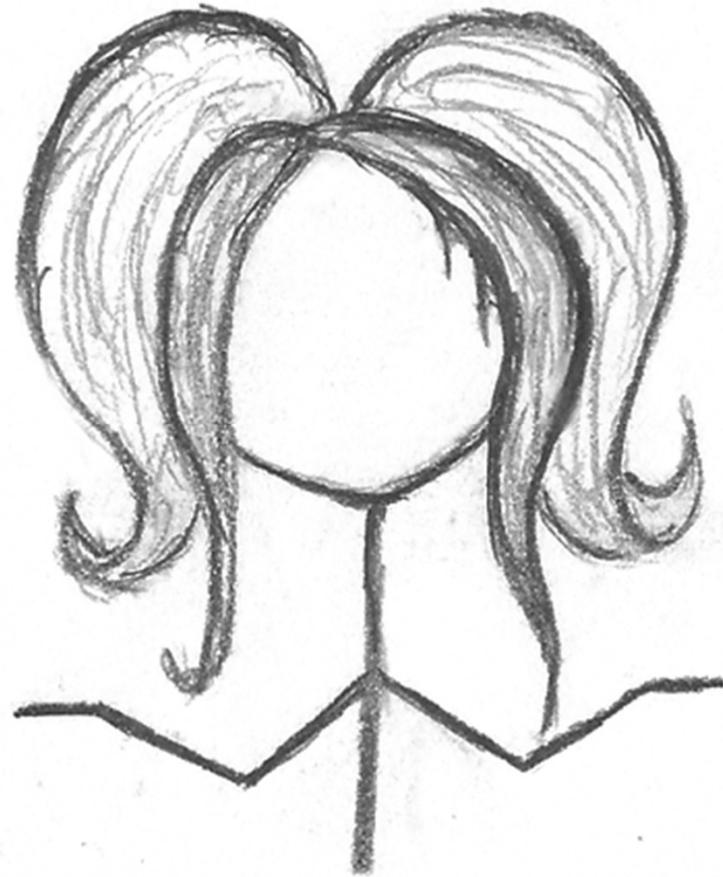


Peer Recognition & Prosocial Cultural Goals

- Prosocial Goals
 - Jackson, M. C., Galvez, G., Landa, I., Buonora, P., & Thoman, D. B. (2016). Science that matters: The importance of a cultural connection in underrepresented students' science pursuit. *CBE—Life Sciences Education*, 15(3), ar42.
 - Zambrano, J., Lee, G. A., Leal, C. C., & Thoman, D. B. (2020). Highlighting Prosocial Affordances of Science in Textbooks to Promote Science Interest. *CBE—Life Sciences Education*, 19(3), ar24.
- Social Recognition
 - Jackson, M. C., Leal, C. C., Zambrano, J., & Thoman, D. B. (2019). Talking about science interests: the importance of social recognition when students talk about their interests in STEM. *Social Psychology of Education*, 22(1), 149-167.

With all these
great ideas,
why aren't we
ALREADY
successful?

What can recent events
teach us about students'
interest in STEM careers?





The Intervention



- Project based science learning intervention.
- Conducted across two regions in the United States.
- NGSS aligned content.
- Teacher professional development



Pre- Pandemic Sample

- 4,928 high school students in 72 classrooms
- Gender
 - 45.90% were female students
- Race:
 - 16.89% of students identified their race as white
 - 34.31% identified their race/ethnicity as Hispanic
 - 11.12% identified their race as black
 - 5.13% identified their race as Asian
 - 19.62% indicated multiple races
 - 12.64% were missing a race indicator



Pandemic Sample

- 900 High School Students
 - 636 matched to their pre-pandemic survey
- 20 Teachers Completed Exit Interviews
- Gender
 - 55.25% were female students
- Race:
 - 22.51% of students identified their race as white
 - 39.84% identified their race/ethnicity as Hispanic
 - 6.41% identified their race as black
 - 6.68% identified their race as Asian
 - 19.62% indicated multiple races
 - 12.64% were missing a race indicator

Instruments

- As a part of the CESE intervention, students were surveyed in Fall 2019 and Spring 2020
 - Fall 2019 Survey
 - Belonging, utility, interest, & career (normally associated with CESE).
 - Identity & positive social interactions regarding science (based on Jackson 2016 & 2019).
 - Spring 2020 Survey
 - Belonging, utility, interest, & career (normally associated with CESE).
 - How recent events have changed the way they view learning science, advice on moving forward with online learning (specific to Covid).
 - Teacher Interviews
 - Questions about adapting to remote teaching and the current landscape.



