A Bridge to the Stars:
An Equity-Minded Early-College Experience for Broadening Participation in STEM

Daniel H. McIntosh, PhD

Chair & Professor of UMKC Physics & Astronomy
Director of STEM Education Innovation
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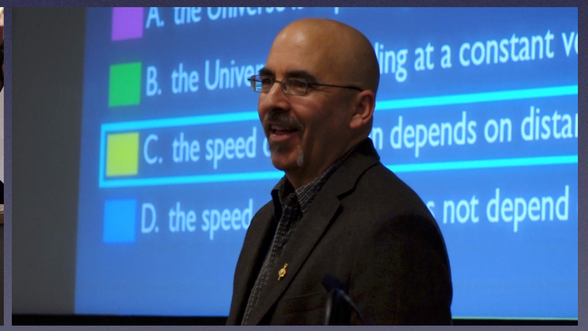
2018-2019 Provost Fellow (STEM+M Ecosystem Framework)
2017-2019 Norman Royall Distinguished Professor
2016 U Missouri President's Award for Innovative Teaching



UMKC Today

News archives

A Bridge to the Stars

Published on September 15, 2016

Photo by Brandon Parigo, Division of Strategic Marketing and Communications

An innovative pipeline to improve STEM diversity

Inner-city high school students in Kansas City now have a unique opportunity to learn in a college classroom with a professional astronomer through A Bridge to the Stars Scholarship and Mentoring Program at the University of Missouri-Kansas City.

The man behind the program is Daniel H. McIntosh, Ph.D., an award-winning professor of physics and astronomy, and a scientist researching the birth and growth of galaxies using the Hubble Space Telescope. As a teacher, McIntosh shares his knowledge, and his enthusiasm, to inspire others.

The Bridge to the Stars Program is a way to reach high school students when they are still excited about learning. McIntosh's program provides low-income and underrepresented minority students,

"Through this program, we're providing students with high impact exposure to science through innovative experiential learning with a professional scientist. It's a bridge between high school and college, and it fosters student success."

— Prof. McIntosh

"A great program taught by a very inspired professor!"

— Dr. Larry Weible
(East H.S. Science Chair)

"This program is not something that happens to you, it is something you are a part of."

— Derrick Jennings II
(ABttS Mentoring Intern)

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March 17, 2022

STEM+

A Bridge to the Stars in a Nutshell

This equity-minded initiative is designed to give historically underserved and underrepresented 10th & 11th graders an early-college experience at UMKC through tuition support, enrollment, and near-peer mentoring in a student-centered introductory astronomy course.

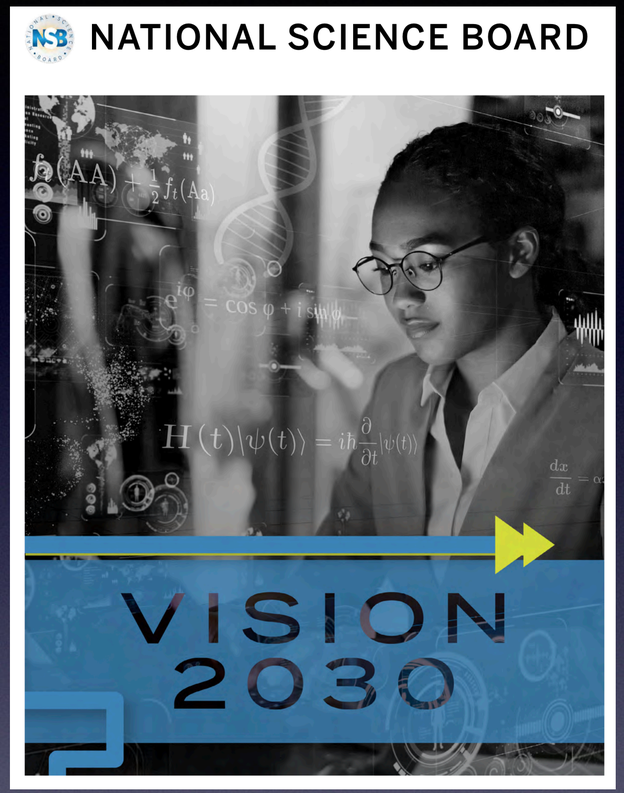
Benefits participants with an immersive, confidence-building experience to increase the likelihood that they matriculate to college and persist through their crucial first year.

High-school Scholars & UMKC Mentors (Spring 2017).

A Bridge to the Stars is made possible by funding from the NASA Missouri Space Grant

- ✦ 81 tuition scholarships over 11 semesters
  (*73 unique students from 14 KC high schools*)
- ✦ equity-minded selection for participation
  (*70% URMs 70% non-male >90% low-$*)
- ✦ 95% success rate
  (*Scholar passed course, earned college credit*)
- ✦ confidence building & sense of belonging
  (*no achievement gap between Scholars and UMKC students enrolled in same courses*)
- ✦ Long-term tracking of former Scholars:
  (*40% of Scholars pursued/pursuing 4-year degree, 60% in STEM*)

A More Representative Science & Engineering Workforce is a National Goal



NSB 2020 (https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf)

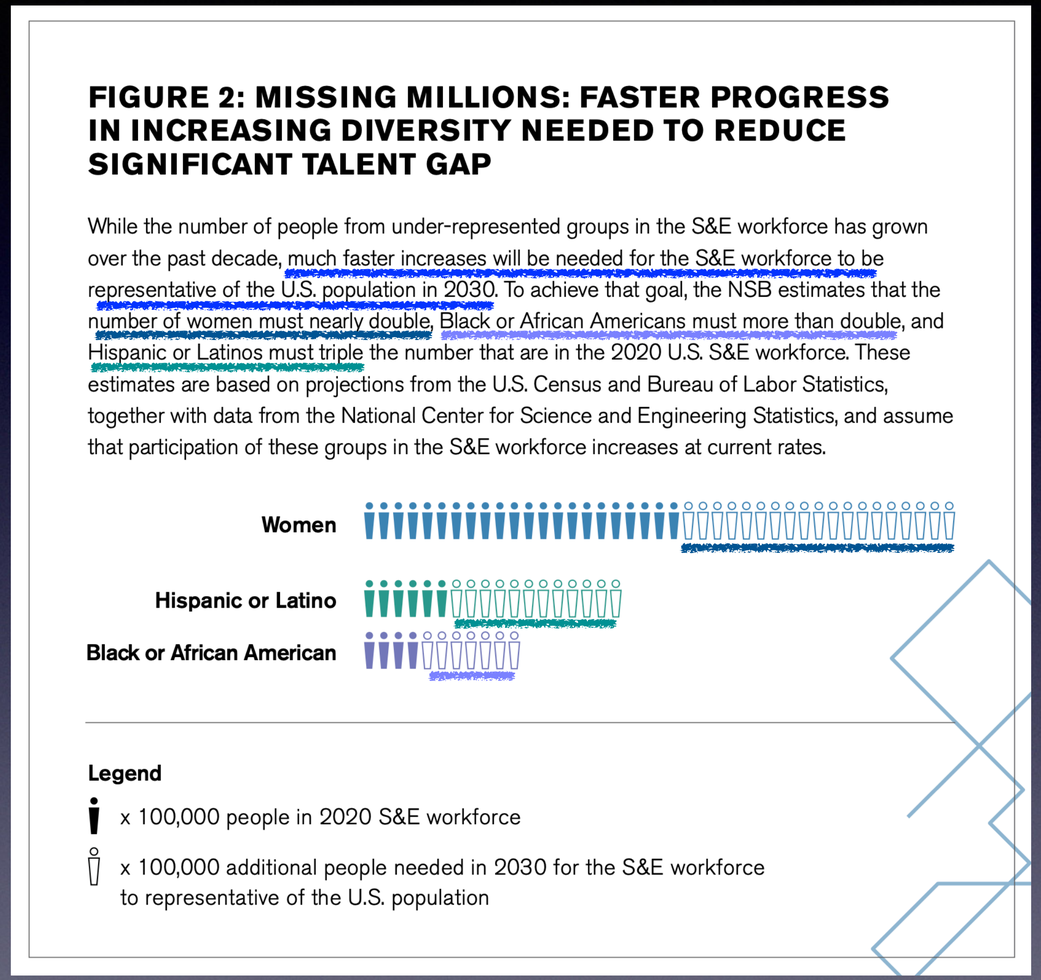
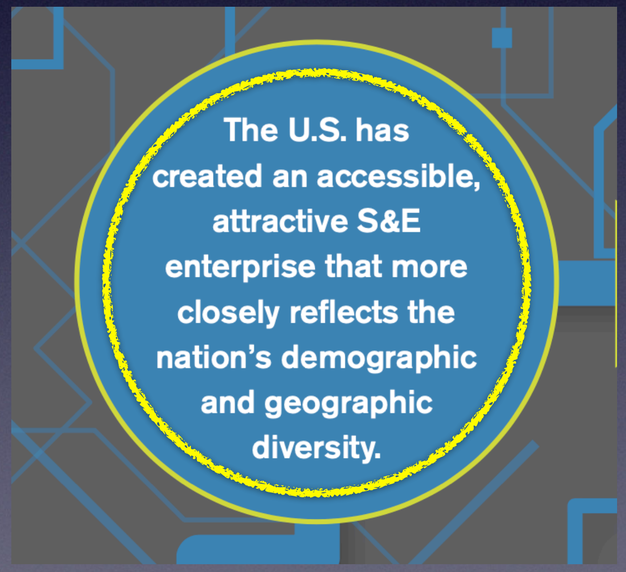


FIGURE 2: MISSING MILLIONS: FASTER PROGRESS IN INCREASING DIVERSITY NEEDED TO REDUCE SIGNIFICANT TALENT GAP

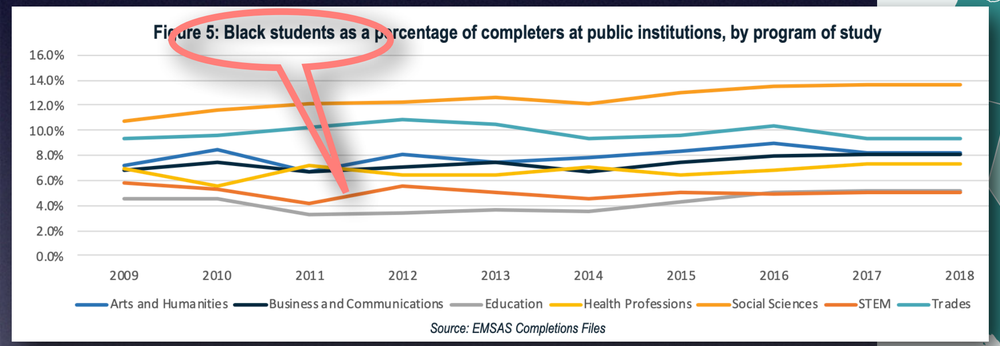
While the number of people from under-represented groups in the S&E workforce has grown over the past decade, much faster increases will be needed for the S&E workforce to be representative of the U.S. population in 2030. To achieve that goal, the NSB estimates that the number of women must nearly double, Black or African Americans must more than double, and Hispanic or Latinos must triple the number that are in the 2020 U.S. S&E workforce. These estimates are based on projections from the U.S. Census and Bureau of Labor Statistics, together with data from the National Center for Science and Engineering Statistics, and assume that participation of these groups in the S&E workforce increases at current rates.

