STEM Competitions as Broader Impacts

MATT JOHNSON
NABI SUMMIT
MAY 2, 2019

This is intended to be a working session

Describe STEM competitions and how they are potential broader impact programs

Describe two STEM challenges we use as broader impacts programs

Work in groups to identify existing competitions

Work to identify goals and relevant assessments

Establish an affinity group for those interested in thinking about these issues further

Our group is a broader impacts center housed in the College of Education

- Collaborate with all five STEM colleges at Penn State
- Propose, implement and evaluate
- Core + soft funding
- Director, admin, 3.5 education specialists, 1.5 outreach liaisons
- Experience in STEM plus education
- Programs are based on current STEM education recommendations

PennState

CSATS Center for Science and the Schools

Kid Wind

National program

Online and brick & mortar

National competition in Houston at the American Wind Energy Association (AWEA) annual tradeshow

Middle school and high school divisions

CSATS holds an annual KidWind teacher workshop

CSATS KidWind Workshop Agenda Dr. Susan Stewart, Amber Cesare, and Gabe Knowles October 25, 2018	
9:00 am	Welcome, complete paperwork including Act 48 forms and pre-test, and breakfast.
9:15 am	**Energy Card Sort** Goal: Teachers will learn about different types of energy production and energy transformation.
9:45 am	**Windmill Component Stations** Goal: Teachers will learn about the components and functions of a wind mill in order to understand how wind energy is converted to electricity.
10:45 am	**Floating Break**
10:50 am	**Parametric Analysis of Blades: "Which blades are best?"** Goal: Teachers will work in teams to test pre-made blades for a model wind turbine and demonstrate an understanding of how wind energy is converted to electricity. Mini-Lesson: Electricity 101: How does a volt meter work?
12:00 – 12:30	**Lunch**
12:30 pm	**Finish Parametric Analysis of Blades: "Which blades best?"** **Debriefing: Discuss data and results from experiment**
1:00 pm	**Susan Stewart to speak**
1:30 pm	**Design your own blades** Goal: Teachers will work in teams to design and test their own blades for a model wind turbine.
2:20 pm	**KidWind Wind Challenge and Wind for Schools Program** Goal: Teachers will learn about the KidWind Wind Challenge, what is involved in the Challenge, and how teachers can register their students.
2:30 pm	Wrap Up: Complete post- test, class evaluation

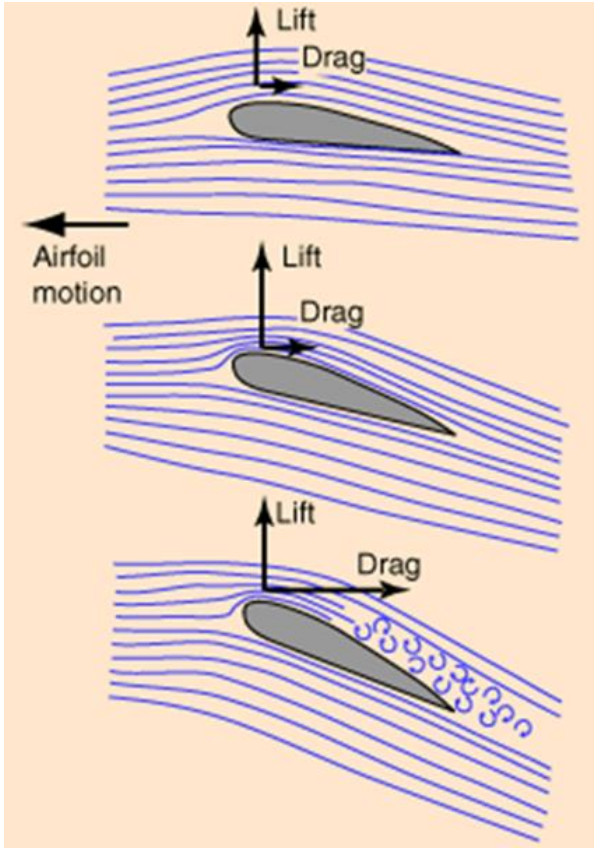
Uses project-based teaching to engage students in practices to learn content

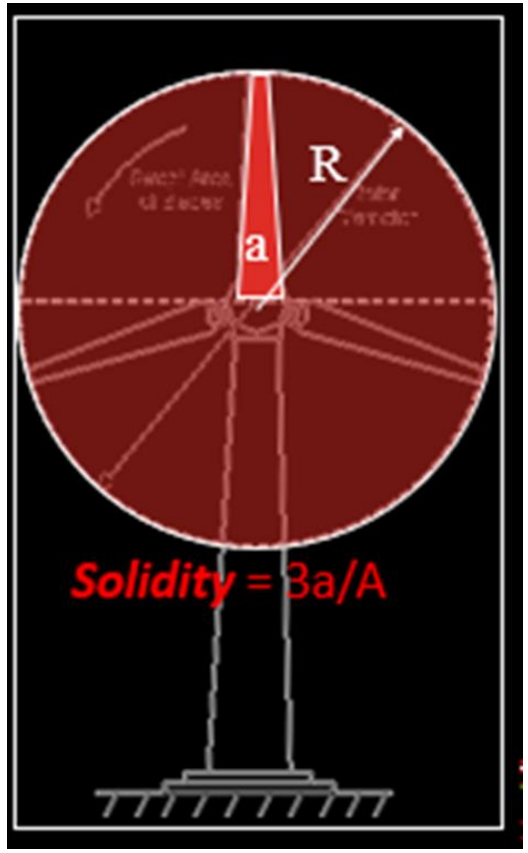
Science content:

- Energy
  - Conversion
  - Electrical circuits
  - Vs. Power
- Forces
  - Lift
  - Drag

Engineering practices

- Optimization
- Balancing trade-offs
- Iteration/improvement
- Applying science/math content



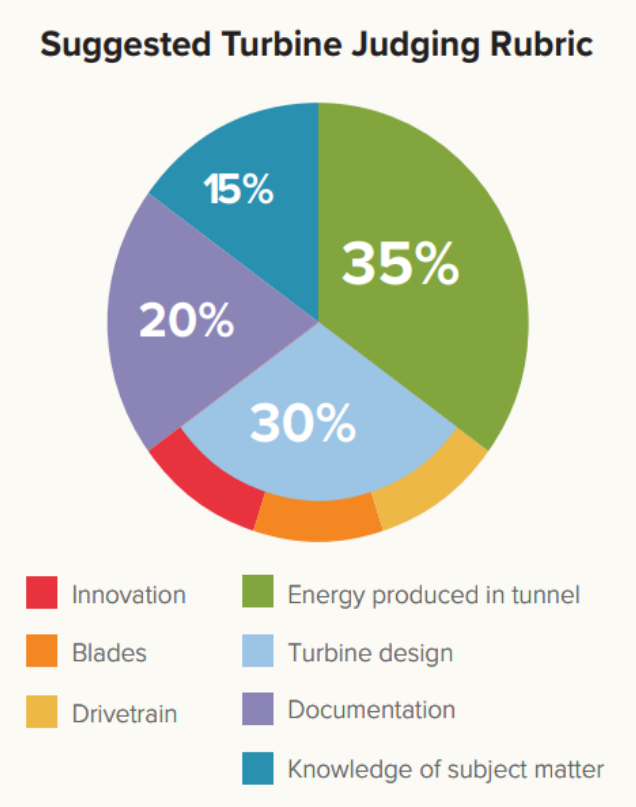


Turbine Testing Procedure

During performance testing sessions

- 2 minutes to set up your wind turbine inside the tunnel
- Wires at the base of your turbine will be attached to a circuit with a 30 ohm resistor
- The tunnel test will run for 60 seconds.
- We will collect power output data during that time using a Vernier data-logging system
- Once tunnel is activated, your wind turbine must be able to produce power without external assistance
- You will be given one restart or retest opportunity. It may be granted after all others have had their initial tests.

Judging criteria



- Energy Produced (35% of score)
- Turbine Design (30% of score)
- Written documentation (20% of score)
- Knowledge of Subject Matter (15% of score)

Students test their wind turbine design at the Pennsylvania Wind for Schools Program KidWind Challenge held in the HUB in April.

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PA Kidwind Challenge

Constellation Energy

TE connectivity

2012	2013	2015	2016
Park Forest Middle School	Londonderry School	Mt Nittany Middle School	Bald Eagle Area High School
State College, PA	Harrisburg, PA	State College, PA	Bellefonte, PA
7 teams	8 teams	23 teams	16 teams

2017	2018
Penn State UP Pictures from last year	Penn State UP
University Park, PA	University Park, PA
25 teams	35 teams

A student wind turbine design at the KidWind Challenge

women of wind of ENERGY

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Wind for Schools

KidWind Program Evaluation

DEANNA BURGESS, TIANA COWAN, GWEN DEGER, HANIE DU, STAR SHARP, & YU XIA

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Evaluation Goals

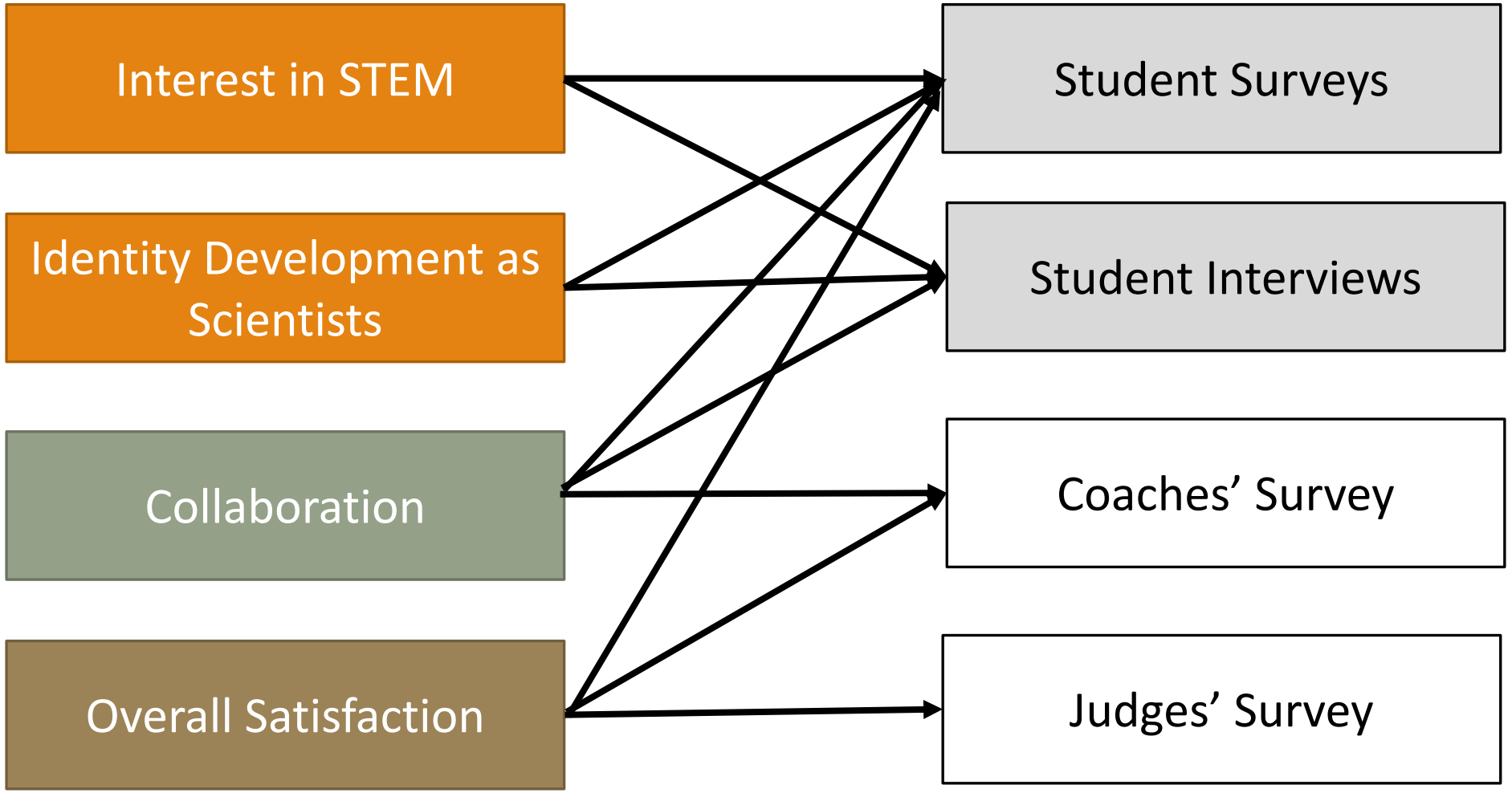
Evaluate key KidWind outcomes:

- Interest in STEM
- Identity Development as Scientists

Explore the process of KidWind participation:

- Collaboration

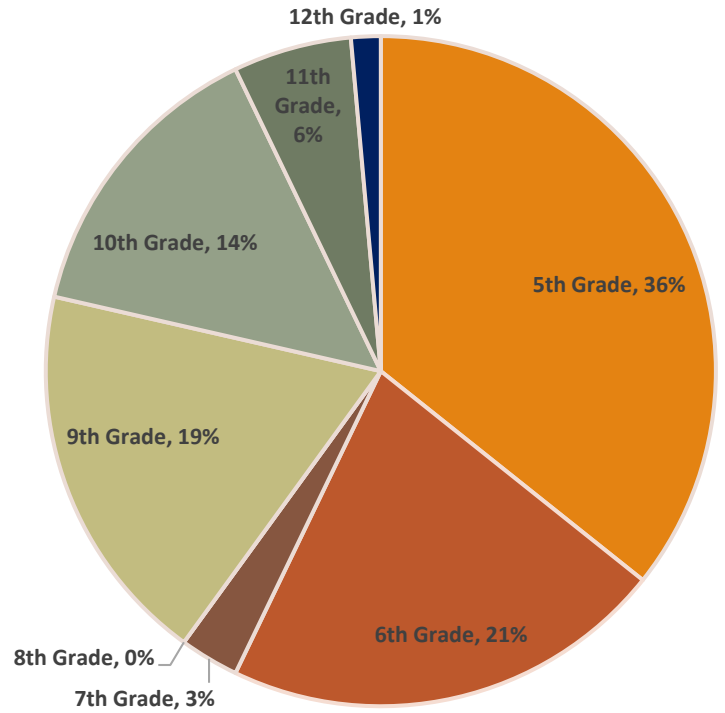
Data Sources



Student Surveys

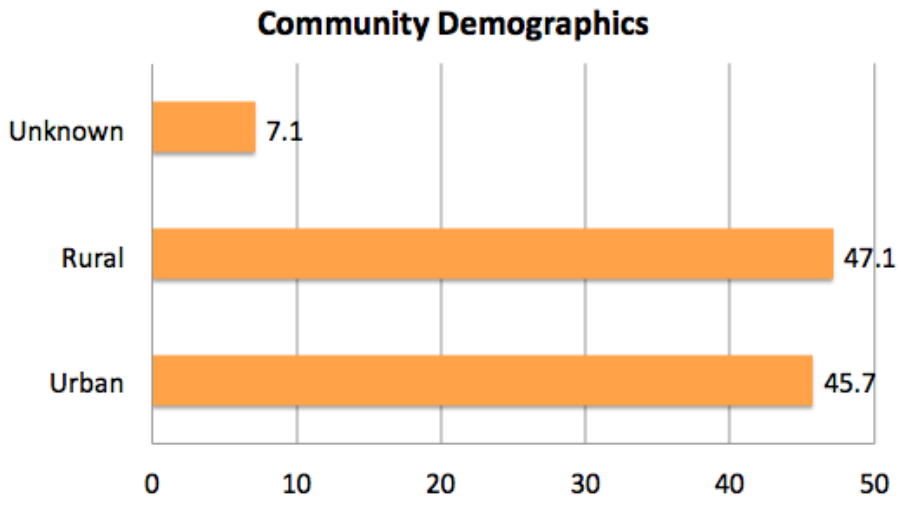
Student Demographics

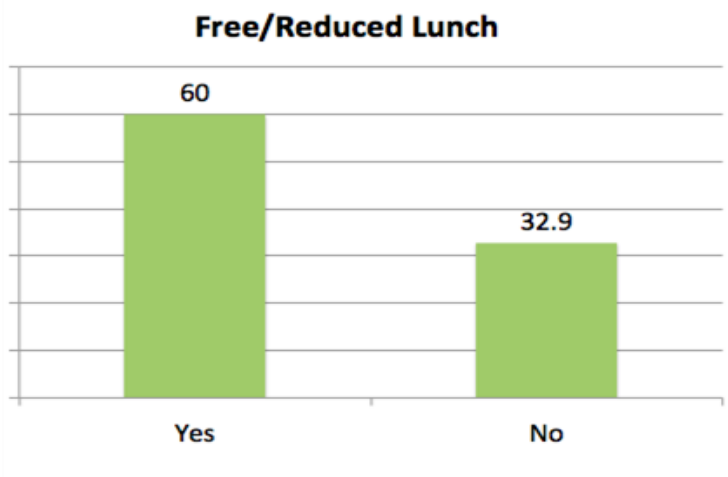
- A total of 70 students, from 15 different schools completed the survey
- Participants included students from 5th – 12th grade (mean age: 12.9 years old)
- There were slightly more male (55.7%, n=39) than female (42.9%, n=30) participants, with one student preferring not to specify their gender
- A majority of students (68.6%, n=48) self-identified as White, with (27.1%, n=19) of students declining to response



Demographic distribution by grade level

School Demographics

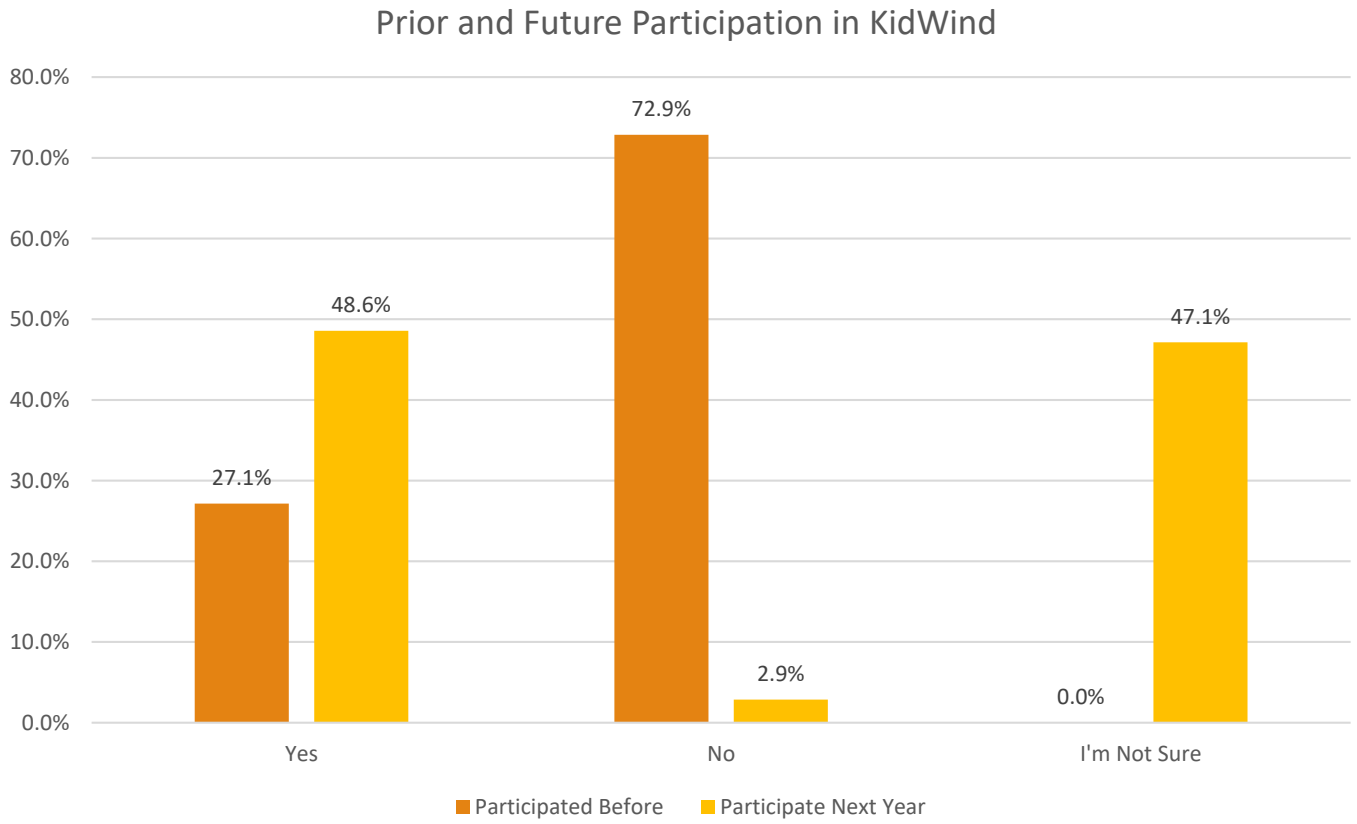




- Participants evenly represented rural (47.1%) and urban (45.7%) communities.
- Slightly more students (60%) come from schools with a high frequency of families qualifying for free/reduced lunch (measure used as an income-indicator).

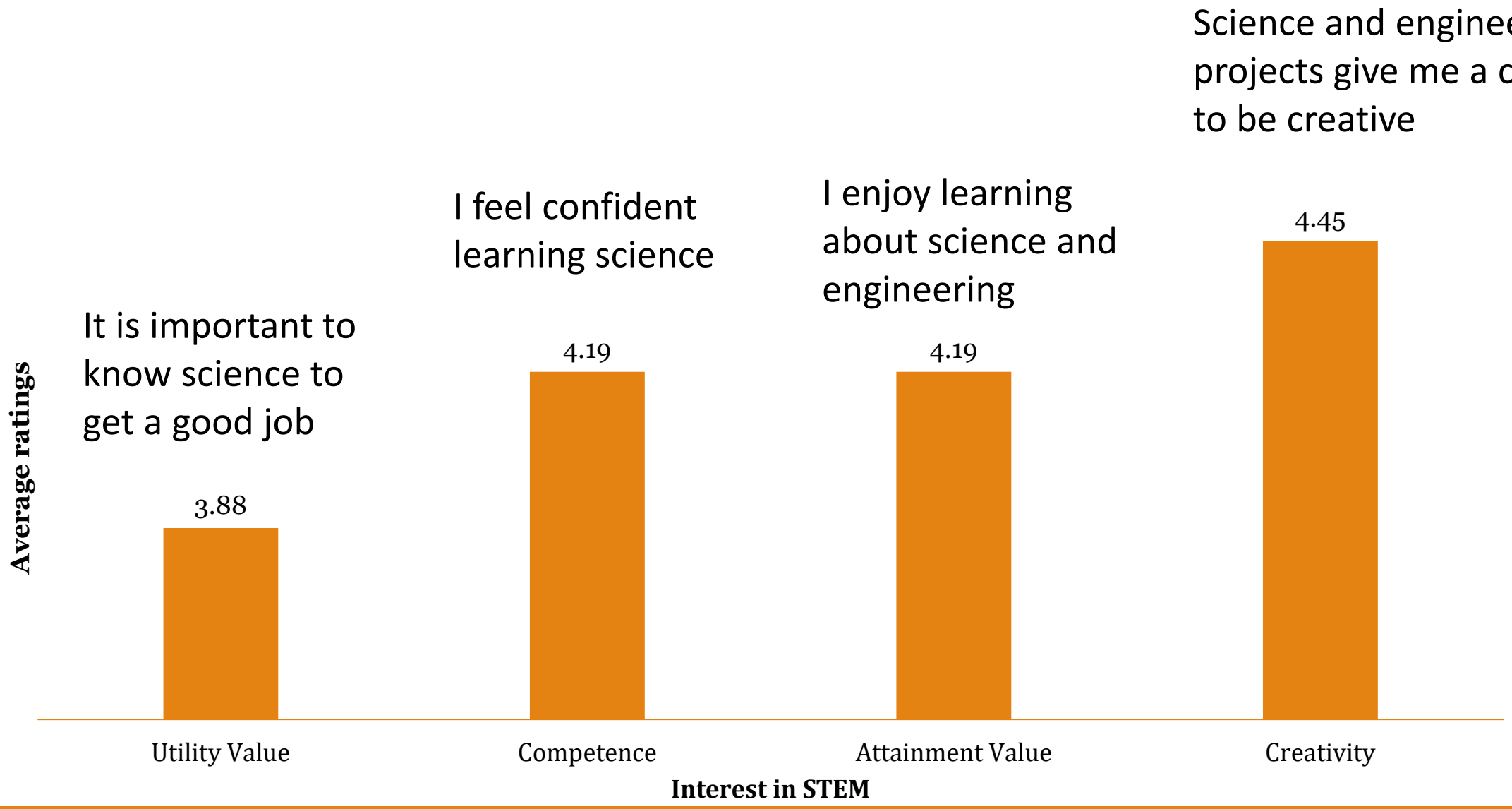
Prior Experience with KidWind

- For the majority of participants (72.9%) this year was their first time participating in the KidWind Challenge.
- Of participants who completed the survey, 48.6% indicated that they plan to participate in KidWind next year.
- A similar percentage (47.1%) stated that they are unsure of whether they will be participating the following year.