Instruments

- Survey items included a combination of open-ended and Likert Scale responses.
- We also conducted one-on-one interviews with teachers.

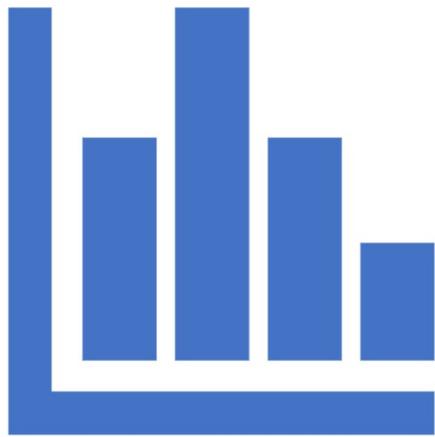


Instruments

- Belonging, utility, interest, and positive social interactions
 - Likert scale
 - Calculated as averages across multiple items in a scale.
- Interest
 - Likert scale
 - Single question initially intended as part of the scale for science engagement.
- Open Ended Responses about Current Events
 - How have recent events changed the way you think about learning science?
 - Do you have advice for teachers about how to make online science learning more interesting for students like you?
- Careers
 - Open ended response to “What kind of job do you expect to have when you are about 30 years old?”
 - Classified using ONET and Michigan State University graduation requirements portal.
 - Student responses were searched using “stemmed” or shortened expressions to reduce errors in spelling or capitalization (e.g. oncology was searched using “ncolog”).

Classifying Careers

- **Medical Careers**
 - Doctor, nurse, oncologist, physician, pediatrician, orthodontist, etc.
- **Prosocial Careers**
 - Medical careers
 - Psychologist, teacher, social worker, therapist, etc.
- **Math Intensive Careers**
 - Chemist, physicist, mathematician, engineer, roboticist, astronomer, etc.
- **All Sciences**
 - Math intensive careers
 - Biologist, zoologist, veterinary medicine



The results and where
the lead us.

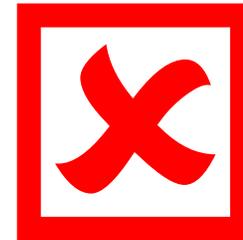


Results

Fall 2019

Before the shift to remote learning

Identity,
Utility,
Positive
Social
Interactions



Identity, Utility, Positive Social interactions

	Expectation	Reality		
Identity				
Combined	Lower for URM students	Asian students higher	✘	
Self	Lower for URM students	Lower for black students Higher for Asian students	✘	✔
Other	Lower for URM students	No significant differences	✘	
Utility	Lower for URM students	Higher for almost all URM groups	✘	
Positive Social Interactions	Lower for URM students	Higher for URM students	✘	

Fall 2019 (Pre-Pandemic)

Science Identity, Utility, and Positive Social Interactions Regarding Science

	Mean Science Identity		Self Science Identity		Other's Perception		Mean Future Science Utility		Positive Social	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Race (White non-Hispanic as comparison)										
Hispanic	-0.02	0.04	-0.03	0.04	0.00	0.04	0.21 ***	0.04	0.21 ***	0.04
Black	-0.10	0.06	-0.14 *	0.06	-0.05	0.06	0.15 **	0.06	0.21 ***	0.06
Other	0.25	0.22	0.17	0.20	0.31	0.23	0.35	0.26	0.55 *	0.23
Asian	0.15 *	0.07	0.16 *	0.07	0.13	0.07	0.33 ***	0.07	0.23 **	0.07
Multiple	0.02	0.05	-0.02	0.05	0.06	0.05	0.18 ***	0.05	0.21 ***	0.05

Note. Each of the outcomes shown in the tables was standardized to facilitate interpretation. This table shows the regression coefficients of each standardized outcome with race as the only predictor. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$;

STEM
Career Goals



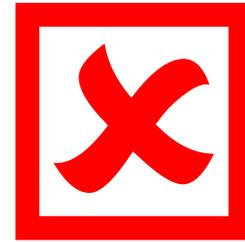
Fall 2019 (Pre-Pandemic)