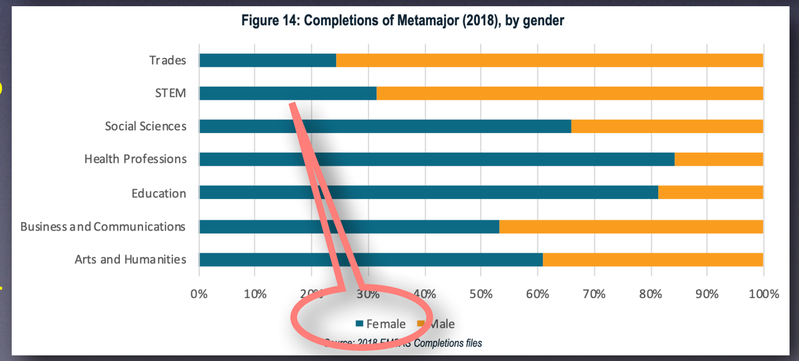


Regional Pressures to Increase & Broaden 4-Year STEM Degree Production to Meet Future Workforce Demands

The State of U.S. Science and Engineering 2022 report confirms that there continues to be large disparities in STEM education and student performance across demographic and socioeconomic categories and geographic regions.

e.g., STEM degree attainment disparities by race & gender persist …

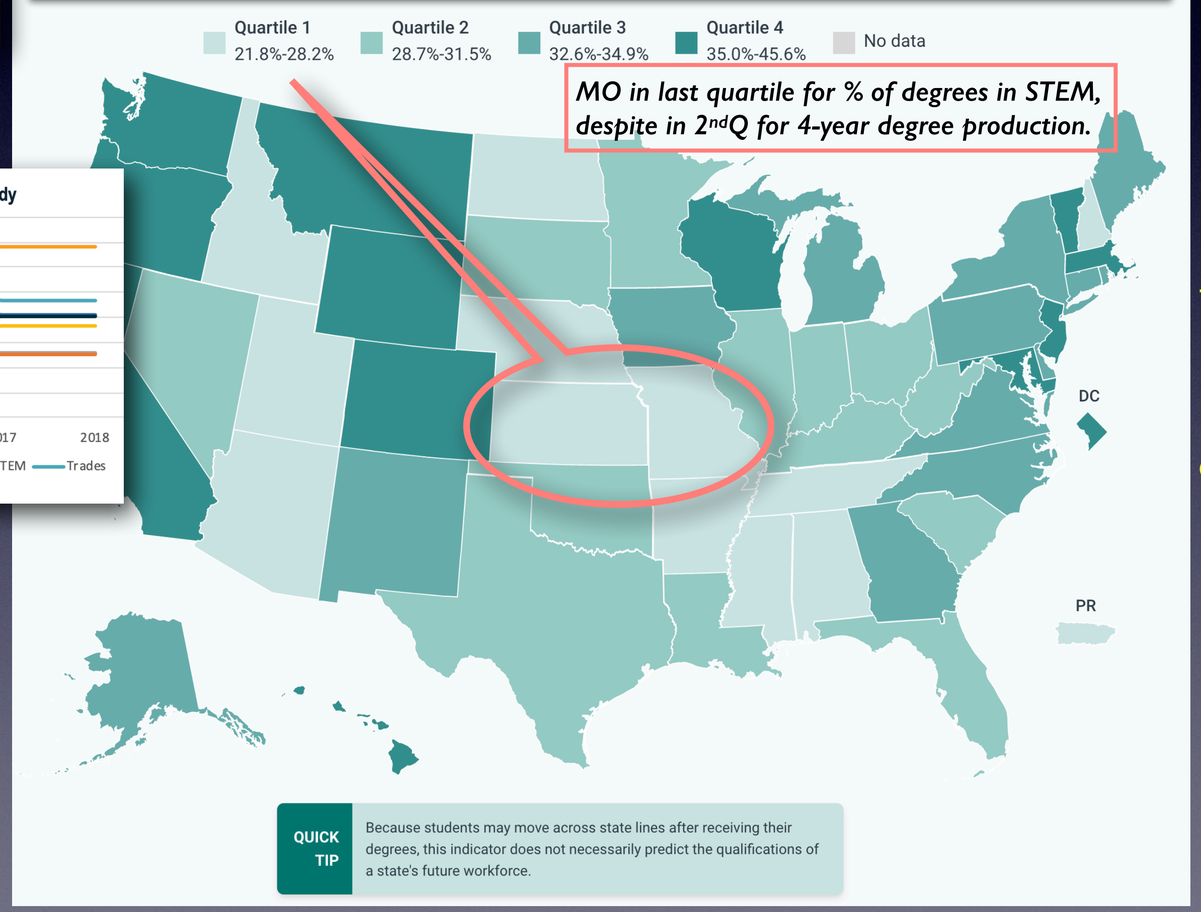




https://dhewd.mo.gov

Science and Engineering Degrees as a Percentage of Higher Education Degrees Conferred (latest data: 2019)

This indicator represents the extent to which a state's higher education degree awards are concentrated in S&E fields. S&E fields include the physical, life, earth, ocean, atmospheric, computer, and social sciences; mathematics; engineering; and psychology. Counts of both S&E degrees and higher education degrees conferred include bachelor's, master's, and doctoral degrees; associate's degrees and professional degrees are not included.

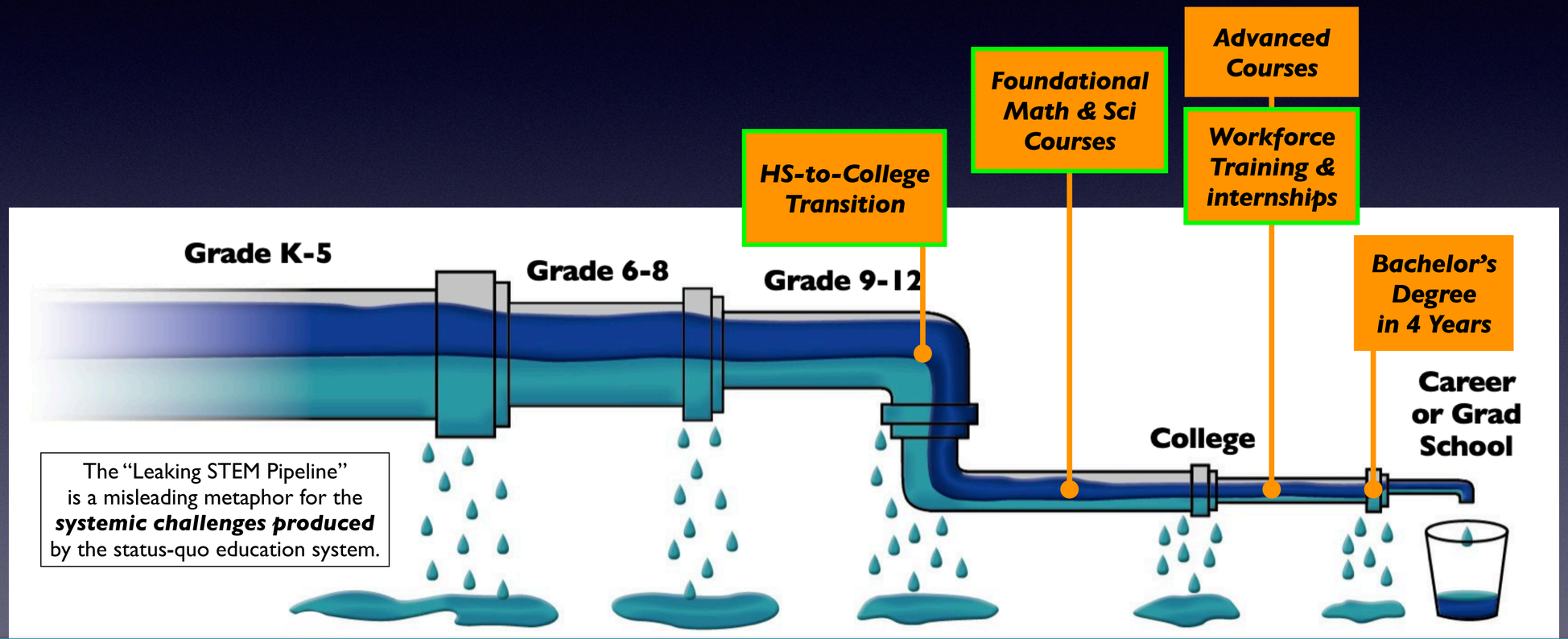


https://ncses.nsf.gov/indicators/states/indicator

Key Attrition Points to College Student Success in STEM

College Student Success: gain discipline-specific skills and content mastery, gain 21st century workforce skills, and graduate with desired Bachelor's degree.

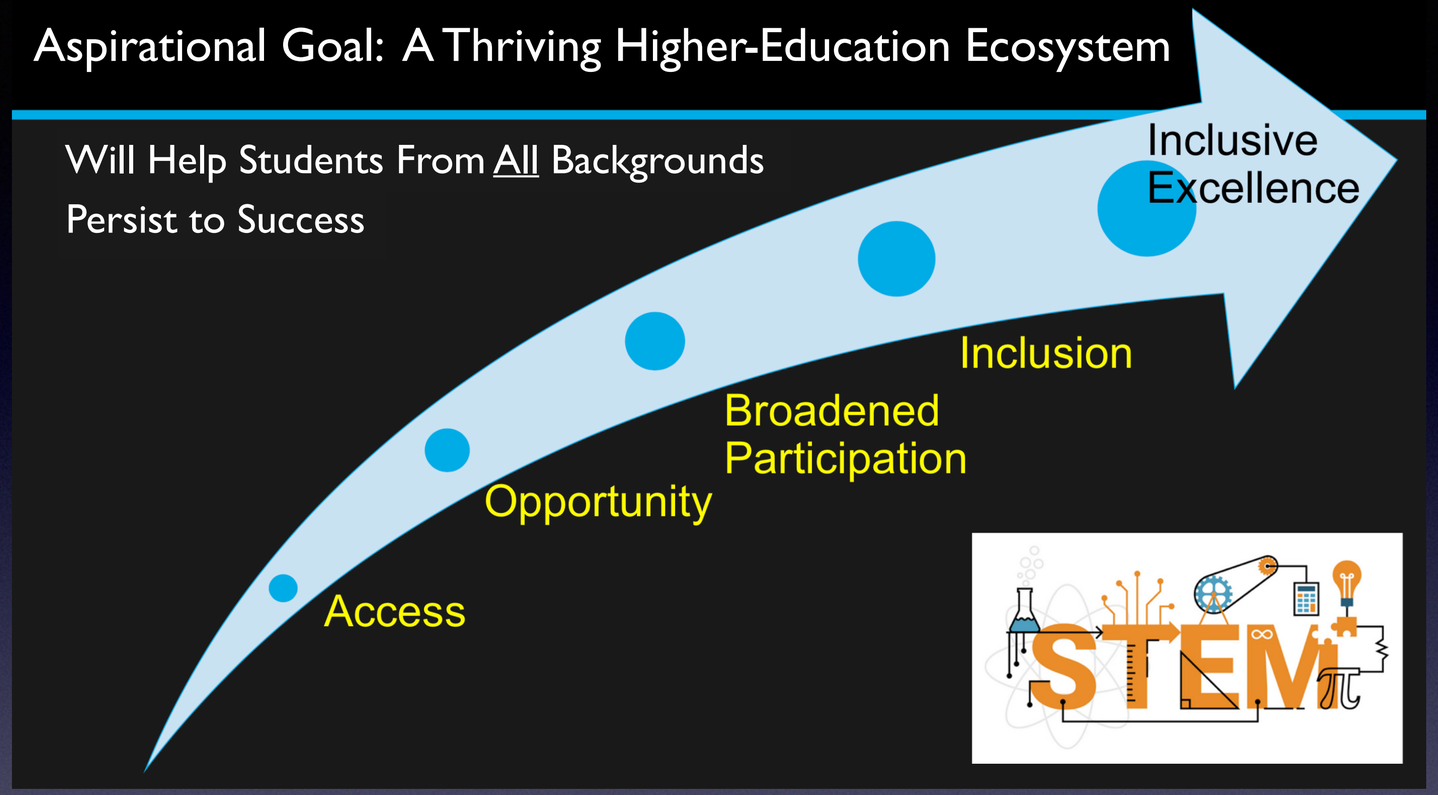
Addressing persistent challenges to growing, broadening, and better preparing the future STEM workforce.