Student Interest in STEM

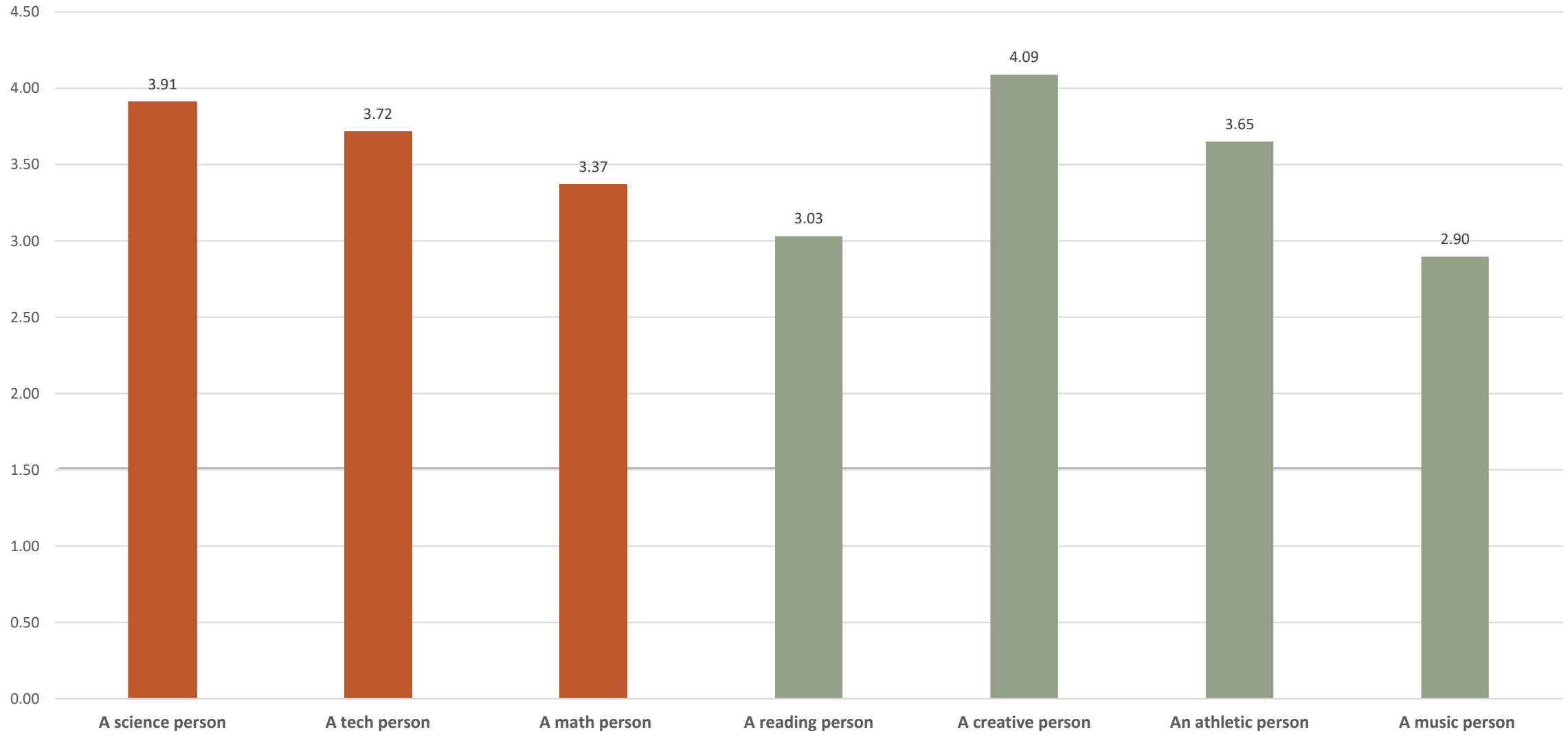
Interest in STEM



Rated on a 5pt. scale

STEM Identity

Average Ratings of Academic Identities



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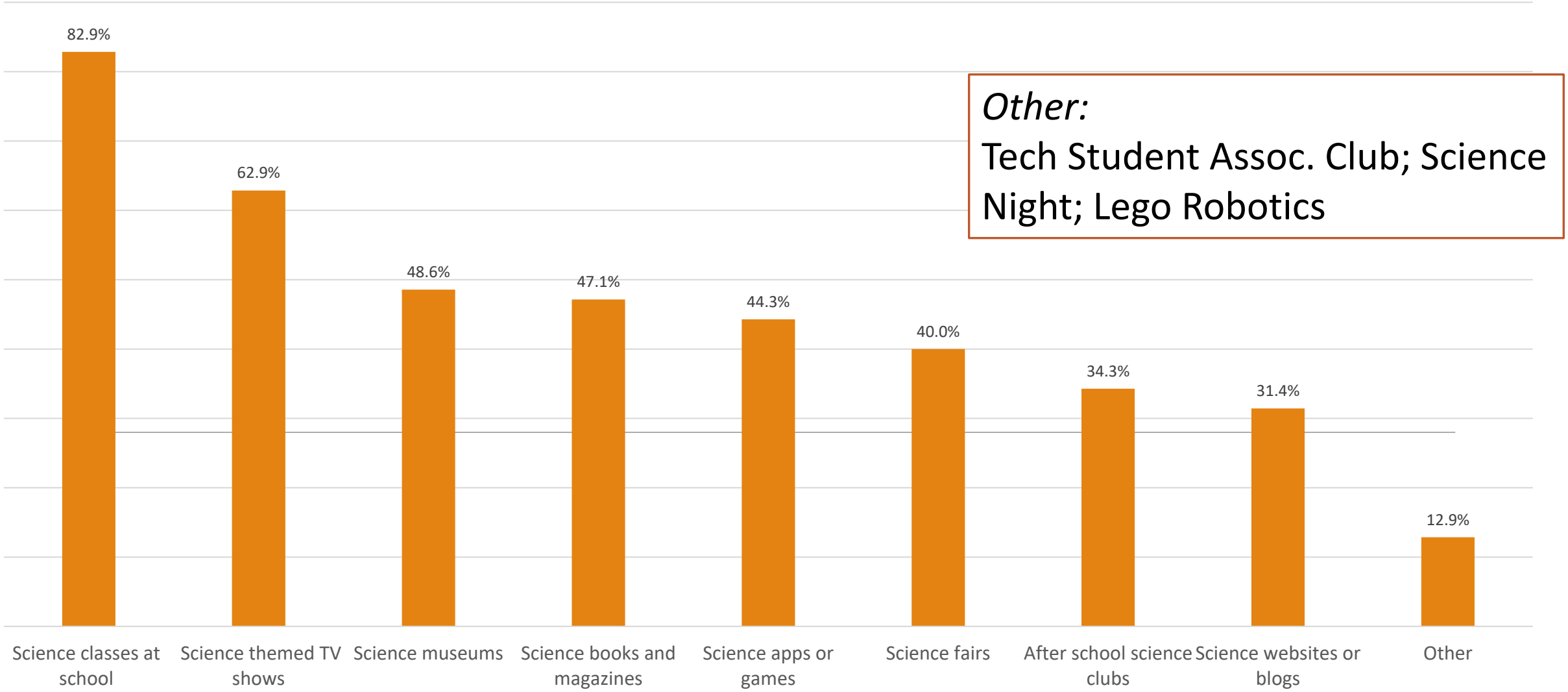
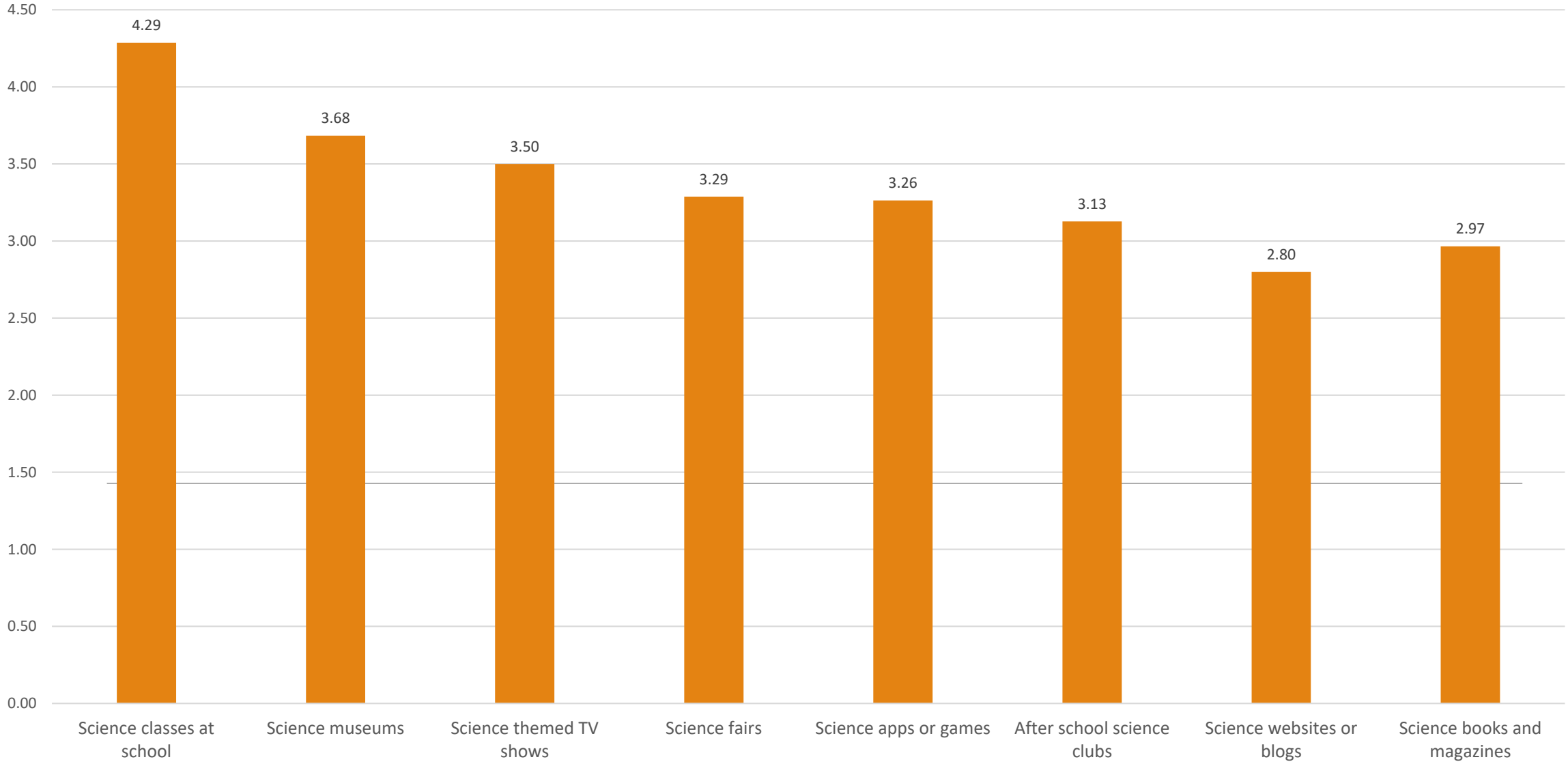
Participation in STEM Activities