Comparing Results of Single and Multilevel Models regarding Stem Career Goals

	All Science		Math Intensive		All Science		Math Intensive	
	Odds Ratio	SE	Odds Ratio	SE	Odds Ratio	SE	Odds Ratio	SE
Race (White non-Hispanic as comparison)								
Hispanic	0.80 *	0.08	0.84	0.11	0.96	0.12	0.97	0.17
Black	0.61 **	0.09	0.66 *	0.12	0.57 ***	0.09	0.49 ***	0.08
Other	1.31	0.71	0.83	0.63	1.52	0.79	0.91	0.70
Asian	1.06	0.18	1.53 *	0.29	0.93	0.13	1.16	0.22
Multiple	0.68 **	0.08	0.64 **	0.10	0.83	0.12	0.74	0.12
Random Effects								
Between School	(N/A)		(N/A)		0.17	0.06	0.34	0.14
Between Teacher	(N/A)		(N/A)		0.08	0.05	0.11	0.08

Note . Math intensive careers are those in computer programming, engineering, chemistry, and physics; careers in "all sciences" include math intensive career choices as well as less math intensive sciences such as zoology and biology; *p < 0.05, **p < 0.01, ***p < 0.001.

Prosocial
Career Goals



Fall 2019 (Pre-Pandemic)

Prosocial Career Goals

	Prosocial with Science Intensive		Prosocial without Science Intensive		Medicine		Nurse		Doctor		
	Odds Ratio	SE	Odds Ratio	SE	Odds Ratio	SE	Odds Ratio	SE	Odds Ratio	SE	
Race (White non-Hispanic as comparison)											
Hispanic	1.25 *	0.12	0.74	0.16	1.16	0.14	1.71 *	0.36	1.71 *	0.47	
Black	1.20	0.15	0.67	0.21	1.49 **	0.22	1.74 *	0.45	1.92 *	0.62	
Other	2.57	1.27	Empty		2.48	1.34	3.45	2.67	2.74	2.90	
Asian	1.38 *	0.22	1.33	0.43	2.13 ***	0.38	1.61	0.54	1.71	0.71	
Multiple	1.01	0.11	0.89	0.21	0.98	0.14	1.25	0.30	1.56	0.47	

Note. Prosocial careers that are non-science intensive are those in teaching, counseling, social work, police, etc.; prosocial careers that include more science intensive coursework include those in medicine, veterinary medicine, and zoology; medical careers are those in all fields of health care listed by students; Nurse and doctor are specific to students using those words in their response; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



Results

Spring 2020

After the shift to remote learning

Attendance in Spring 2020

CESE teachers reported students had little incentive to attend their online courses.

- Inequitable access to resources
- No attendance requirements
- No grades
- 5%-25% attendance



Attendance

Students regarded their science teachers as valuable resources in understanding what they were seeing in the news.

Students came to class to ask about:

- News about Covid-19
- Virus Mutations
- Personal protective equipment
- How to prevent climate change
- Environmental Concerns
- Hand sanitizer
- Conflicting information in the media
- Reliable resources
- Differences between cotton and N-95 masks

Teacher Innovations

Teachers managed to create project-based lessons with immediate tangible value to their students

- Making Hand Sanitizer
- Making personal protective equipment (face shields, masks, etc.)
- Adapting CESE lessons on evaporation to cover handwashing & sanitizer





Teacher Innovations

Regarding discussions about current events:

“I feel like most kids are actually engaged. Even my not engaged students are engaged with that discussion.”

Students' advice on moving forward with future science learning.

“I think online science learning could be more fun by including lessons about current issues, like the COVID-19 pandemic. I think we can also watch more experiments and do text-based assignments.”

“Use topics related to the real world and current events.”



How have recent events changed your views on learning science?

In personal accounts, students reported the importance of prosocial applications of the science they are learning.

Covid-19

“Due to the certain circumstances that we are all facing in this pandemic. I think it has opened my eyes to see how important science especially chemistry is. Studying the bonds and the atoms and particles of a virus is the beginning of a cure.”

“I think right now science is very important if anyone is going to find a cure for COVID-19 is probably going to be a scientist or doctor. Which in regard use science so right now I'm praying everyday that a cure can happen to return life to how it was.”

Climate Change

“I think it's even more important now that we know what's going on in our world and in our planet. Seeing how now that everyone's in quarantine the environment has definitely changed and we can see the damage we have actually done.”

“I feel like news or science feels more real in the news. It hits home. Adding the humanitarian side to things of like climate change, isn't just like an outside thing. This is affecting real people. If you care about social justice, if you care about people, if you care about all these things, you should care about climate change too.”