Losses of students at every step of the STEM education pathway is disproportionately greater for underrepresented groups based on race, income, and gender.

Vision for Rethinking STEM Higher Education

Aspirational Goal: A Thriving Higher-Education Ecosystem

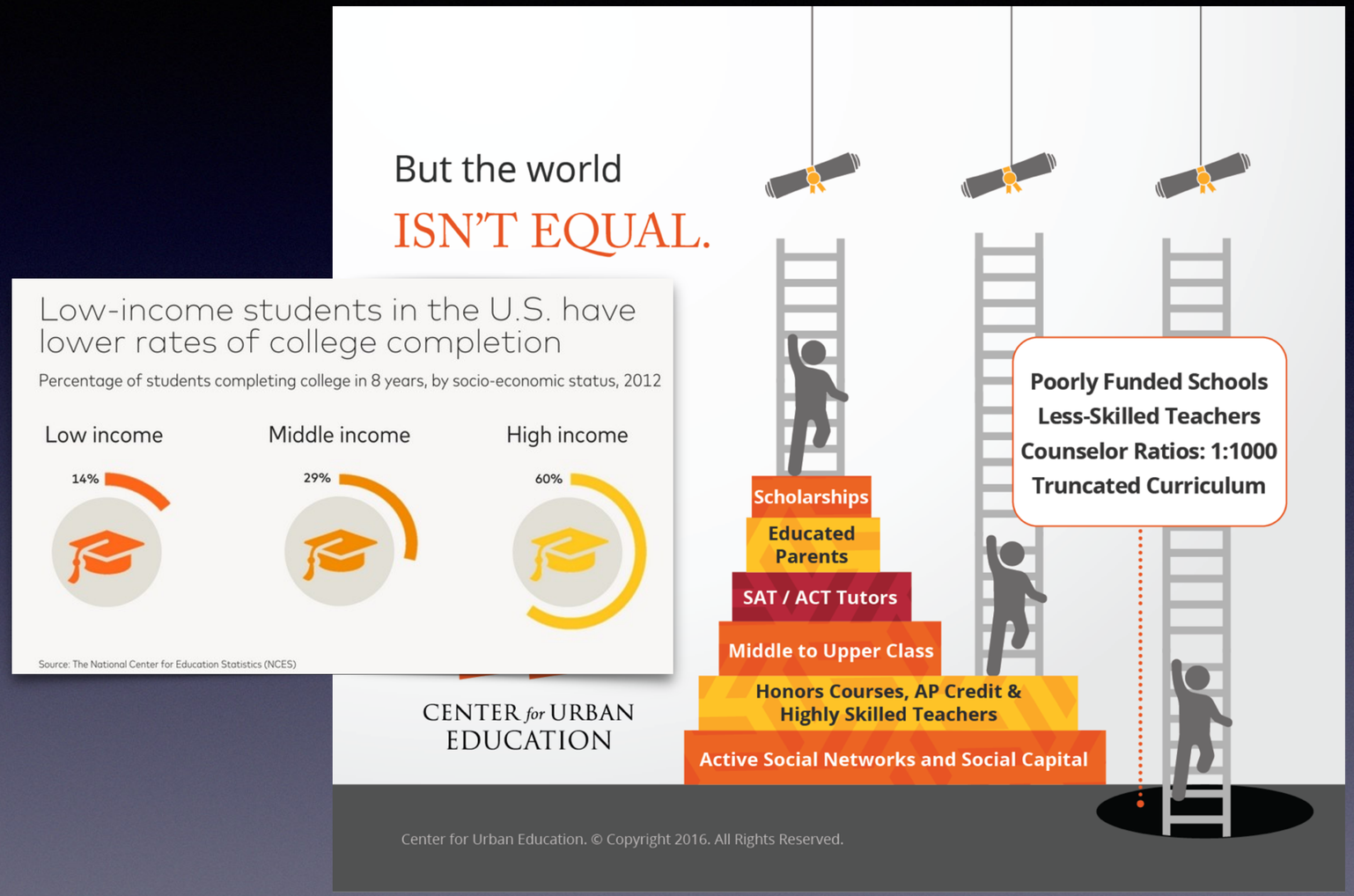


*To truly **broaden success**, we must do more than provide access to opportunity. We must encourage inclusive engagement in learning and STEM workforce skill development. The outcome will not only be vast improvements in equity, but a thriving educational system that helps all students achieve their full potential.*

1. Student-centered teaching (*intentional with regard to student engagement and learning outcomes*)
2. Equity-mindedness (*intentional with regard to fostering a sense of belonging and removing barriers to inclusion*)
3. Supporting faculty adoption and success with best practices (*intentional with regard to faculty roles and incentives*)

An Equity-Minded Approach

ABttS is intentional with regard to fostering a sense of belonging and removing barriers to inclusion:



- Scholarship selection is needs-based (>90% of participants have free/reduced lunch).

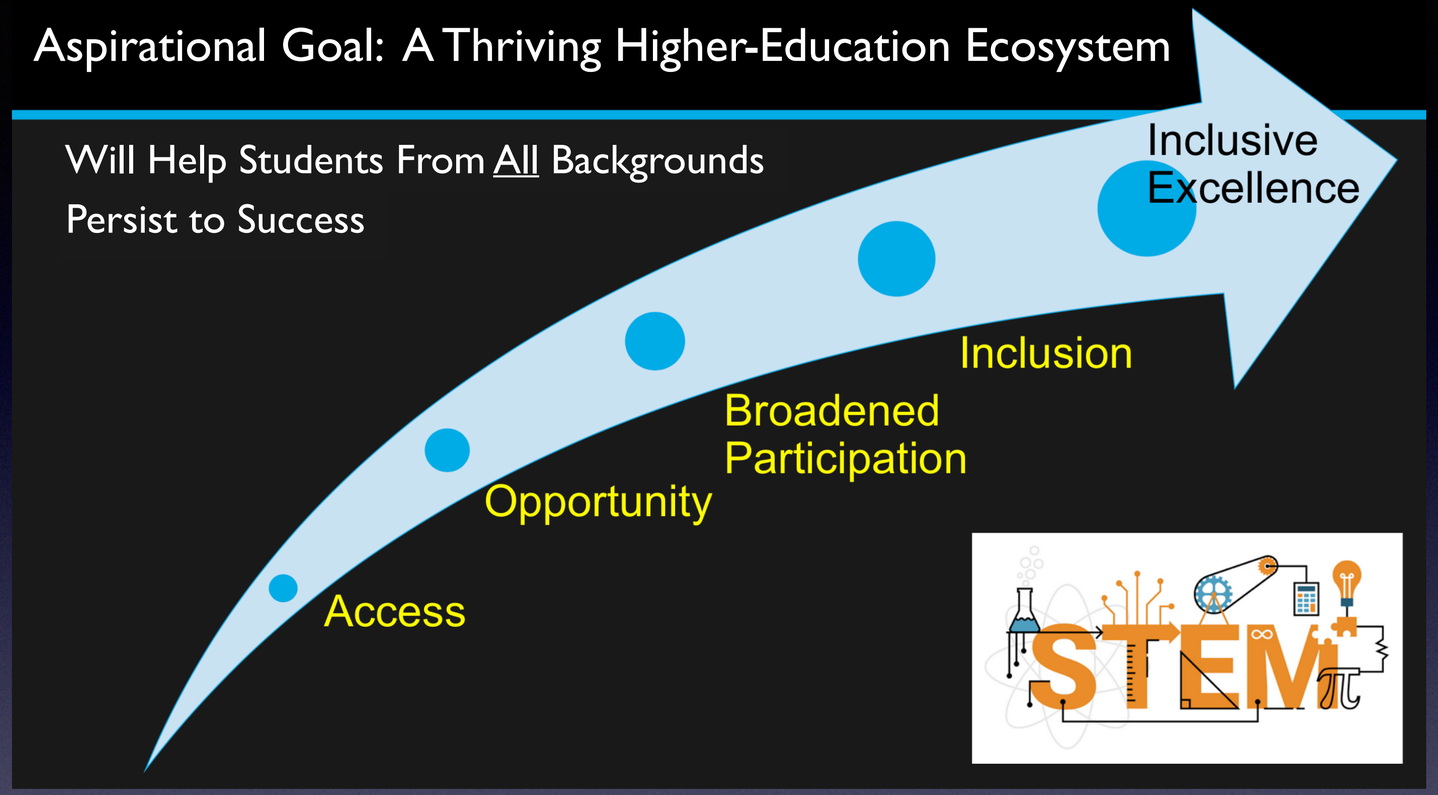
An Equity-Minded Approach

ABttS is intentional with regard to fostering a sense of belonging and removing barriers to inclusion:

- Scholarship selection is needs-based (>90% of participants have free/reduced lunch).
- Scholarship selection is based on aspirations rather than HS academic performance.
- Program focus is on student success utilizing evidence-based teaching & mentoring practices.