Other:
Tech Student Assoc. Club; Science Night; Lego Robotics

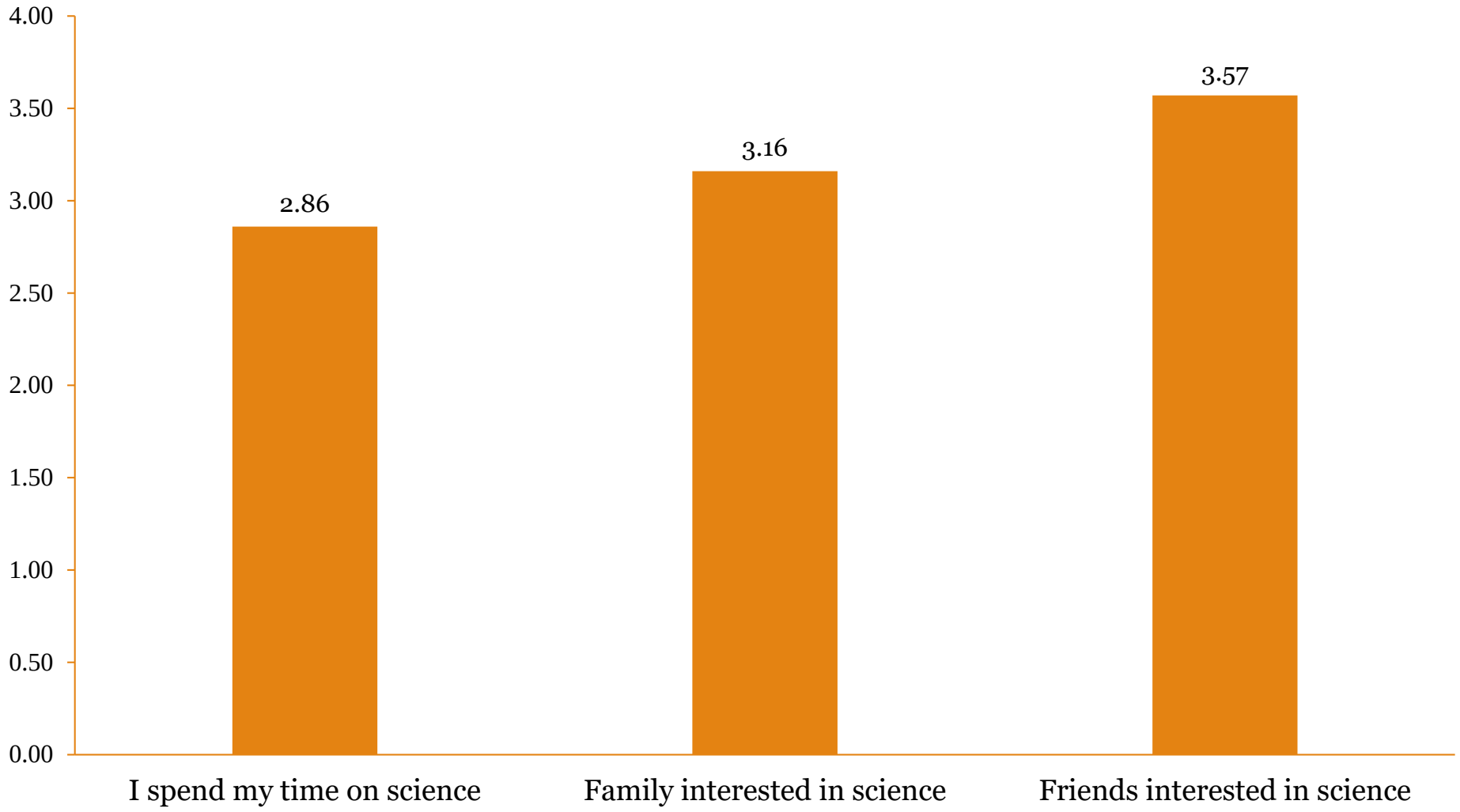
Rated on a 5pt. scale

Interest in STEM Activities



Rated on a 5pt. scale

Support for STEM



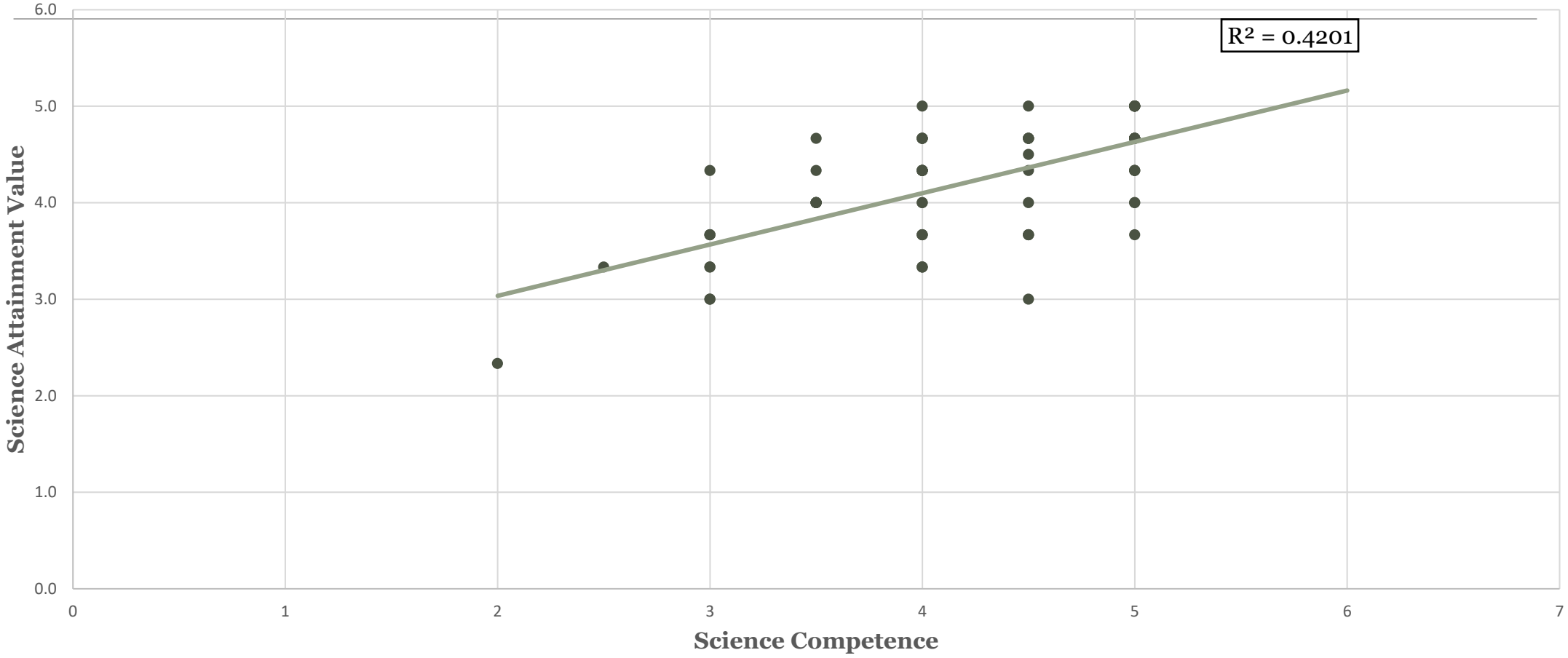
Rated on a 5pt. scale

Correlations Among Interest and Identity Indicators

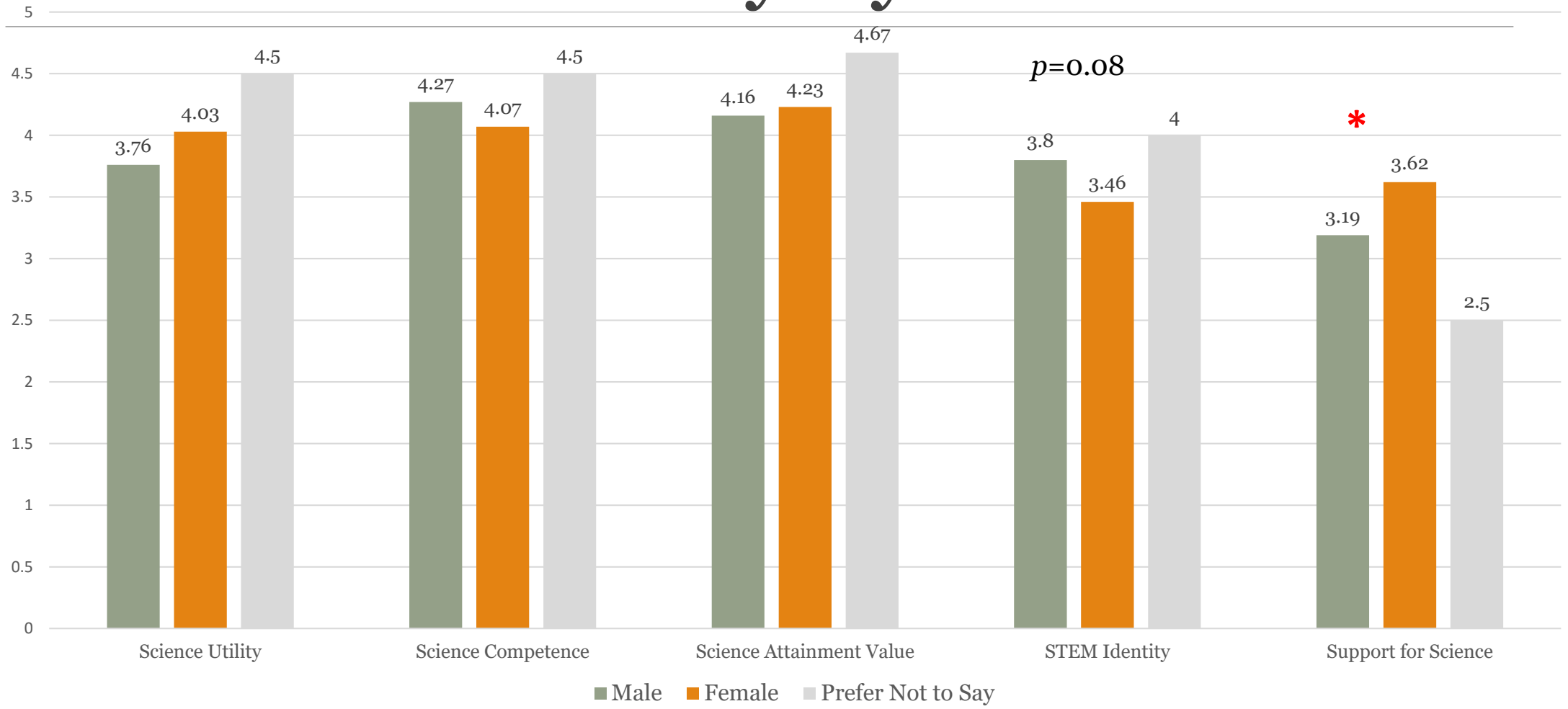
	Utility Value	Science Competence	Attainment Value	Identity
Utility Value	1.00			
Science Competence	0.51***	1.00		
Science Attainment Value	0.61***	0.65***	1.00	
Science Identity	0.21	0.31*	0.36**	1.00
Science Support	0.45***	0.34**	0.38***	0.13

*p<0.05; **p<0.01; ***p<0.001;