Fall to Spring

Question	Fall	Spring		Difference	p
All Science	0.25	0.19	↓	0.06	< 0.001
Math Intensive	0.14	0.12	↓	-0.02	= 0.09
All Medical	0.19	0.19		-0.01	= 0.56
Utility	2.97	3.09	↑	-0.12	< 0.001
Interest	2.27	2.77	↑	0.05	< 0.001

Factors Associated with Sustained Career Ambitions

Analyzing the career intentions of students surveyed during the pandemic:

- Utility and belonging as measured in Spring were significant predictors of STEM ambition.
- All 3 measures of identity were positively correlated to STEM ambition.
- Science utility was inversely correlated with intentions for non-science-intensive prosocial careers.



Spring 2020 (During the Pandemic)

Logistic Regression Coefficients for Individual Predictors When Controlling for Race/Ethnicity

Predictor	Math Intensive		All Science		Medical		Prosocial		Nurse		Doctor	
	Odds Ratio	S.E.	Odds Ratio	S.E.	Odds Ratio	S.E.	Odds Ratio	S.E.	Odds Ratio	S.E.	Odds Ratio	S.E.
Social Interactions	1.01	0.16	1.04	0.13	1.09	0.15	0.95	0.15	0.82	0.2	1.55	0.38
Overall Identity	1.36	0.24	1.35 *	0.18	1.00	0.12	0.78	0.14	0.76	0.16	1.61	0.43
Other Identity	1.32	0.25	1.30 *	0.17	0.97	0.11	0.83	0.14	0.81	0.19	1.51	0.41
Self Identity	1.34	0.22	1.34 *	0.17	1.02	0.12	0.77	0.14	0.74	0.16	1.61	0.41
Fall Utility	1.27	0.20	1.22	0.15	1.27	0.17	0.70 *	0.11	1.45	0.29	1.37	0.30
Spring Utility	1.42 *	0.24	1.45 **	0.18	1.42 *	0.21	0.69 *	0.12	1.33	0.29	1.47	0.44

Note. Due to correlations between predictors, each was included in its own individual logistic regression model controlling for race/ethnicity and the students' desires to pursue the specific career when surveyed in the fall; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.



Discussion & Conclusion

STEM-Attitudes

- We found that URM students reported fewer STEM career ambitions despite
 - Talking more about science class with peers and family.
 - Reporting higher beliefs that science would be useful for their futures.
 - Having similar measures of identity as compared to their white peers.
- Both students and teachers reported the importance of connecting science to current events and real-world issues.