Vision for Rethinking STEM Higher Education

Aspirational Goal: A Thriving Higher-Education Ecosystem



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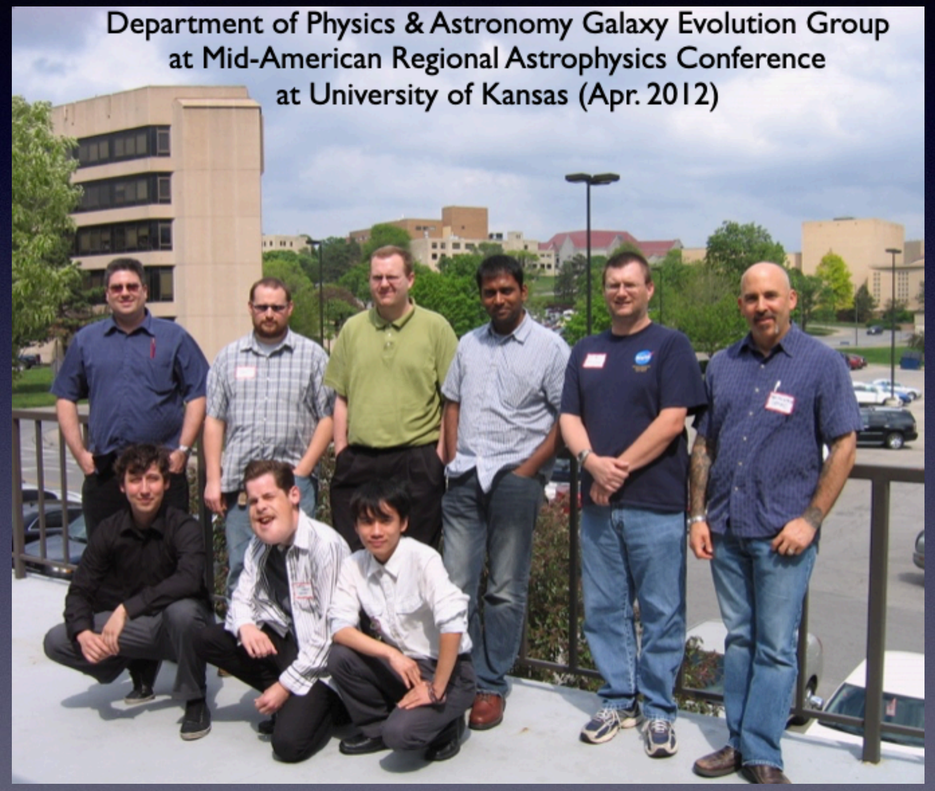
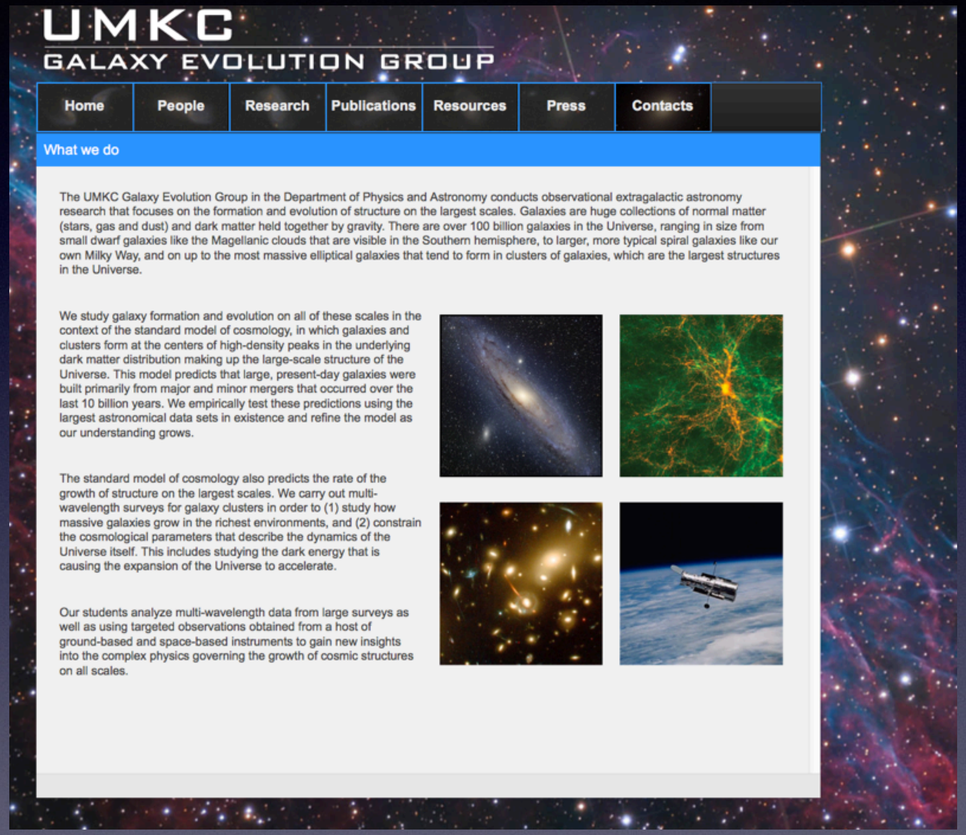
1. Student-centered teaching (*intentional with regard to student learning engagement & outcomes*)
2. Equity-mindedness (*intentional with regard to overcoming barriers to inclusion & to fostering a sense of belonging*)
3. Supporting faculty adoption and success with best practices (*intentional with regard to faculty roles & incentives*)

2022 Marks the 10th Anniversary of A Bridge to the Stars

10 years ago I was an Asst Prof focusing on building a new astronomy program at UMKC





2022 Marks the 10th Anniversary of A Bridge to the Stars

April 2012, the initial proposal to MO Space Grant Executive Board for increasing representation in STEM

The Pipeline: A Targeted Solution

Astro pipeline bridging minority students to STEM degrees/careers → scholarships for H.S. students to enroll in Intro Astro w/ a *professional* astronomer → recruitment of key target demographic

- Engaging/recruiting under-represented & disadvantaged minorities remains a critical problem in STEM.

Typical engagement solutions involve limited contact time with a broad audience (i.e., all students in a class or at a one-time event).

Typical recruitment targets college students, but cream of the crop are focused on more lucrative career tracks.

21st Annual Spring Meeting of the NASA-Missouri Space Grant Consortium (U.Missouri-Rolla) Apr. 20, 2012 Dr. Daniel H. McIntosh

A nascent guiding hypothesis: to increase representation by meaningful amounts requires engaging a larger pool of capable and curious students in meaningful ways.

The Pipeline: A Targeted Solution

Astro pipeline bridging minority students to STEM degrees/careers → scholarships for H.S. students to enroll in Intro Astro w/ a *professional* astronomer → recruitment of key target demographic

- My unique solution:

maximizes *my* impact - a dynamic, student-centered, concept-driven course
maximizes contact time (25 x 1.25h lectures)
maximizes science engagement of strong minority students before college
maximizes success by including UG mentor/ambassador scaffolding

21st Annual Spring Meeting of the NASA-Missouri Space Grant Consortium (U.Missouri-Rolla) Apr. 20, 2012 Dr. Daniel H. McIntosh

2022 Marks the 10th Anniversary of A Bridge to the Stars

2013 & 2014, established a network of partners

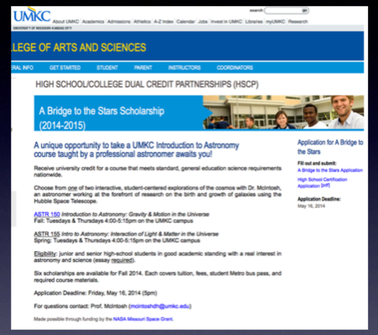
A Bridge to the Stars

- Developing *Bridge Network*

Partnerships established with:

KC Public Schools
KC STEM Alliance
PREP-KC
Science Pioneers
UMKC High School College Partnerships
UMKC Institute for Human Development

plus counsellors/administrators at
Hogan Prep. Academy
KCMSD South West Early College Campus
Lincoln Prep. Academy



23rd Annual Spring Meeting of the NASA-Missouri Space Grant Consortium (U.Missouri-Rolla) Apr. 25, 2014 Prof. Daniel H. McIntosh

2015, expansion to more local high schools with largely high-needs and URM student populations

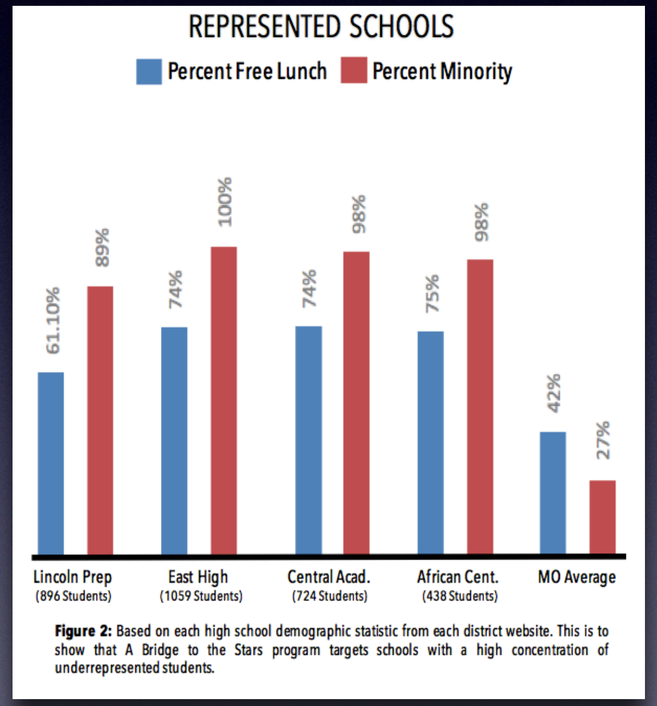


Figure 2: Based on each high school demographic statistic from each district website. This is to show that A Bridge to the Stars program targets schools with a high concentration of underrepresented students.

June 2016, first national conference presentation

Bridge Program Experiential Impact

mentoring sessions

Scholar F. Mohamed w/ *Mentor* B. Liles (Spr 2014)

Scholars C. Smith & D. Wooten w/ *Mentor* C. Gilliam (Spring 2013)

gain university credit

Scholars M. Crisp, E. Verge, A. Woolley, N. Ulloa, T. Lindsey, & F. Mohamed w/ *Mentors* C. West & B. Liles (Spring 2014)

STEM degree discussions

Scholars C. Holmes, V. Capadanno & A. Seawood (Spring 2016)

intern presentations

Mentoring Intern Linda Pham (Spring 2016) at MO Space Grant Annual Meeting

AAS #228 June 13, 2016 A Bridge to the Stars Prof. Daniel H. McIntosh

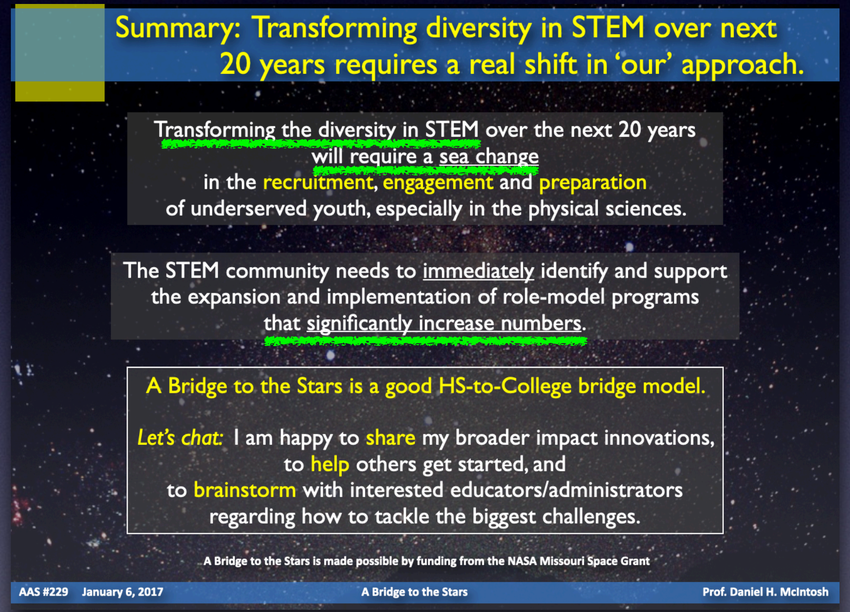
2022 Marks the 10th Anniversary of A Bridge to the Stars

2016, added an intern to develop web-based application and initiate longitudinal tracking

Apr 2018, intern poster at MO Space Grant Annual Meeting

UMKC Mentors, from left to right, Lauren Higgins, Jaime Crouse, Rubyet Evan (*former 2x Bridge Scholar!*), Osiris Hines.