Science Competence and Attainment Value



Interest and Identity By Gender



Rated on a 5pt. scale; *$p<0.05$

Collaboration

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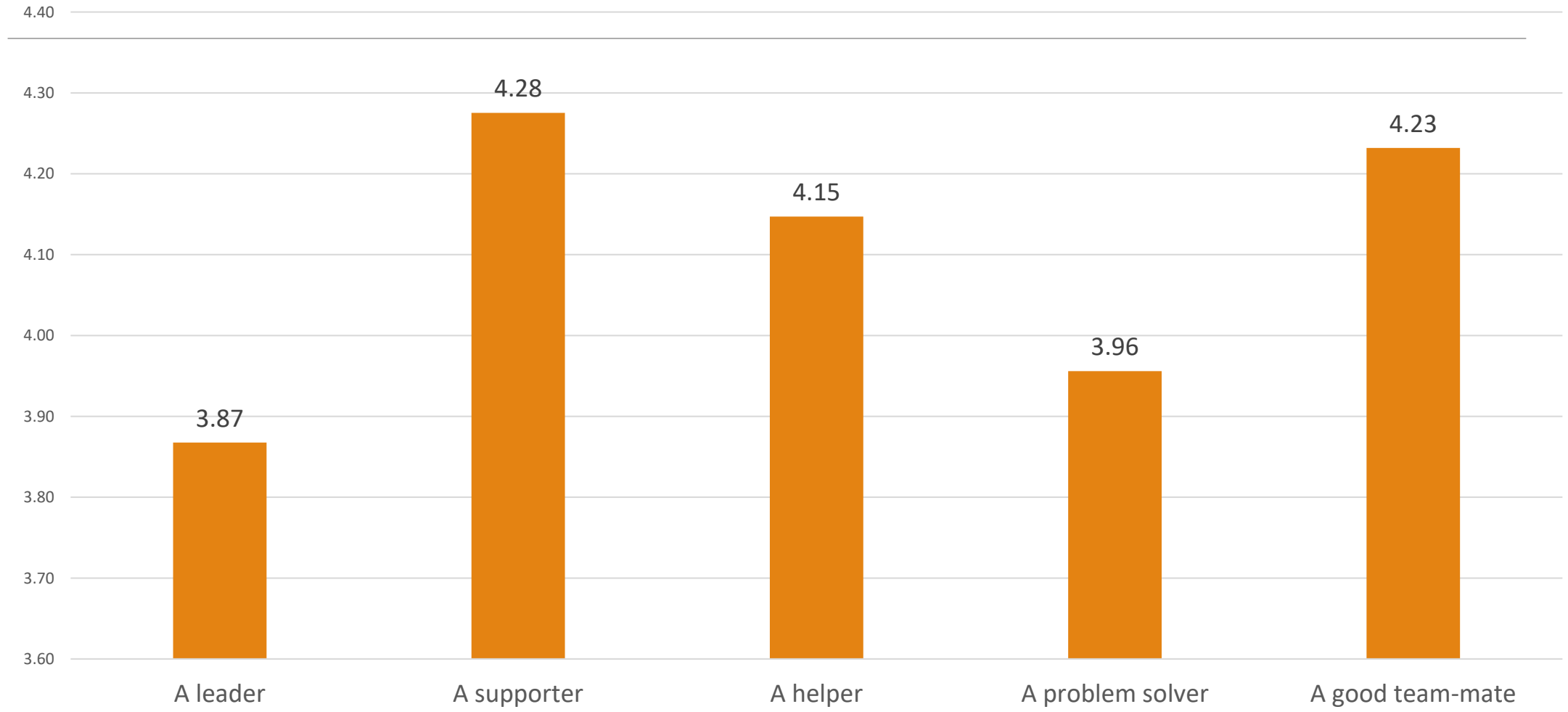
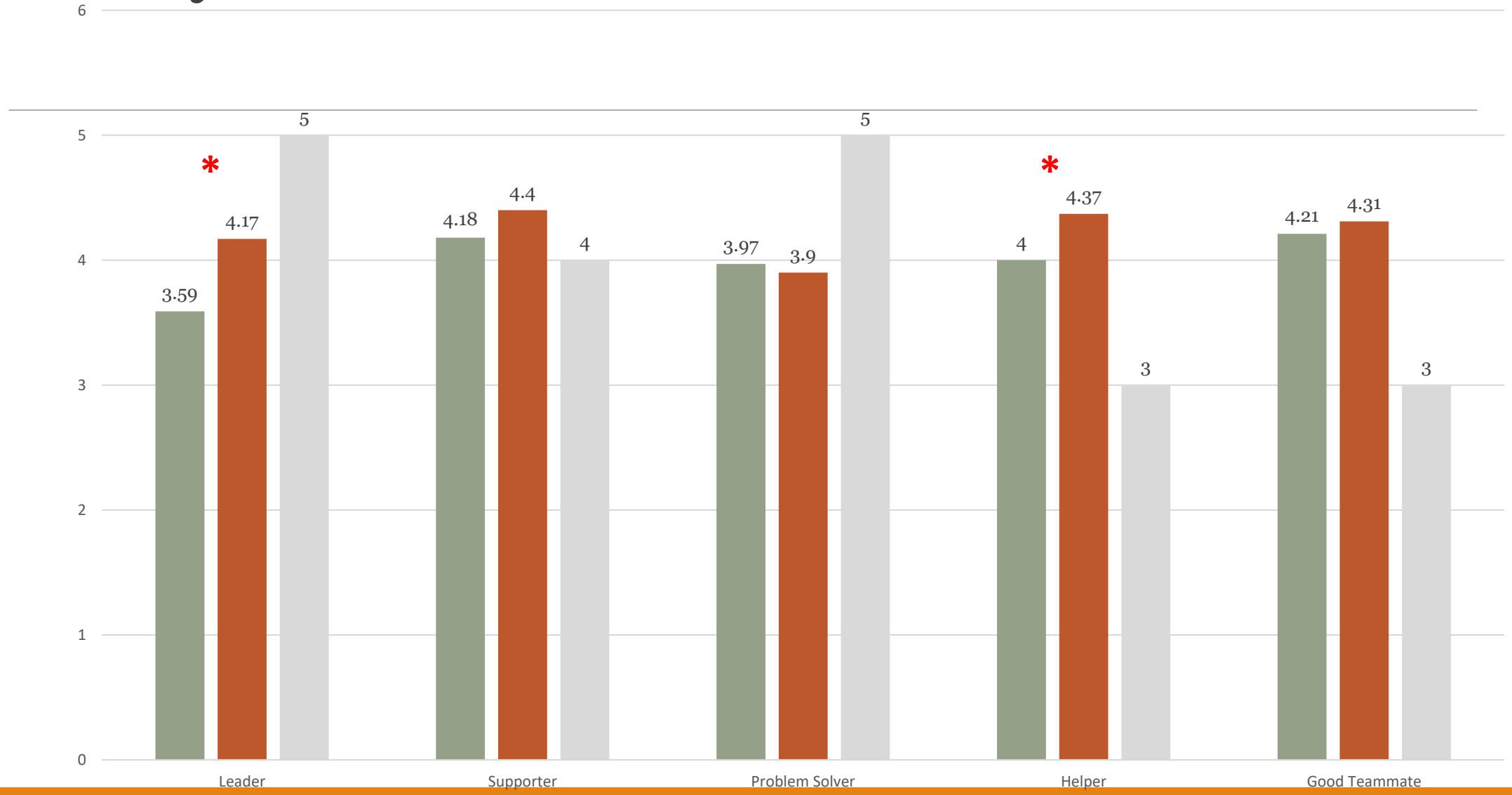
Group Roles



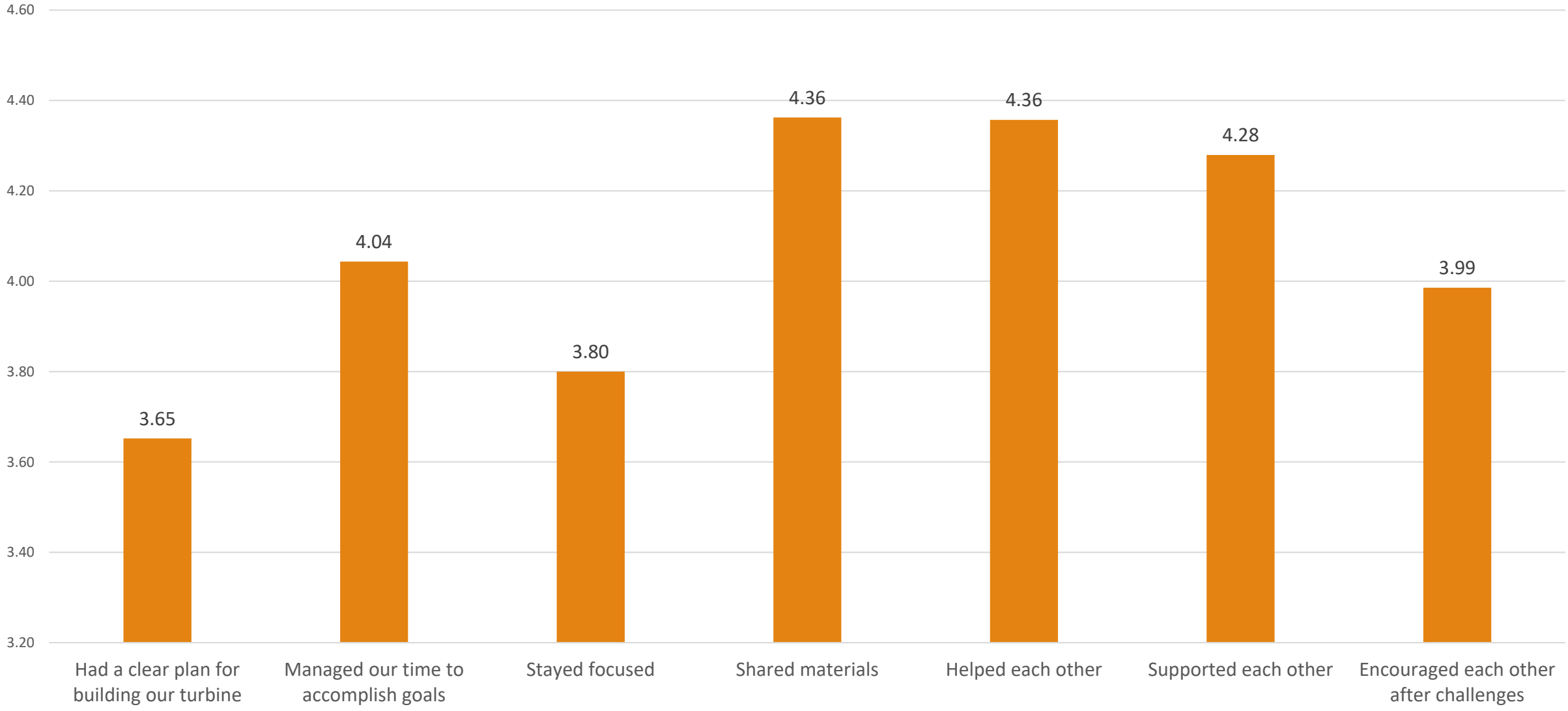
Rated on a 5pt. scale

Role by Gender



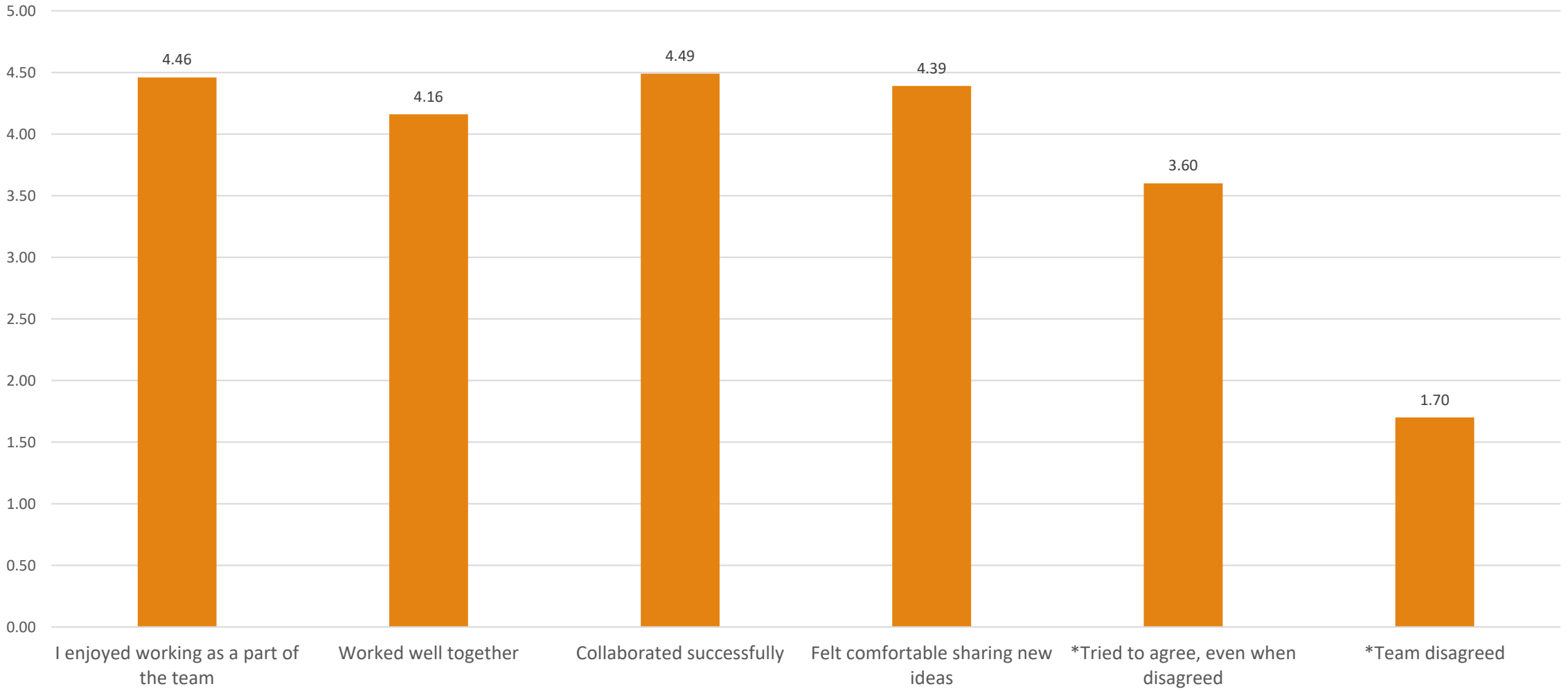
Rated on a 5pt. scale; *$p<0.05$

Ratings of Team Behavior



Rated on a 5pt. scale

Team Work Evaluation



Rated on a 5pt. scale

Student Interviews

Analysis of Student Interviews

22 students, representing at least 12 schools and 10 teams were interviewed

1. Students' overall experience with the KidWind Challenge

2. Students' experiences with collaborating

3. Students' experiences when their group disagreed

Themes in Students' Overall Descriptions of Their Experience

- Overall, students described their day at the **KidWind Challenge as a positive experience**.
- Students clearly expressed an **interest in STEM** and/or expressed that they deemed **STEM knowledge to be helpful**.
- Students also shared that for projects like the KidWind Challenge, they **prefer to work as a group,** to work together and learn from others.
- Some students reported mixed feelings due to challenges in preparing for the KidWind Challengs and working as part of a team

Overall Experience with the KidWind Challenge

Subcategories	Representative Quotes
Positive Experience	"It's a great experience. It's really fun. You get to hang down with your friends and then you get to meet new people." "I feel like it's really worth the experience. It really is."
STEM Lover	"I've always been interested into science, engineering and math, the STEM."
Team Lover	"I like to work with a team. I feel like it's a lot easier to get things done, and you get to be around people and interact and stuff like that."
Mixed Feelings	"I feel nervous and a little scared because my team really wants to win but we are down because everybody else's looks better and everything."