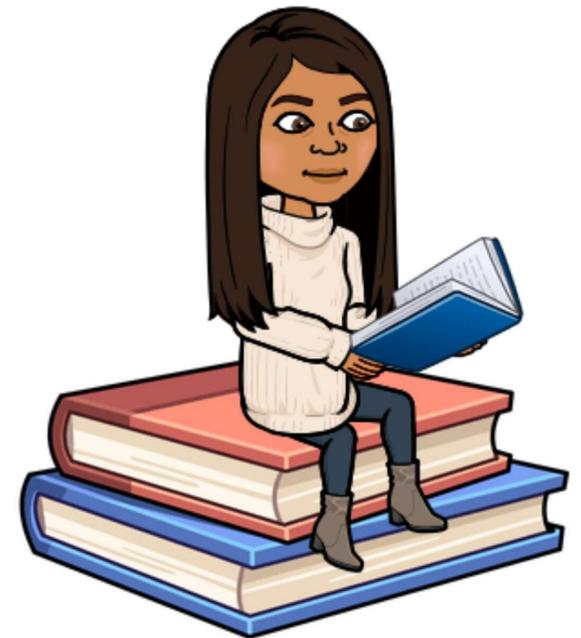


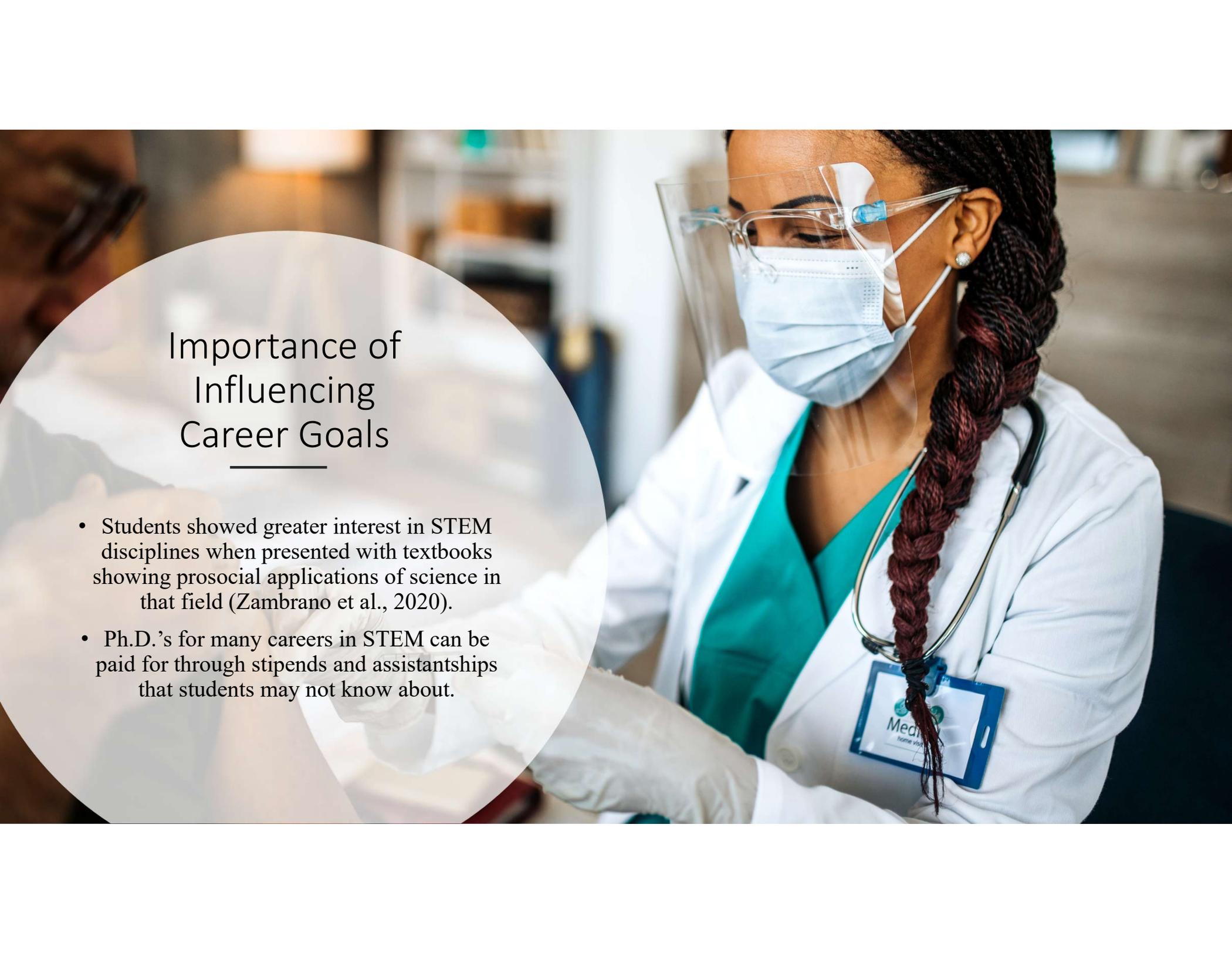
Career Goals

- As compared to their white peers in the 2019-2020 CESE study:
 - Black and Hispanic students were more likely to report plans for non-specialized careers in medicine.
 - Hispanic students were only overrepresented in prosocial career goals when including science intensive majors.

Career Goals

- URM students in the CESE study seem to apply their STEM interest and ambitions to careers in medicine.
 - Visible in the media
 - High earning potential
 - Provide opportunities to help others
- Medical careers also have very high student debt.
 - Where 62.1% of students expected to graduate with student loan debts over \$150,000 (Dugger et al, 2013).
 - 77.3% for black students
 - 65.1% for white students
 - 57.2% of Hispanic students
 - 50% of Asian students
- Black students are already likely to acquire higher amounts of student loan debt than their white peers (Jackson & Reynolds, 2013).





Importance of Influencing Career Goals

- Students showed greater interest in STEM disciplines when presented with textbooks showing prosocial applications of science in that field (Zambrano et al., 2020).
- Ph.D.'s for many careers in STEM can be paid for through stipends and assistantships that students may not know about.