Jan 2017, advocating at national conference for scaling up like-minded programs

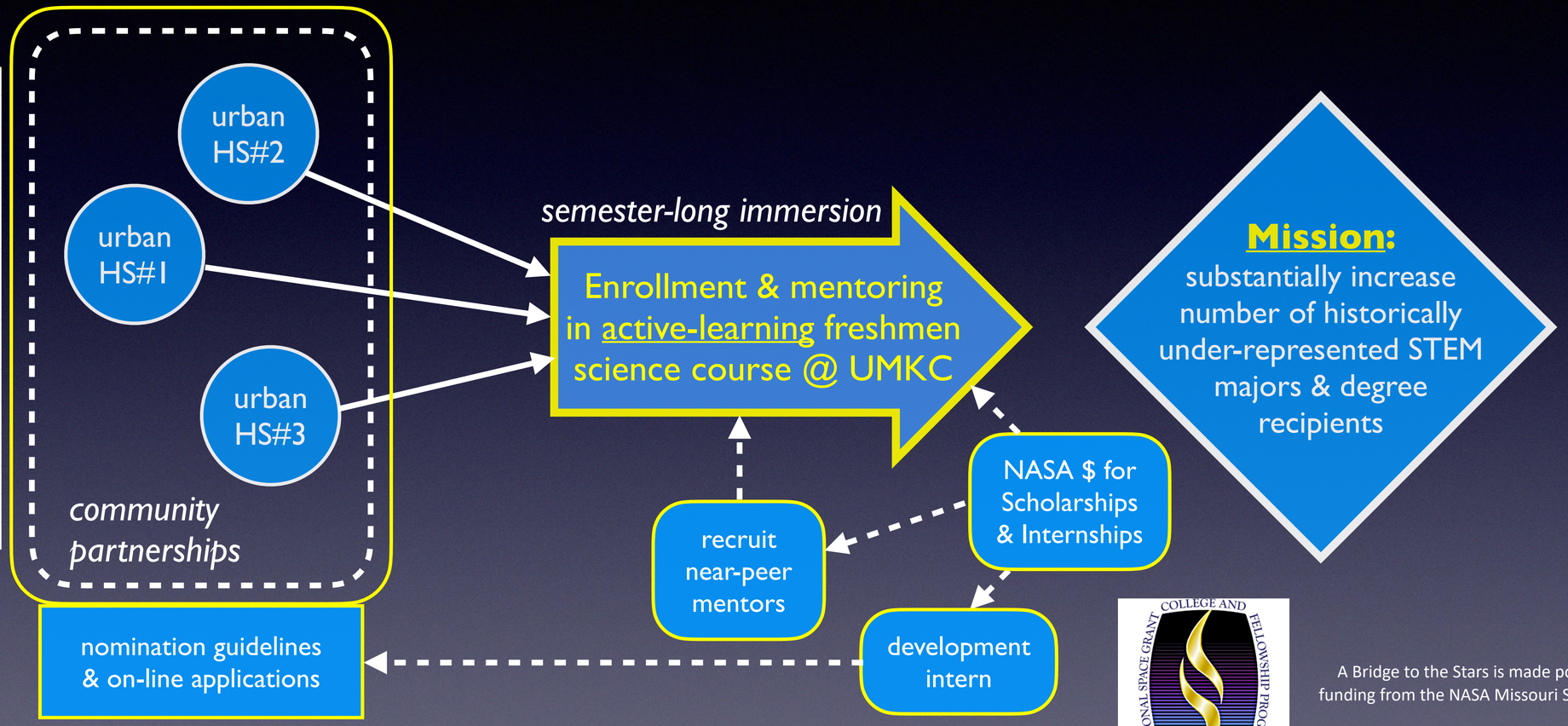


A Bridge to the Stars: Logistics

Fall Semester Promotion, Recruitment, and Enrollment

14 KC high schools

African Cen. Prep.
Allen Village
Blue Springs
Center
Central Academy
East High School
Frontier School of Excellence
Grain Valley
Grandview
Hogan Preparatory Academy
Lee's Summit West
Lincoln Prep
SWECC
University Academy

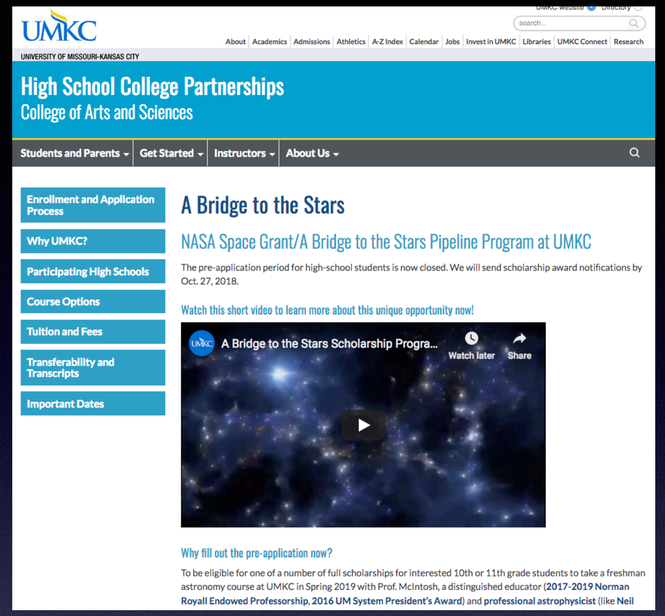


A Bridge to the Stars is made possible by funding from the NASA Missouri Space Grant

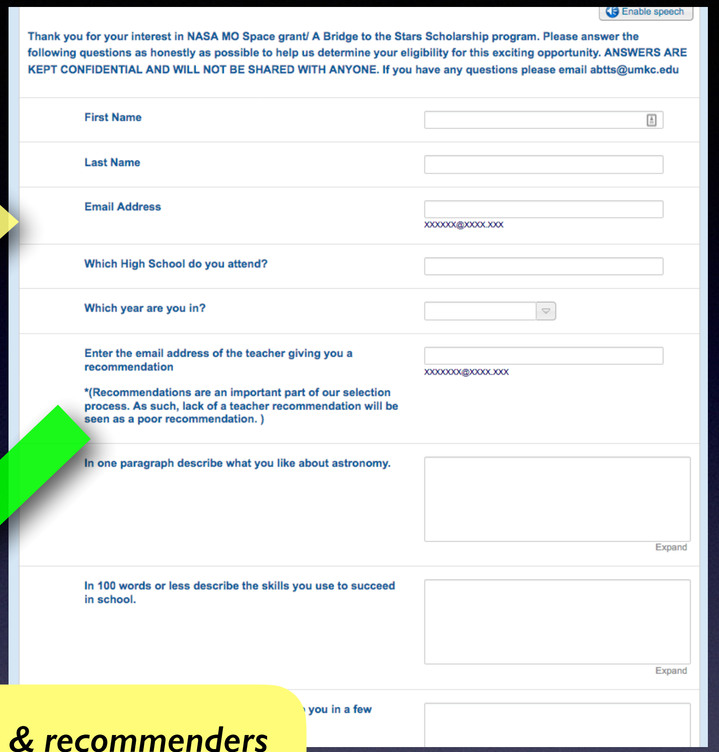
partners & infrastructure - - - - - - ▶

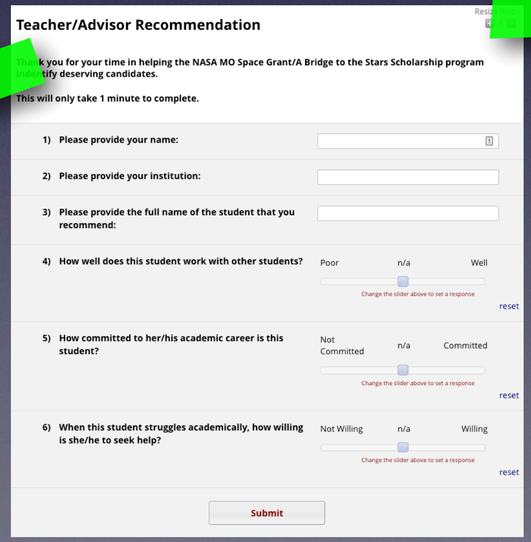
9th — 11th graders college & STEM aspirational ——▶

High-School Scholar Recruitment



https://cas.umkc.edu/areas-of-study/hscp/bridge-to-the-stars.html





+ email instructions to select HS contacts & KC STEM Alliance partners (due mid Sep)

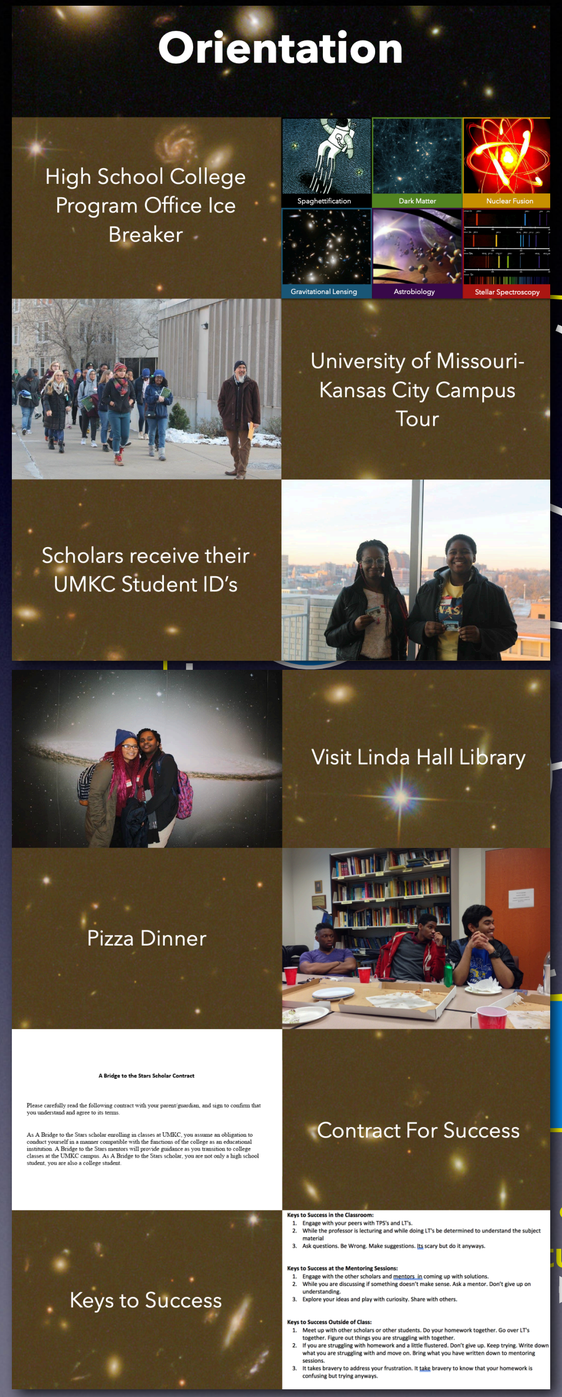
students & recommenders (due mid Oct)

awards to students (Nov 1)

registration & enrollment (w help from Registrars, HSCP)