Themes in Students' Collaborative Experience

- Students reported a number of strategies for collaborating or working together:
  - **role assignment**, when individual group members assumed and took responsibility for a specific role
  - **active communication**, when individual members actively and openly communicated with each other;
  - **sharing common interests or goals**, when different members, despite having different strengths, shared common goals
  - **good time management**, when students managed their time, in ways that helped with group coordination and scheduling

Strategies for Collaboration

Strategies	Representative Quotes
Role assignment	“We all did different parts. Like, I worked on the blades and also the grafts for the board.”
Active communication	“We have a little group chat, so we're able to communicate. We also tell them the day before they go what we're doing and what they want us to do, or if they're gonna do it the next day and we're gonna be a little bit behind, or we'll probably stay after school the next day after that to get them a little bit caught up.”
Sharing common interests or goals	“Don't work as people that you don't have any common interests with. Like, it helps to know the person prior if possible and share a lot of common goals.”
Good time management	“I guess we didn't really manage our time as well as we should have in the beginning, and even though it was rushed at the end, it still turned out pretty good.”

Themes in Students' Experiences with Disagreement

- When students experienced disagreements, they used four strategies to resolve those conflicts
  - **Objective methods:** Students test competing hypotheses when they disagree on design elements; teams referenced testing different designs to choose the best option.
  - **Democratic:** teams voted when they disagreed on design decisions
  - **Compromise focused:** Teams tried a strategy that occurred between two differing ideas or some member would defer to the group's preferences
  - **Unilateral:** One person made a decision when the group could not agree on a design element.

Strategies When Students Disagreed

Strategies	Representative Quotes
Objective	"Then we built two other things and we see which one worked and which one didn't work."
Democratic	"Say I wanted three, they wanted two, but my teammates wanted two blades, and I wanted three blades, so it was like four against two or something."
Compromising	"The most common angle we found was 25 degrees but, for instance, one of my teammates was thinking, 'Let's do five degrees.' Another one saying, 'Let's do 15.' But we ended up going with 10."
Unilateral	"Our one team member was like, 'Yeah I'm cutting it' and then he cut it."

Descriptives of Themes in Student Interviews

Theme	Sub-Category	Frequency (N=22)
Overall experience	Positive experience	**18**
Strategies for collaboration	Role assignment	**12**
	Active communication	**7**
	Sharing common interests or goals	**2**
	Good time management	**3**
Strategies for conflict resolution	Objective	**17**
	Democratic	**3**
	Comprising	**1**
	Unilateral	**1**

Coaches Survey

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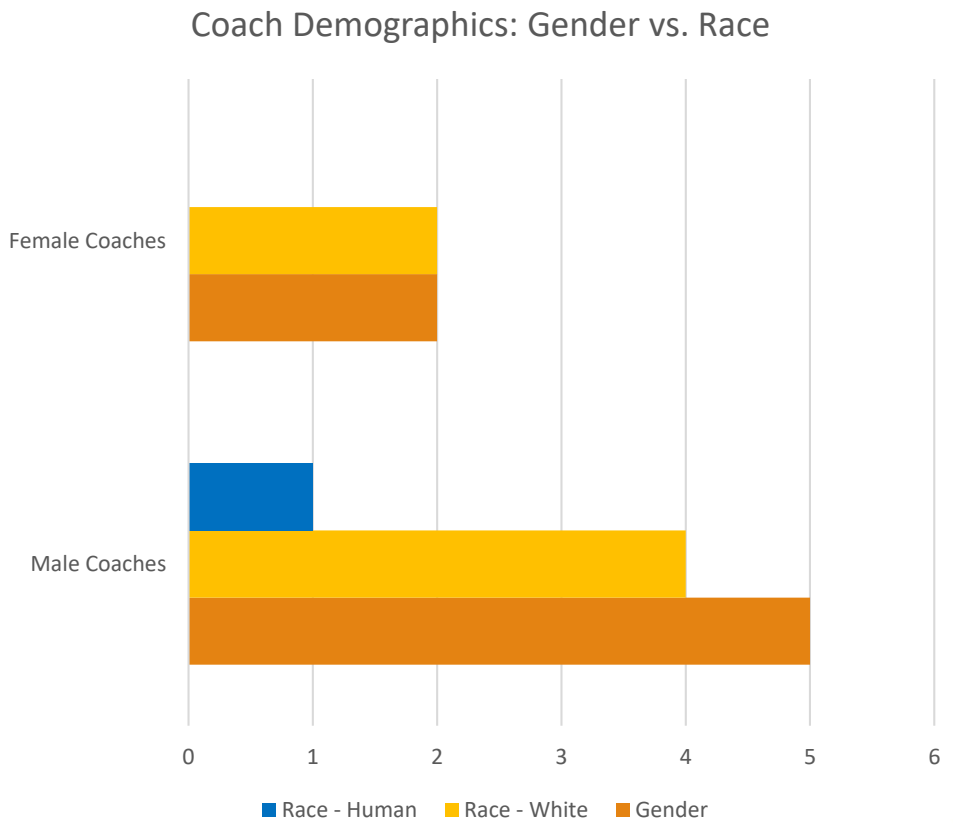
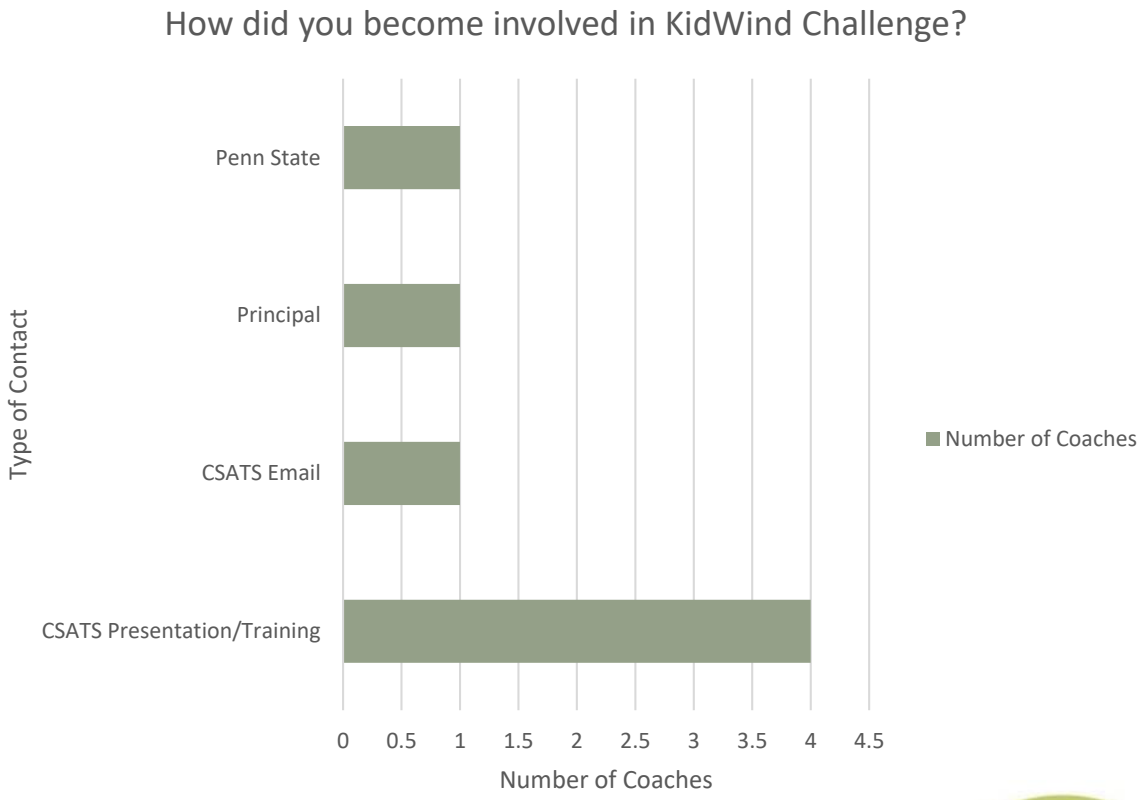
Coach Demographics

- 7/12 coaches responded to the coaches survey (58.3%)
- 100% of coaches are STEM Teachers
- 1/7 coaches indicated that they were a volunteer
- **71.4% of coaches indicated that they have coached for the KidWind Challenge before**

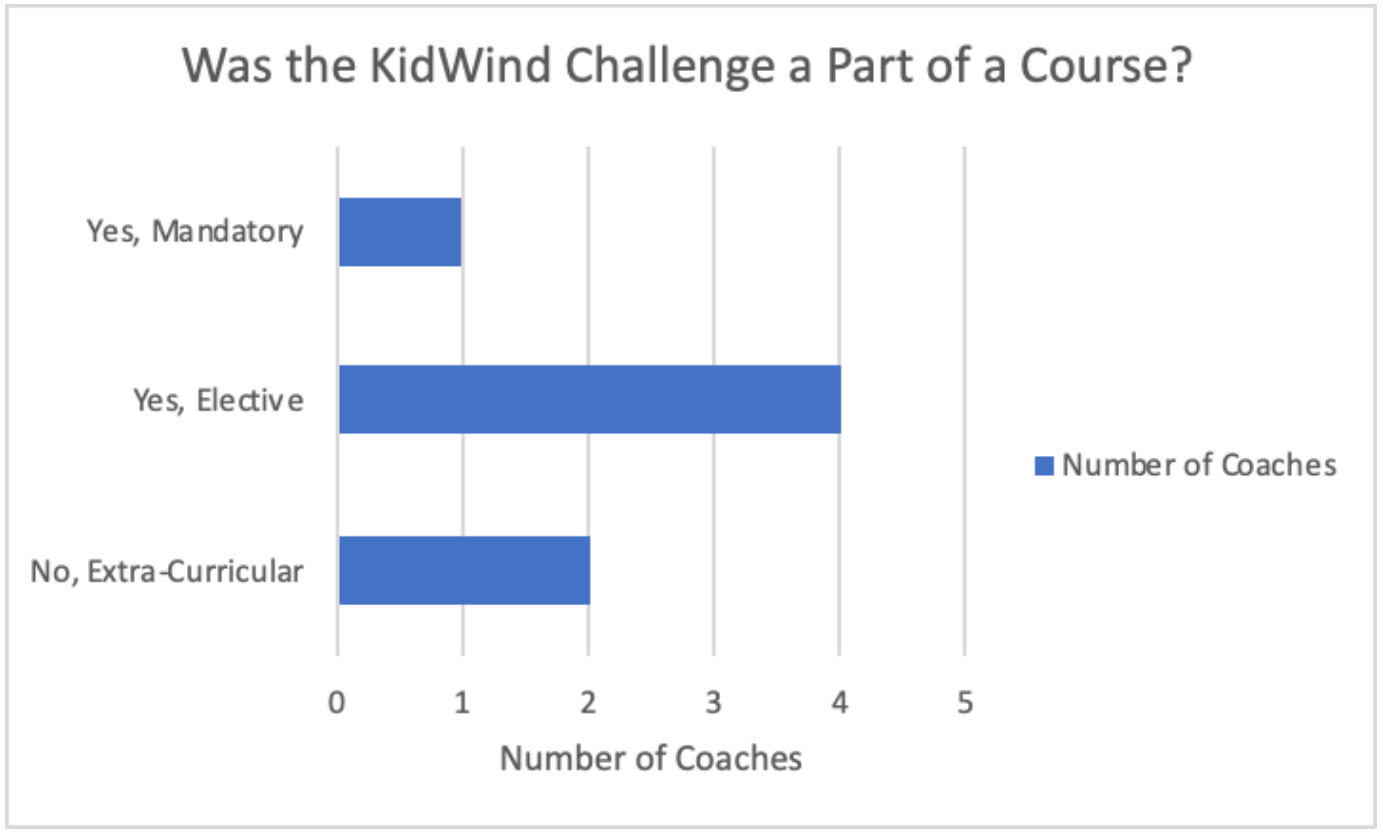


How Coaches were Recruited?

- Most coaches were recruited through presentations from CSATS, at their local IU or School District (57.1%)
- One coach contacted a former professor at Penn State
- One coach heard about it from their Principal



Was Participation a Part of a Course?