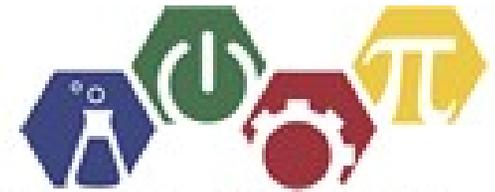
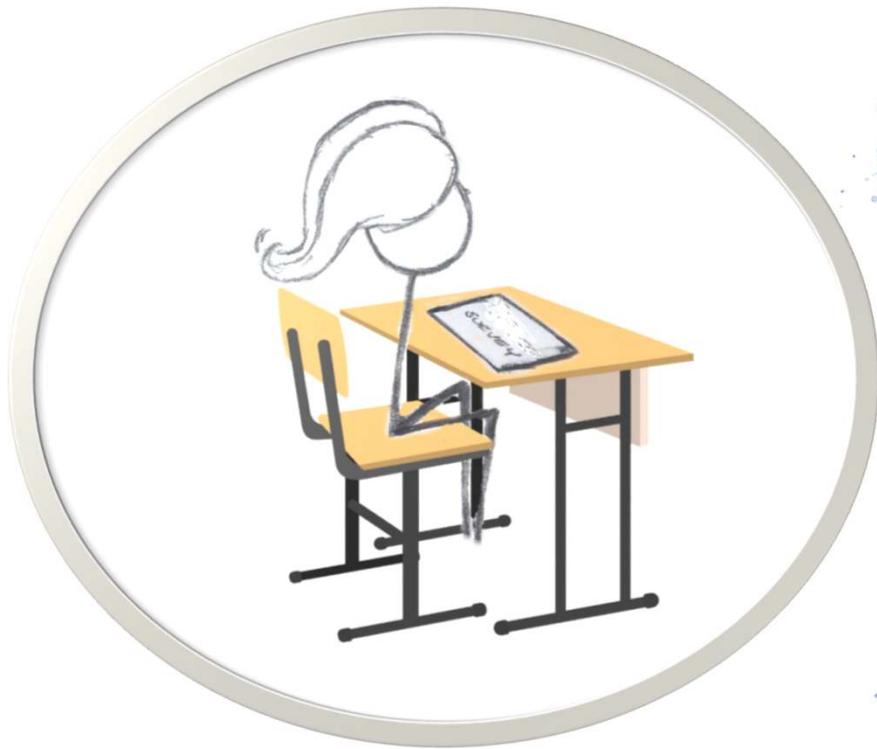
What can we do?



Teach the prosocial **APPLICATIONS** of science learning associated with relevant social and cultural issues occurring in the real world.

References

- Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, 54(2), 169-194. <https://doi.org/10.1002/tea.21341>
- Celia., P. D. A. H. S. A. D. E. G. (2017). *Culturally Sustaining Pedagogies: Teaching and Learning for Justice in a Changing World*. Teachers College Press.
- Dibner KA, Schweingruber HA, Christakis DA. Reopening K-12 Schools During the COVID-19 Pandemic: A Report From the National Academies of Sciences, Engineering, and Medicine. *JAMA*. 2020;324(9):833–834. doi:10.1001/jama.2020.14745
- Dugger, R.A., El-Sayed, A.M., Dogra, A., Messina, C., Bronson, R., & Galea, S. (2013). The Color of debt: racial disparities in anticipated medical student debt in the United States. *PloS one*, 8(9), e74693
- Hrabowski, Freeman A., III. "How to Get More Black Men Into Science." *The Chronicle of Higher Education*, vol. 61, no. 09, 2014. *Gale Academic OneFile*, link.gale.com/apps/doc/A393032236/AONE?u=msu_main&sid=summon&xid=988f5f0c
- Jackson, B. A., & Reynolds, J. R. (2013). The price of opportunity: Race, student loan debt, and college achievement. *Sociological Inquiry*, 83(3), 335-368.
- Jackson, M. C., Galvez, G., Landa, I., Buonora, P., & Thoman, D. B. (2016). Science that matters: The importance of a cultural connection in underrepresented students' science pursuit. *CBE—Life Sciences Education*, 15(3), ar42.
- Jackson, M. C., Leal, C. C., Zambrano, J., & Thoman, D. B. (2019). Talking about science interests: the importance of social recognition when students talk about their interests in STEM. *Social Psychology of Education*, 22(1), 149-167.
- Jiménez, D., & Glater, J. D. (2020). Student debt is a civil rights issue: the case for debt relief and higher education reform. *Harv. CR-CLL Rev.*, 55, 131.
- Schleicher, A. (2019). *PISA 2018: Insights and Interpretations*. *OECD Publishing*.
- Zambrano, J., Lee, G. A., Leal, C. C., & Thoman, D. B. (2020). Highlighting Prosocial Affordances of Science in Textbooks to Promote Science Interest. *CBE—Life Sciences Education*, 19(3), ar24.



**CREATE for STEM Institute
at Michigan State University**



OISE: 1545684

**A special thanks to our students,
teachers, team members, and sponsors.**