A Bridge to the Stars: Logistics

Spring Semester Onboarding, Learning, and Offboarding



interactive experiential learning

early college experience

university science credit

scholarship line item for college apps

LinkedIn network

semester-long immersion

Enrollment & mentoring in active-learning freshmen science course @ UMKC

Mission: substantially increase number of historically under-represented STEM majors & degree recipients

pre-semester orientations

weekly near-peer mentoring

celebration & college prep advising

campus partnerships (HSCP, ASM)

long-term tracking (surveys, LinkedIn)

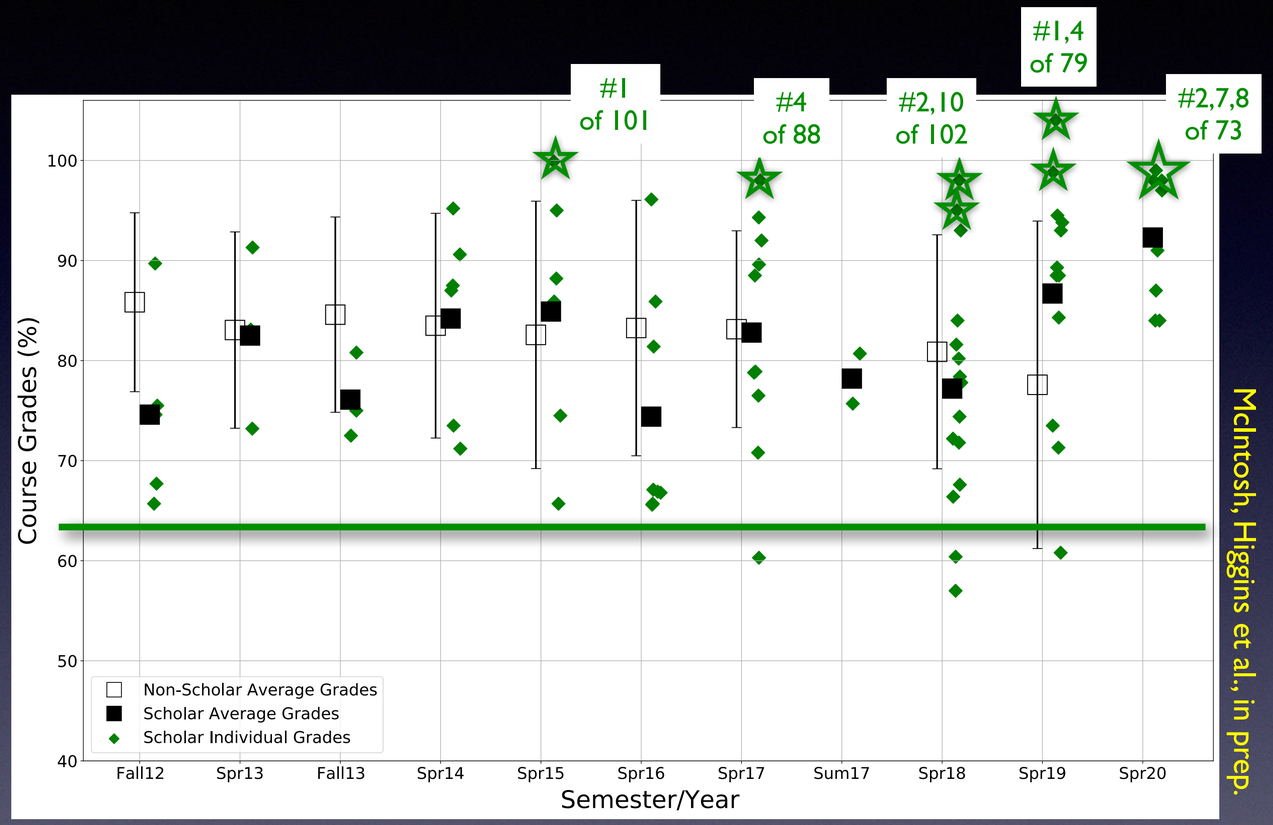
development intern

9th — 11th graders college & STEM aspirational

benefits to HS students

A Bridge to the Stars: Metrics of Success

- 81 tuition scholarships over 11 semesters
  (*73 unique students from 14 KC high schools*)
- equity-minded selection for participation
  (*70% URMs 70% non-male >90% low-$*)
- 95% success rate
  (*Scholar passed course, earned college credit*)
- confidence building & sense of belonging
  (*no achievement gap between Scholars and UMKC students enrolled in same courses*)
- Long-term tracking of former Scholars:
  (*40% of Scholars pursued/pursuing 4-year degree, 60% in STEM*)



McIntosh, Higgins et al., in prep.

- Scholar average course grades are same (~80%) as >800 'peer' UMKC students (*enrolled in same classes!*)
- Scholar course grade spread is similar to that of UMKC 'peers'

A Bridge to the Stars: Metrics of Success

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- ✦ Long-term tracking of former Scholars:
  (*40% of Scholars pursued/pursuing 4-year degree, 60% in STEM*)

(preliminary findings; data collection is ongoing)

Informal surveying within one year of program:

- 49% of Scholars (36 of 73) responded
  — 72% (26 of 36) of respondents planned to pursue a 4-year STEM degree

National Student Clearinghouse, surveying, and other data:

- at least 40% (29 of 73) of Bridge Scholars did pursue, or are pursuing, a 4-year degree
  — 59% of these in STEM, thus, 1/4 of all Scholars at a minimum
- 75% of Scholars known to be pursuing a 4-year degree have completed, or are on track to complete

A Bridge to the Stars: Metrics of Success

Select written feedback from surveying former Bridge Scholars:

"The program, the mentorship I've received, and the astronomy class itself has definitely given me the confidence that I needed to know that it is possible for me to succeed in a STEM field. I was always discouraged in the past because I was never really "good" at math, but the program has taught me that STEM goes beyond just math, and that there is always another side to the story (i.e. concept wise)."

"This program was my first look into what it felt like to be a college student. It realistically prepared me for college courses and the level of studying I would need to do. I am proud to have been granted the opportunity to take the course."

"I believe that A Bridge to the Stars has helped me by giving me a deeper understanding of how college works. … This program gave me connections to an abundance of great people, and I would definitely recommend this to everyone that has the opportunity to take. Overall I appreciate Professor McIntosh, I believe he was a wonder professor and everything he taught me stuck with me!"

Success Factor #1: Active Learning

ABttS is intentional with regard to student engagement and learning outcomes.

Following 4 guiding principles of quality implementation:

Bridge Scholar's typical learning experience:

Roughly half of lecture time in activities carefully-designed for student practice with peers on higher-order thinking and problem solving in the presence of their instructor.

collaborative active learning

authentic

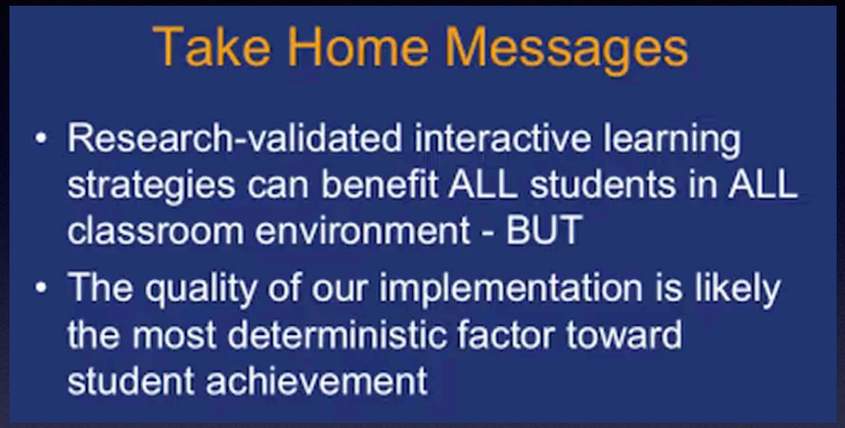
frequent

inclusive

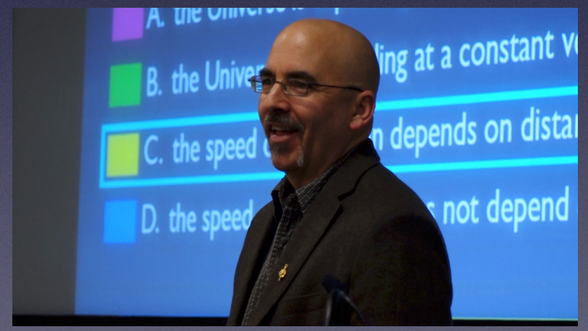
encouraging

Active Learning is Learner-Centered Teaching

Specifically: utilize carefully designed activities that intellectually engage students in rich collaborative discussions and practice with peers on key higher-order thinking and problem-solving difficulties in the presence of their instructor.



Edward Prather, Director
Center for Astronomy Education (U Arizona)



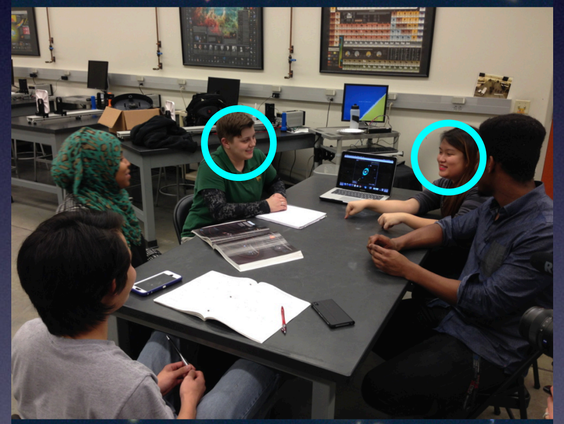
Happy to share during Q&A an example of active learning from a student perspective.

Success Factor #2: Near-Peer Mentoring

ABttS is intentional with regard to student engagement and learning outcomes.

Mentoring Sessions

- Applied Study Habits
  - Lecture Tutorials
  - Think-Pair-Share
  - Practice Exams
  - Post Exam Review



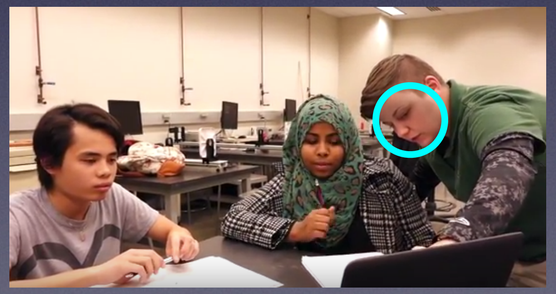
- Peer-Peer Mentoring
- Mandatory Weekly
- Dynamic Guidance
  - Active Feedback
  - Adapt Quickly
  - Weekly Check-Ins

Near-peer mentoring: 21 UMKC students from 9 degree programs

Top left: Scholars and Mentors in front of image of Galaxy in Linda Hall. **Top right:** Mentors Jaime, Rubyet, and Osiris by the Galaxy Image at Linda Hall Library. **Bottom left:** Dr. Mcintosh with scholars outside of his Office. **Bottom right:** Jaime with scholars at Lind Hall Library.

Bridge Mentors

High-school Scholars & UMKC Mentors (Spring 2017).



High-school Scholars & UMKC Mentor (Spring 2014).

Program Challenges and Key Lessons Learned

Hypothesis behind A Bridge to the Stars:

To increase representation by meaningful amounts requires engaging a larger pool of capable and curious students in meaningful ways.