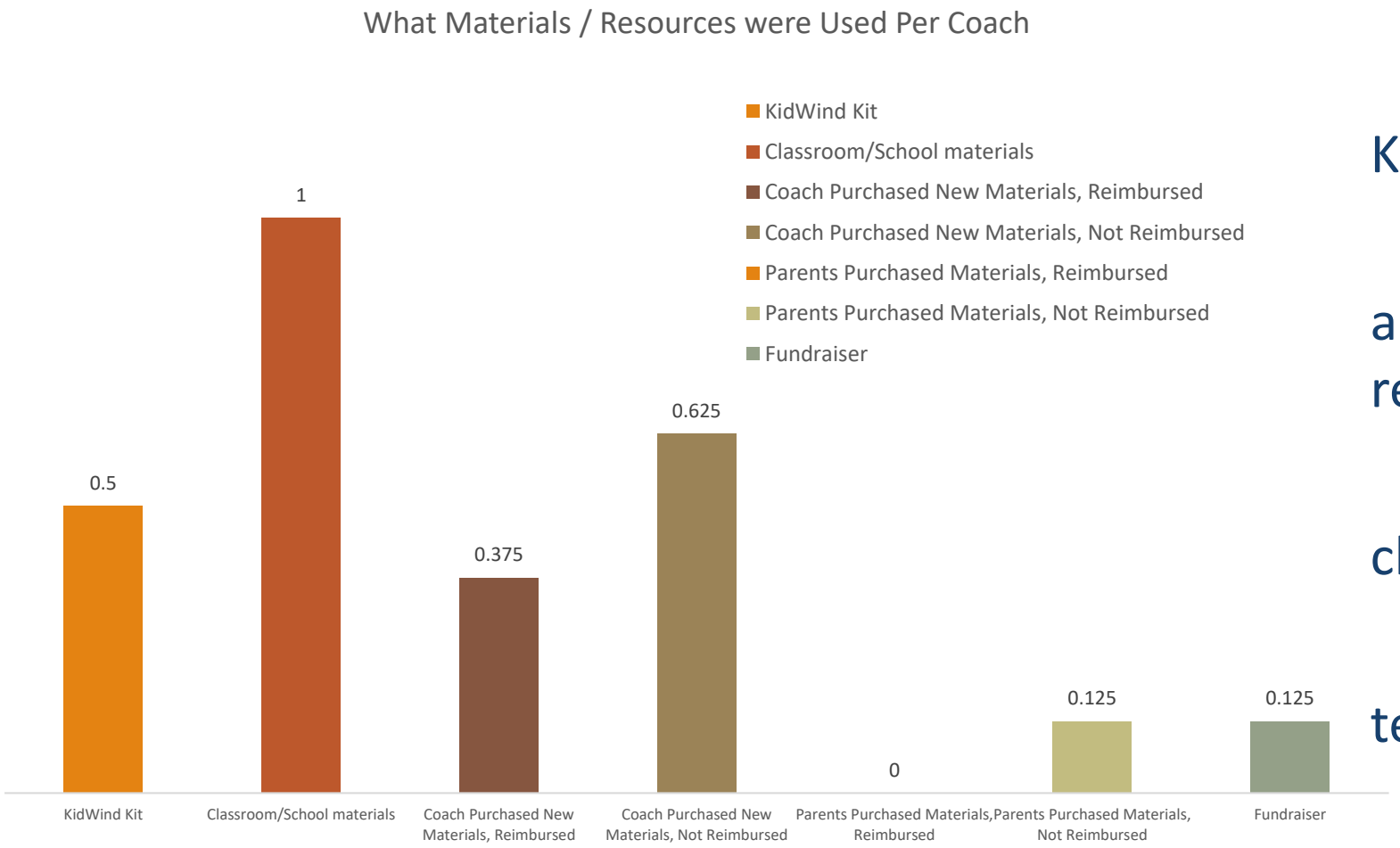


Most coaches indicated that the KidWind Challenge was a part of an elective course (57.1%).

28.6% of coaches indicated that the KidWind Challenge was an extracurricular activity

One coach indicated that they mandated participation through a required course

Materials/Resources Used



57.1% of coaches indicated using KidWind Kit

71.4% of coaches purchased additional materials without being reimbursed

100% of coaches used classroom/school materials

1 coach did fundraising with their team to earn additional funds

Coaches spent between $10 to $300 per team

Strengths & Weaknesses

Team Strengths:

Coaches reported that:

- 33.33% of teams worked well together
- 16.67% of teams were determined or persistent
- 16.67% of teams met outside of class/club time
- 1/18 teams used higher level thinking and reasoning skills to solve problems
- 1/18 teams demonstrated a willingness to try different suggestions

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Team Weaknesses:

Coaches reported that:

55.56% of teams had at least one or two members who led or dominated, potentially causing conflict

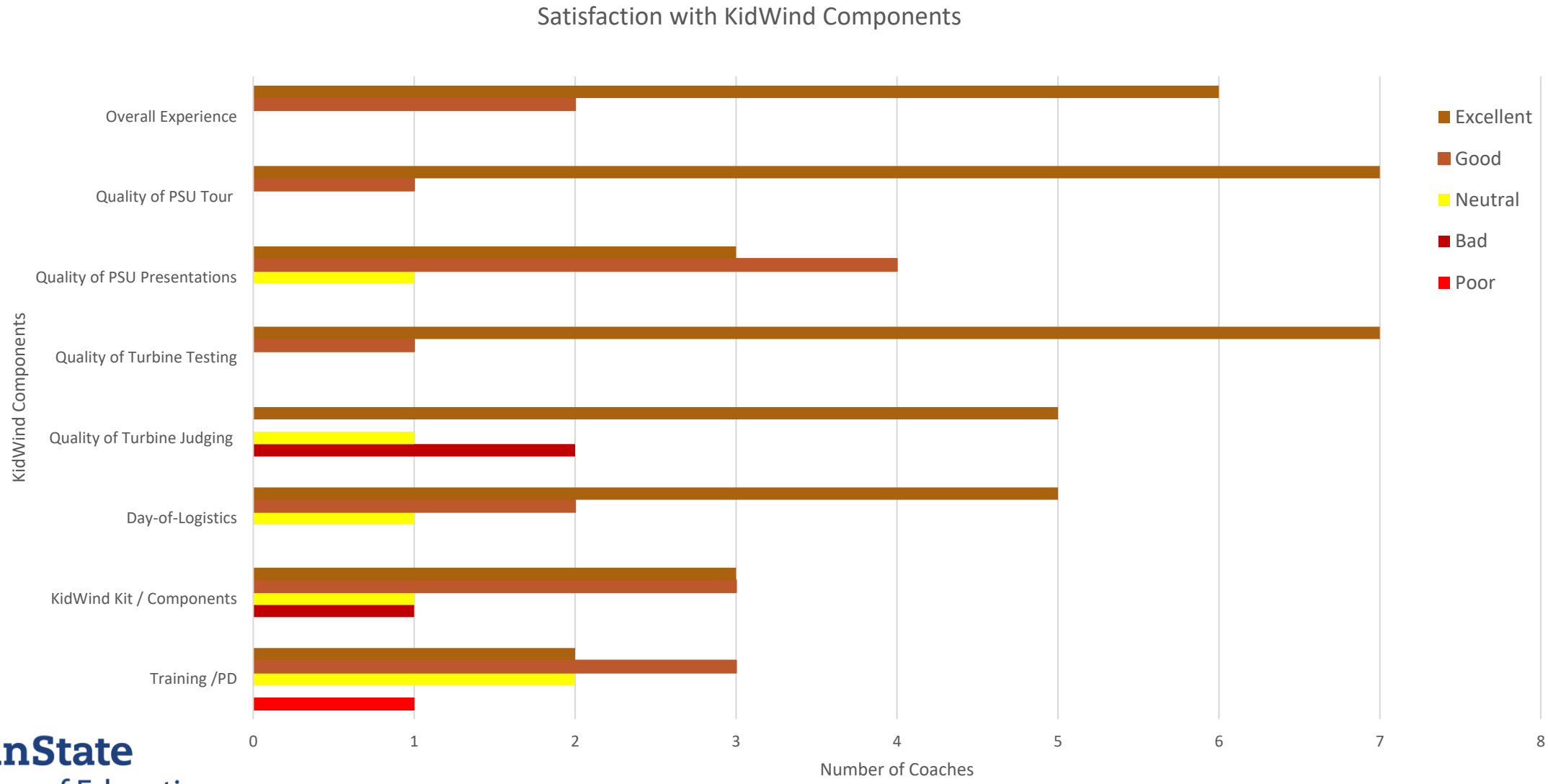
33.33% of teams had at least one team member who did not really help or caused distractions

16.67% of teams had limited tools and supplies, often having to share with other teams

16.67% of teams procrastinating or did not managing time well

11.11% of teams were not well prepared for the presentation

Coaches Satisfaction



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Judges Survey

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Judges Demographics

A total of 4 judges participated in the survey

- 100% were White
- 100% were Male

Occupation

- 50% of judges were Engineers
- 25% Education/ Researcher
- 25% Self-Employed

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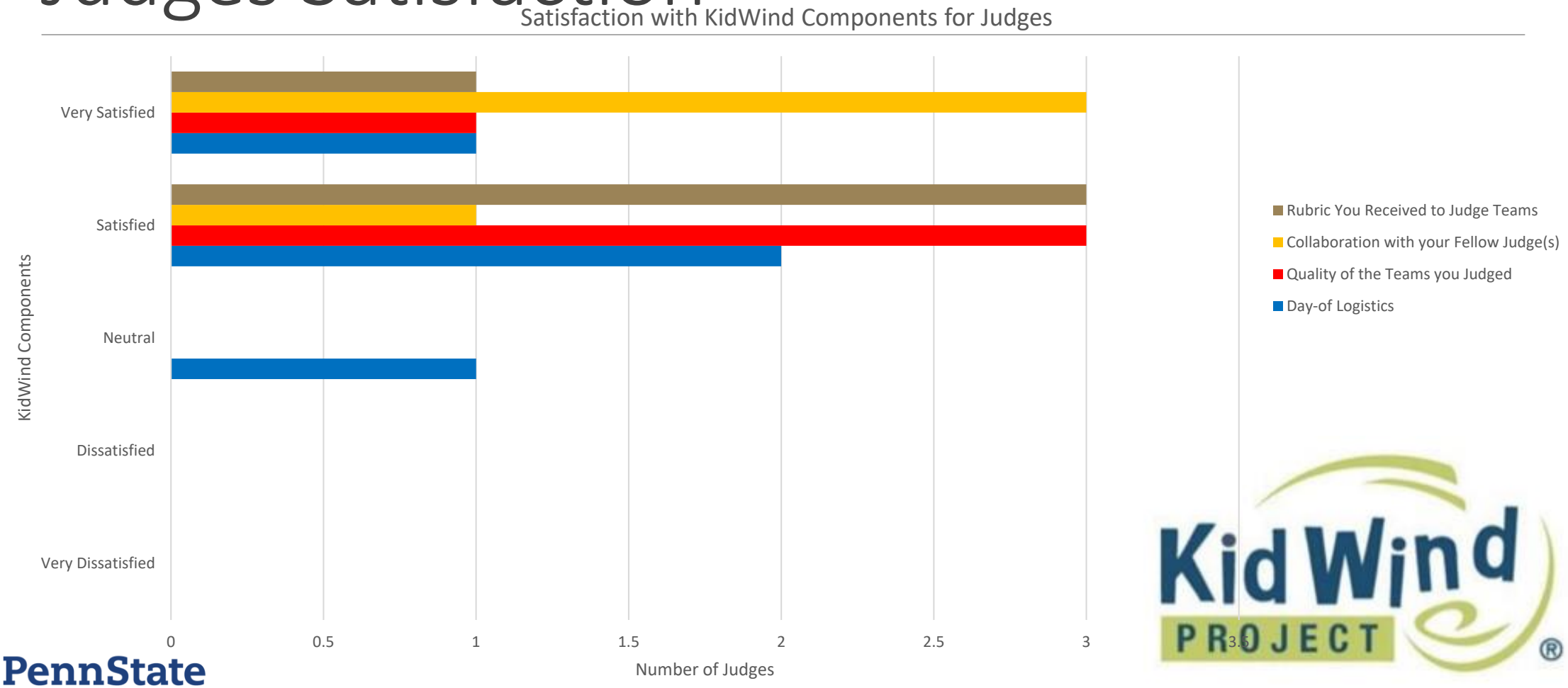
Judges Satisfaction



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Recommendations

“I provided my feedback to Amber previously. I was very discouraged at not only the lack of ethnic diversity in the participants, judges, Lion Ambassadors, and engineering students, but was the fact that a panel of completely white judges chose nothing but completely white teams in their award selections. Away from the actual wind-tunnel testing the grading of, say, a 6 for one group and a 7 for the next is fairly ambiguous. Tie that in with such awards as the "Judges Choice" awards all going to completely white children, and it left me with a very bad taste in my mouth. My kids are from an urban district steeped in poverty. Many of them will regularly say that "people like them", or from where they are from, never amount to anything. This was only reinforced, even subconsciously, when they saw better off, white students time and time being called up for their awards. I had a team full of diversity who came in 4th for power output (and 3rd for PO last year), I suppose that I am a bit salty over them being passed by, because being forgotten is the status-quo for them in their daily life. The fact that not even one of the judge's choice award went to a team with students of color on it really upset me, and I am sure I am not alone. This, although not intentional, caused harm.”

Recommendations

1. **Diversify the KidWind Challenge**
   - *Need for more women and people of color in judging pool and more people of color among presenters on "what engineering is"*

     →Targeted recruitment

     →Recruit graduate students from diverse student interest groups on campus (NSBE, SHE, SWE)

   - *Diversify the participants*

     →CSATS is primary way that coaches get involved → Emphasis on conducting presentations at schools with large underrepresented populations

Recommendations

- *Find some way to balance the disparity in the resources available to teams.*

  → Perhaps introduce additional judging categories (e.g., Innovative Thinkers, Most Creative Use of Resources)

- *Increase visibility of diverse teams already attending*

→Find ways to recognize diverse teams in judging outcomes

→Address disparity in resources (both financial and knowledge-based)

→ Provide awards for first-time versus repeat entrants; create separate 3D printing category

Recommendations

2. Create more opportunities for engagement

- *Have activities available for down-time*

  →Conduct more structured simulations, demonstrations, or activities for students

  →"Interview an engineer" (with diverse student engineers represented)

- *Opportunities for interaction*

  →Opportunities for cross-school or cross-grade interaction

- *Consider cross-grade differences*

  →Diversify and complexify activities for middle school versus high-school students

Recommendations

3. Logistics

Finding the location of the event

- Clear and consistent signage
- Facilitators (e.g., graduate students) meeting busses in t-shirts and leading schools to the designated room

Share day-of instructions, particularly for first-time attendees

Ensure all schools know to bring games/activities for down-time

Recommend lunch options for schools, given the traffic in the HUB during lunch

- Have lunch early
- Recommend that schools bring/order lunch

Seek some sponsorship that could support lunches and snacks for all.

Wearable Device Challenge

A part of an NSF-funded Engineering Research Center

Meant to mimic the kind of work the engineers do at an appropriate level of complexity

Supported by two types of teacher professional development

Enhances the infrastructure for other BI programs

ASSIST Engineering Research Center

Develop wearable sensing devices to collect data on physiological and environmental conditions

Develop energy harvesting technologies to make the platforms battery-less

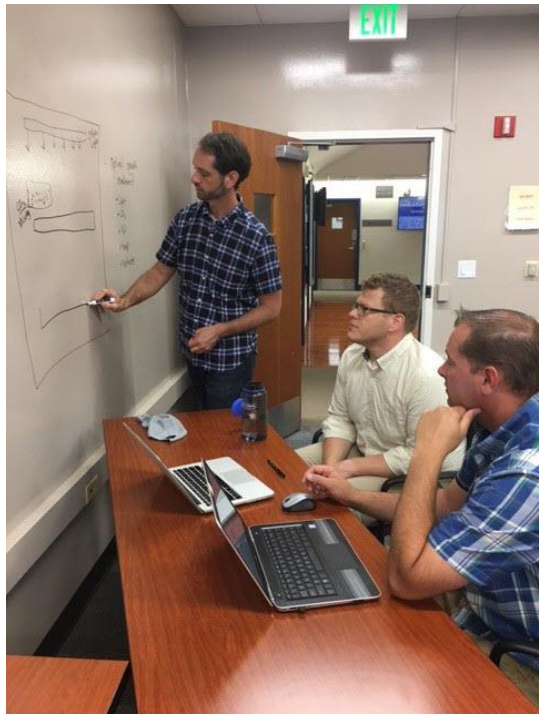
Collaboration between NC State, Penn State, University of Virginia, and others

Industry partners

Education and Workforce Development

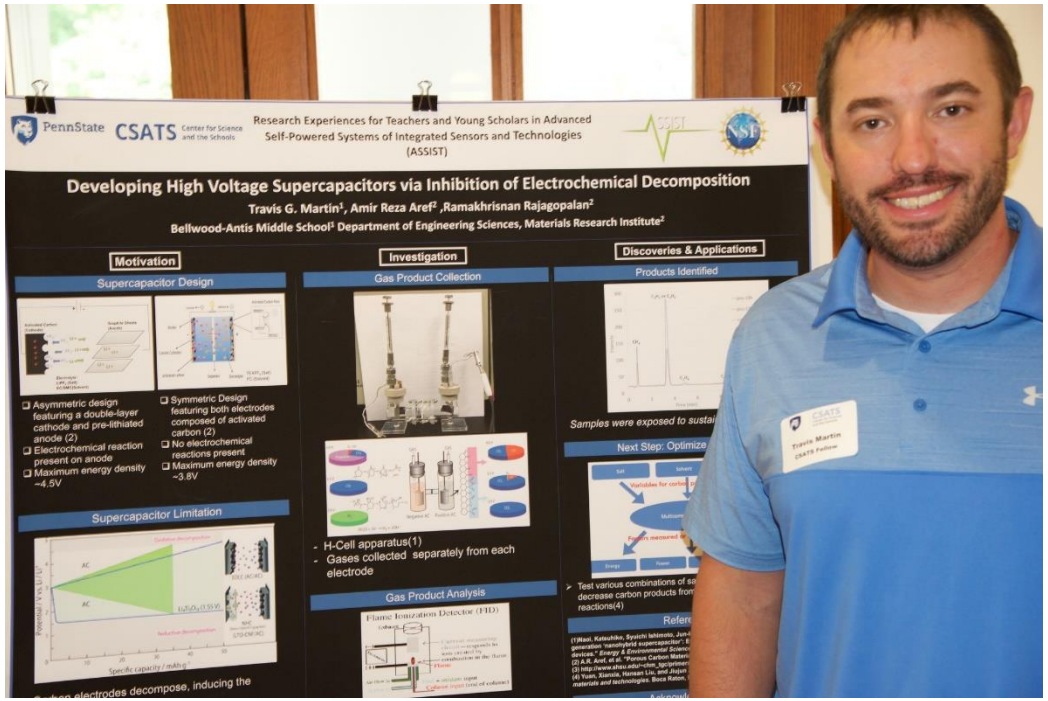
WDC is supported by two kinds of teacher professional development

RESEARCH EXPERIENCE FOR TEACHERS



ONE-DAY TEACHER WORKSHOP

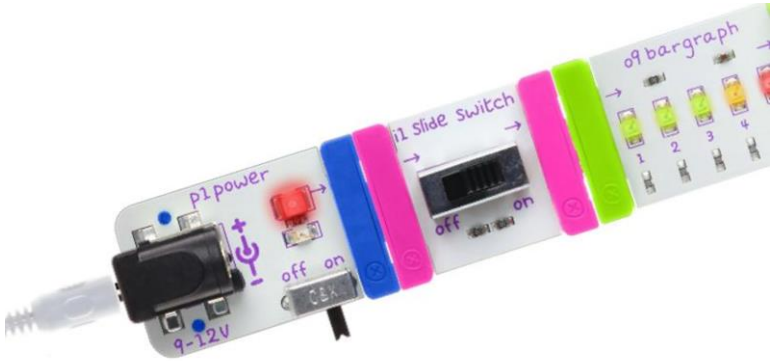
Research Experience for Teachers

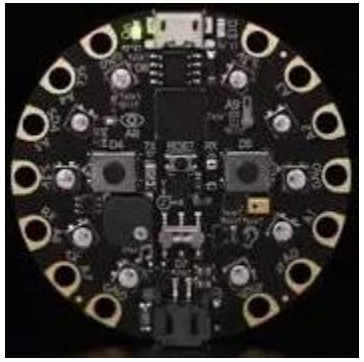


Travis did research on energy storage optimization of supercapacitors

His students developed energy harvesting shoes to power an LED for runners

One-day workshop

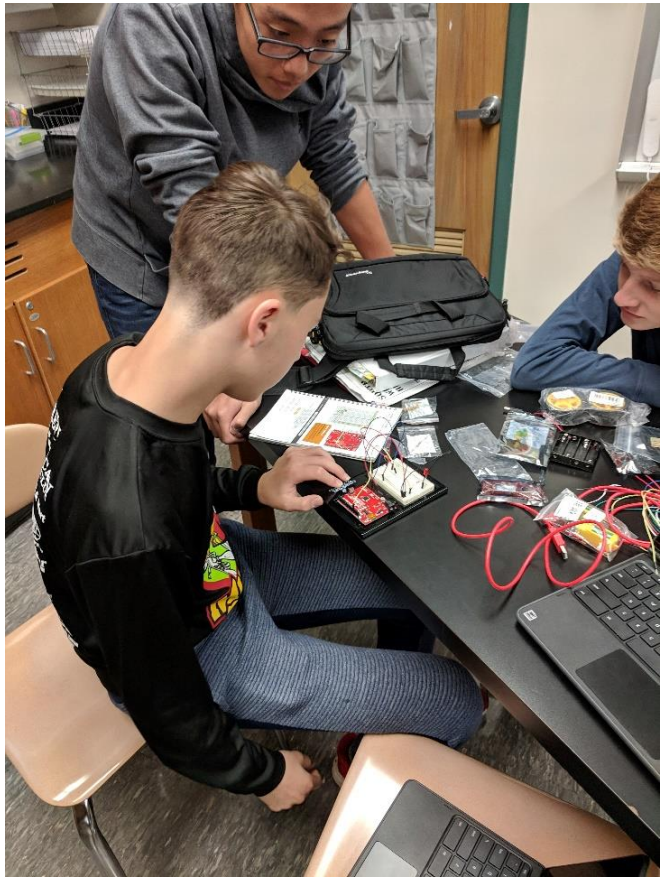




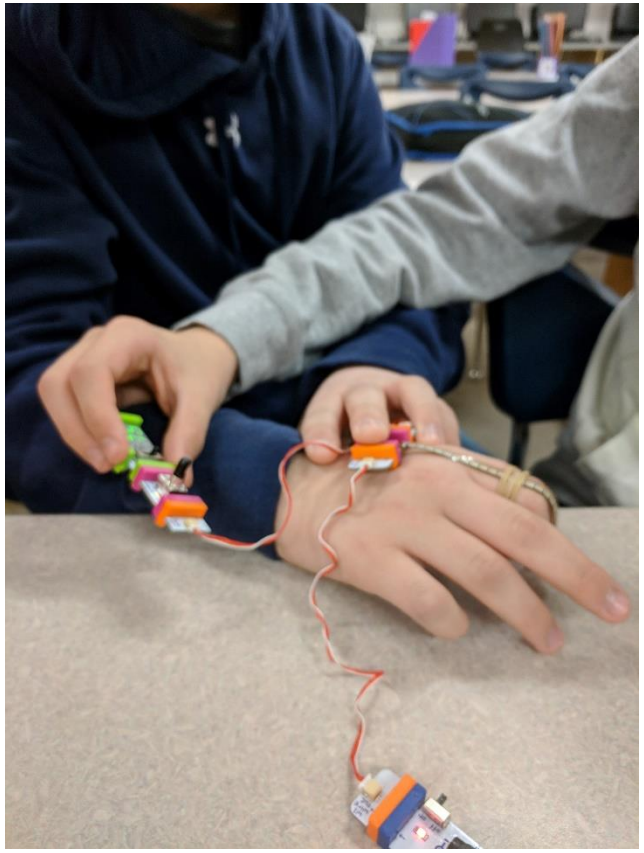
Competition is held at a local business accelerator

happy valley launchbox™

powered by PNC Bank



Emphasis is on engineering design and entrepreneurship



What STEM competitions exist (or should)?

https://bit.ly/2J7eAUz

Share findings

Evaluation

What goals should be evaluated?

What instruments exist?

What should be developed?

Moving forward

Affinity group

What are the next steps?

ARIS fellowship?

ARIS Fellowships

2019-2020 Fellowship Priorities

Applications that address one of the following priorities are encouraged. However, applications to advance scholarship or synthesis and create resources in other topical areas are also invited. All applications must provide justification for their stated focus and the need or gap being filled.

- Evaluation practices for research impacts in a given domain (some examples include evaluation of K-12 field trips, citizen science programs, or use of interactive web tools).
- Creating research impacts through broadening participation.
- Designing research impacts in the fundamental physical sciences and/or mathematics.

Thank you!

Matt Johnson
mjohnson@psu.edu