- Running a program like this is a significant (~10%) time commitment for a STEM faculty member.
- Continuous evaluation of a program like this requires additional workload and proactive planning.
- Status-quo HE promotion and merit practices do not adequately account for the faculty workload.

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- Maintaining a network of HS contacts is a major barrier to consistent recruitment.
  — target schools have especially high turnover rates
- Sustaining and scaling programs like this is beyond the capacity of typical faculty roles and responsibilities.

Long-term Goal: Help Others Adopt Similar Programs to Substantially Increase STEM Representation

NSB: "… *much faster increases will be needed for the S&E workforce to be representative of the U.S. population in 2030.*"

Tried approaches for scaling this pre-College broadening STEM participation model:

- [no success] Grassroots advocacy to STEM faculty at national conferences:

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effectively combine your service and teaching efforts
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establish a visible program that your upper admin will find positive

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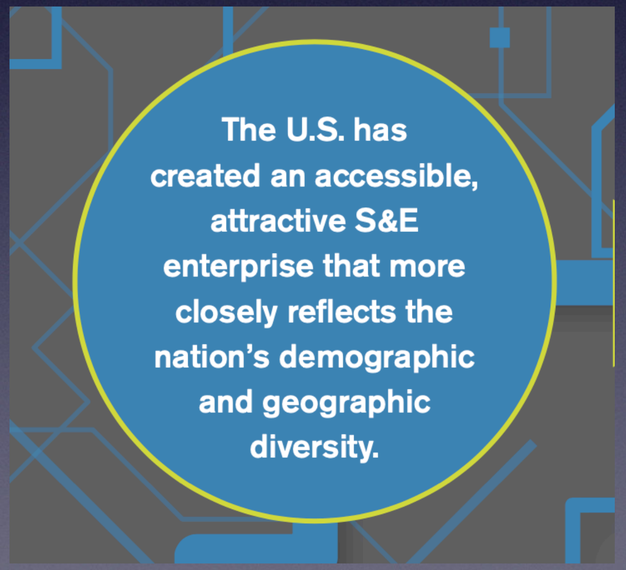

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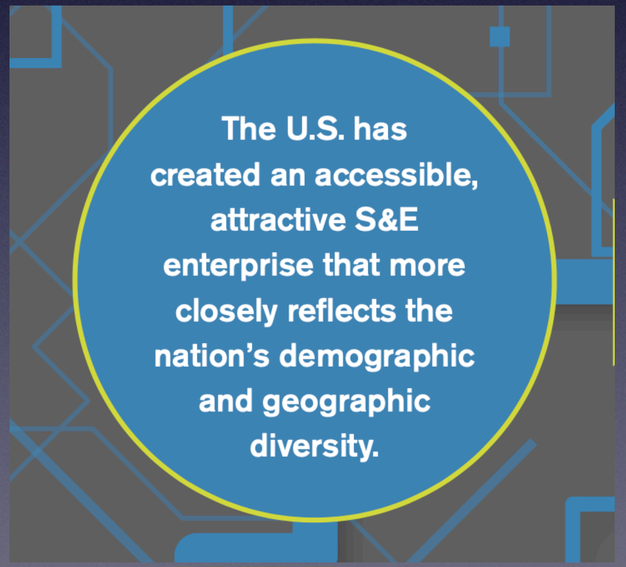

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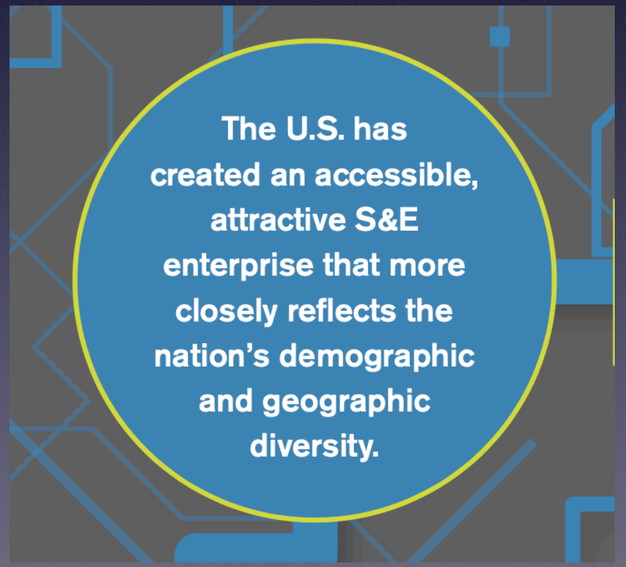

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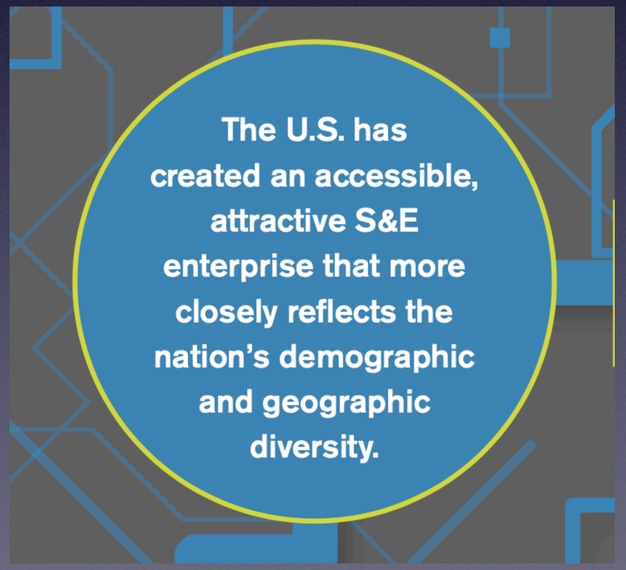
Necessary ingredients for scaling this pre-College broadening STEM participation model:

- Institutional leadership is essential for scaling across multiple disciplines.
  — increased enrollment is the leverage for program sustainability

- Gen-Ed science courses scheduled during AY semesters after normal HS hours.
  — recommend phasing in new STEM disciplines



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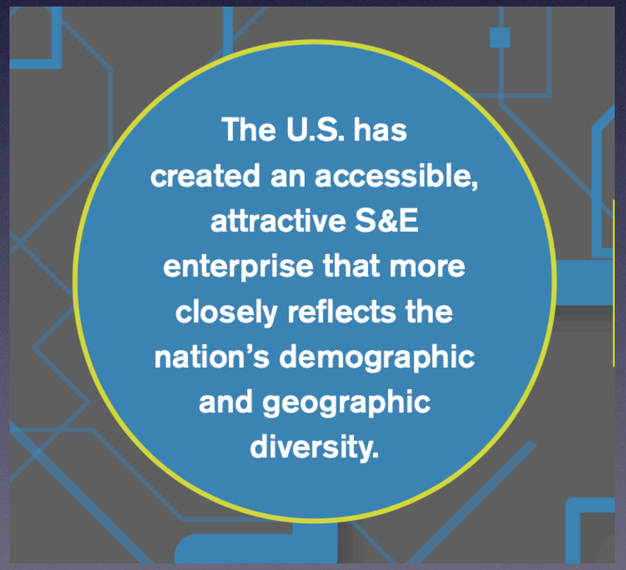

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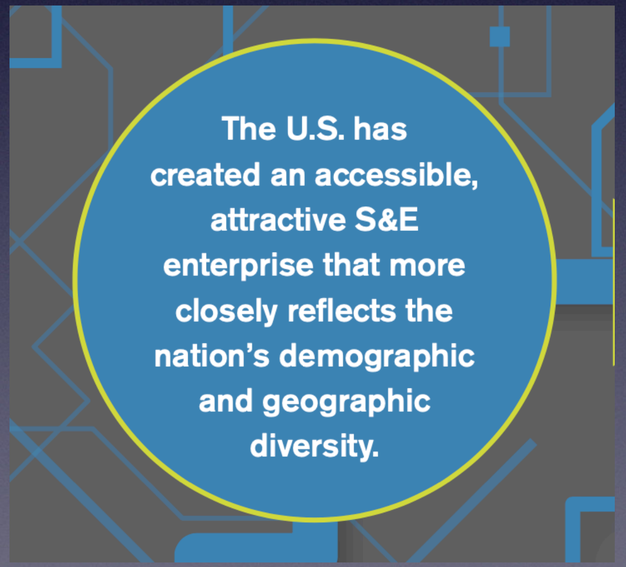
- Dynamic faculty instructors with the commitment and passion for helping students learn using evidence-based practices.
- Equitable accounting of the additional faculty workload (~10%/semester)*:
  — recruit, select, and supervise UG mentoring interns from an available candidate pool
  — oversee the recruitment and selection of HS participants
  — coordinate with campus offices in charge of scholarships, enrollment, etc
  — coordinate pre-semester orientations and end-of-semester celebrations
  — provide HS student college preparatory advising

* Much of this work could be assigned to admin support.



Summary

This equity-minded initiative is designed to give historically underserved and underrepresented 10th & 11th graders an early-college experience at UMKC through tuition support, enrollment, and near-peer mentoring in a student-centered introductory astronomy course.

Benefits participants with an immersive, confidence-building experience to increase the likelihood that they matriculate to college and persist through their crucial first year.

High-school Scholars & UMKC Mentors (Spring 2017).

A Bridge to the Stars: https://cas.umkc.edu/areas-of-study/hscp/bridge-to-the-stars.html

- Successful 10-year program provides a role model for broadening the successful transition from HS to College (in STEM or non-STEM).
- My long-term goal is to scale and sustain the adoption of similar programs across my campus, across Missouri, and across the U.S.
- I welcome feedback and collaboration …

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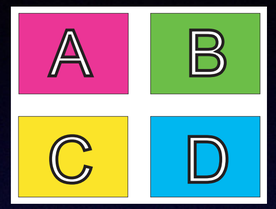
A Bridge to the Stars is made possible by funding from the NASA Missouri Space Grant

extra slides for 3/17/22

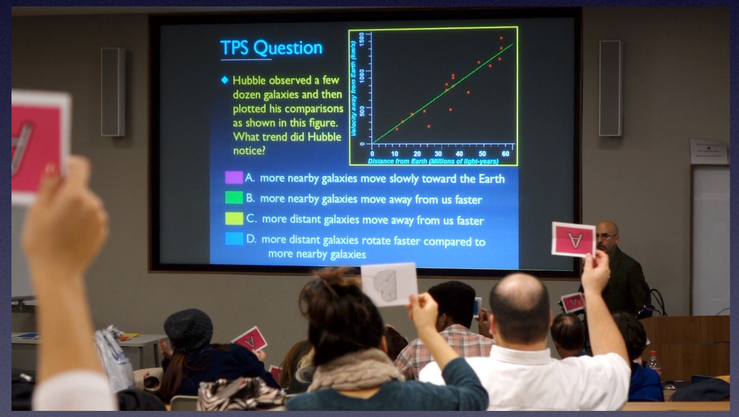
Guide to Adding Active Learning to Existing Lectures

Keep it simple!



E.g., a great starter strategy: Think-Pair-Share questions

- Easy to implement in large-enrollment, face-to-face or even asynchronous online courses.



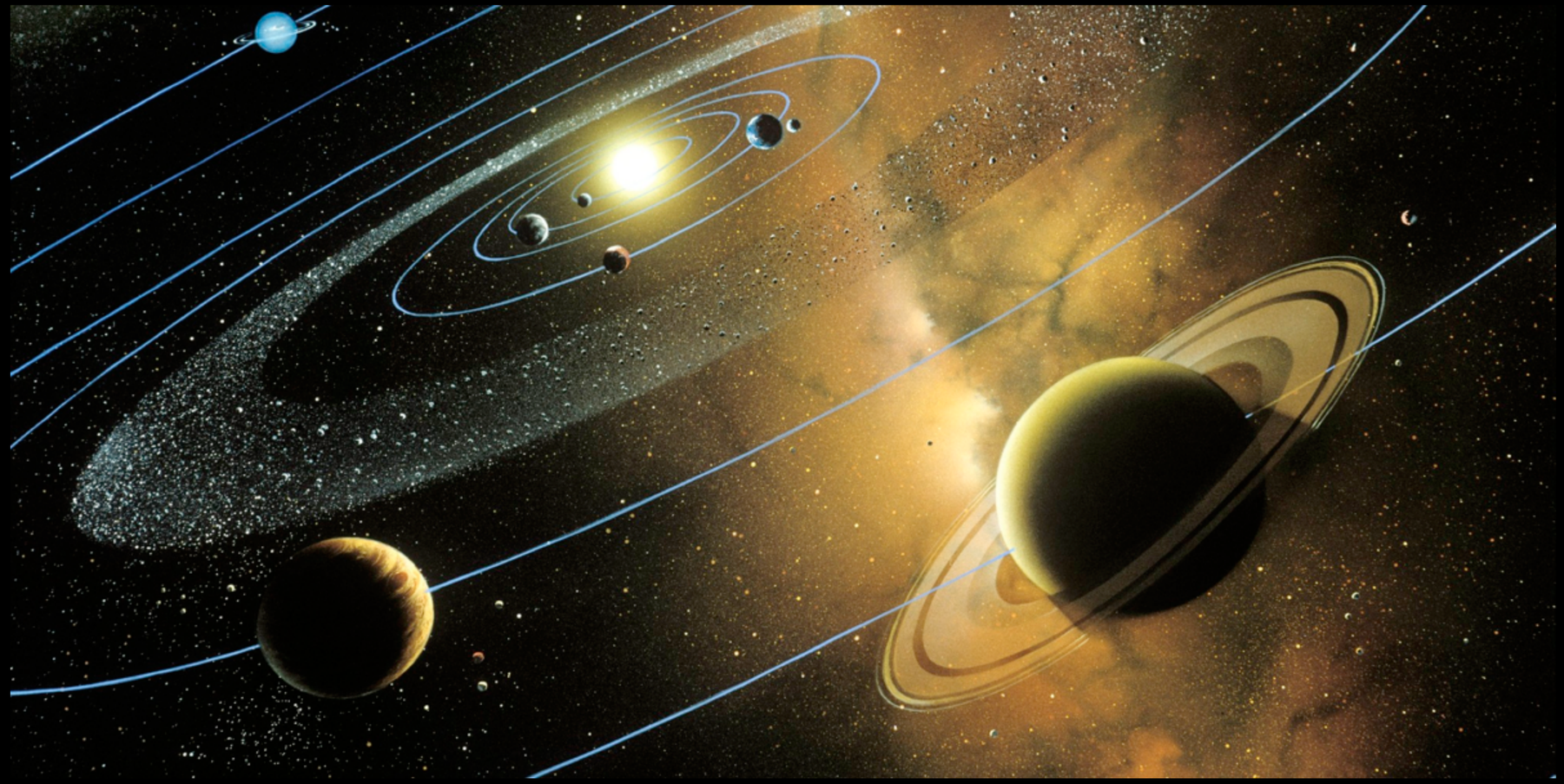
A B C D

Utilize TPS in existing lecture or unit on a topic.

Unit: A Unique Tour of Our System

Clues to Earth's Formation

A grand tour of the Solar System's large "worlds" reveals many clues to how the Earth and the rest of Sun's family of planets, moons, asteroids & comets formed 4.6 billion years ago.



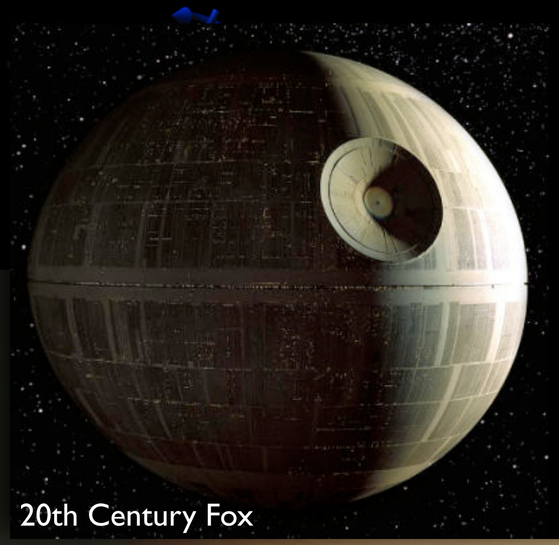
A B C D

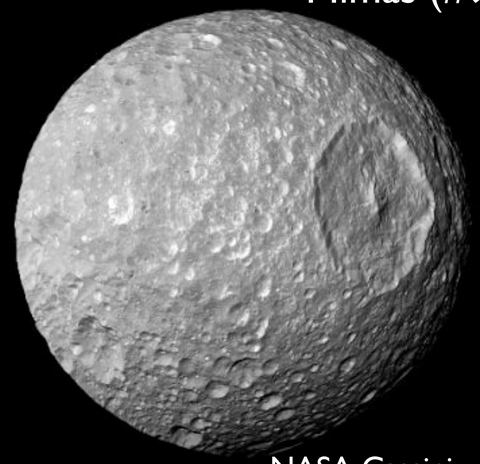
Set up TPS with a mini lecture to introduce new topic.

Saturn

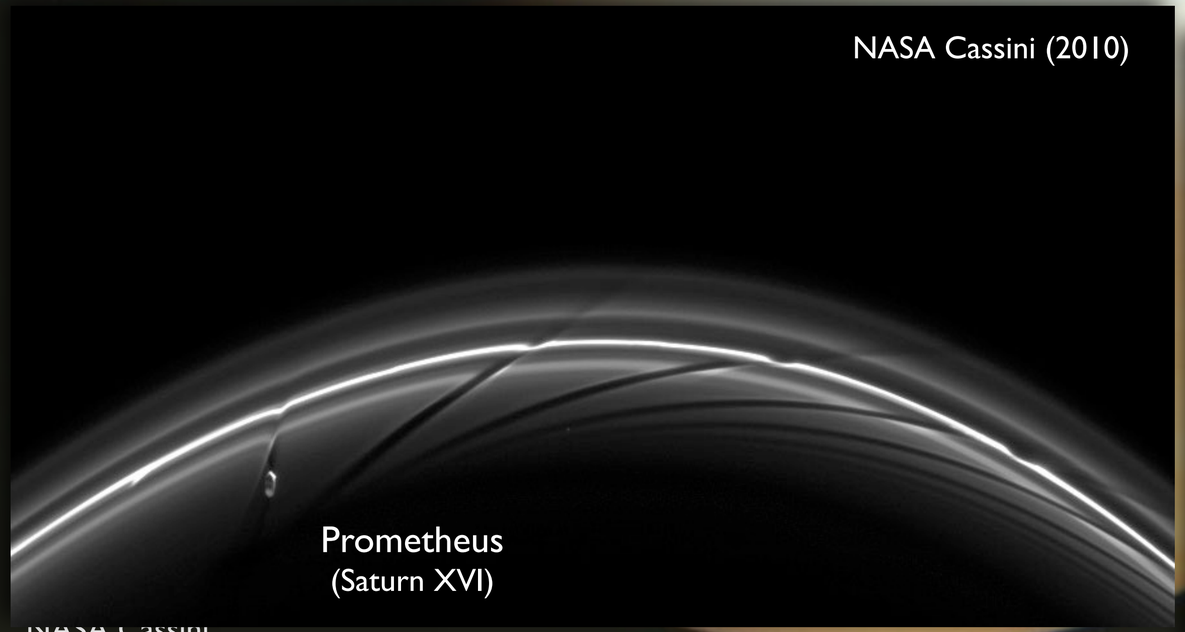
Atmosphere: thick (mostly H)
Composition: H ice, rock, metal
- Moons: 82 (ice, rock)
- Rings: yes (water ice)

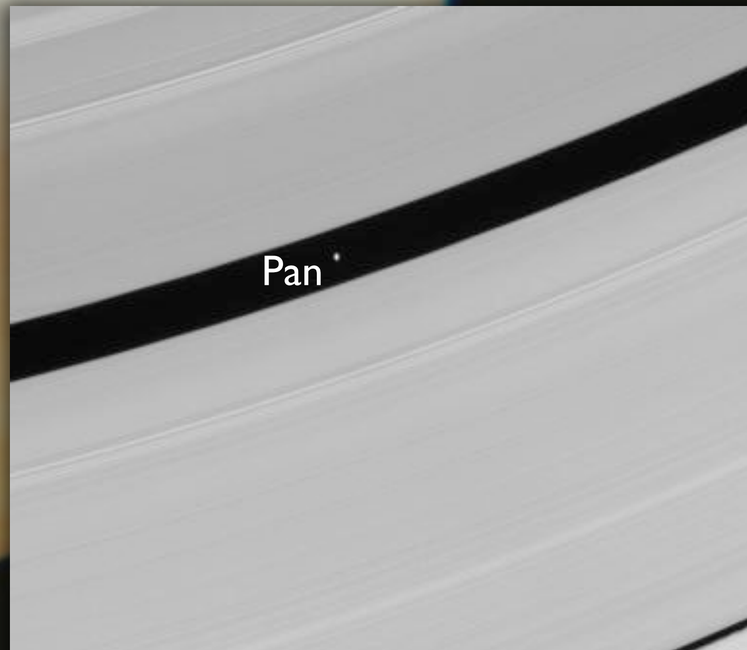
#2
116,464 km
9.1 Earths


20th Century Fox


Mimas (#96)
NASA Cassini

moons all orbit in same plane as the rings


NASA Cassini (2010)
Prometheus
(Saturn XVI)
NASA Cassini


Pan

TPS Question

"Techniques provide the framework, the structure, the context. What really matters is what we put in the structure — what students are thinking about and sharing when they're pairing."

from Weimer, *Deeper Thinking about Active Learning*, in Faculty Focus, Feb. 2018

- The composition of most moons around large planets is _____ and the composition of moons around small (terrestrial) planets is _____ .

A. more like comets, just like the host planet

B. more like comets, more like asteroids

C. just like the host planet, more like asteroids

D. more like asteroids, more like comets

Use a TPS question to assess student comprehension and to initiate rich peer discussions.

TPS Process: (1) pose question, give time for students to read question and answers
(2) prepare class to vote together on answer … "prepare your vote, ready, 1-2-vote!"
(3) if >85% correct, show answer and move on, otherwise ask students to ***pair & share***
(4) let peer discussion run until it starts to die down … "pause, let's revote, 1-2-vote!"
(5) repeat as needed until reach >85% consensus

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TPS conclusion:
Reveal answer, provide additional info for studying, address open questions.

Comets: composition mostly ice (*frozen Hydrogen compounds like water, methane & ammonia*)

Asteroids: composition mostly rock (*elements like oxygen & silicon*) and metal (*elements like iron & nickel*)