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Finding FOCIS: A Framework for Examining Lessons and Learning Activities

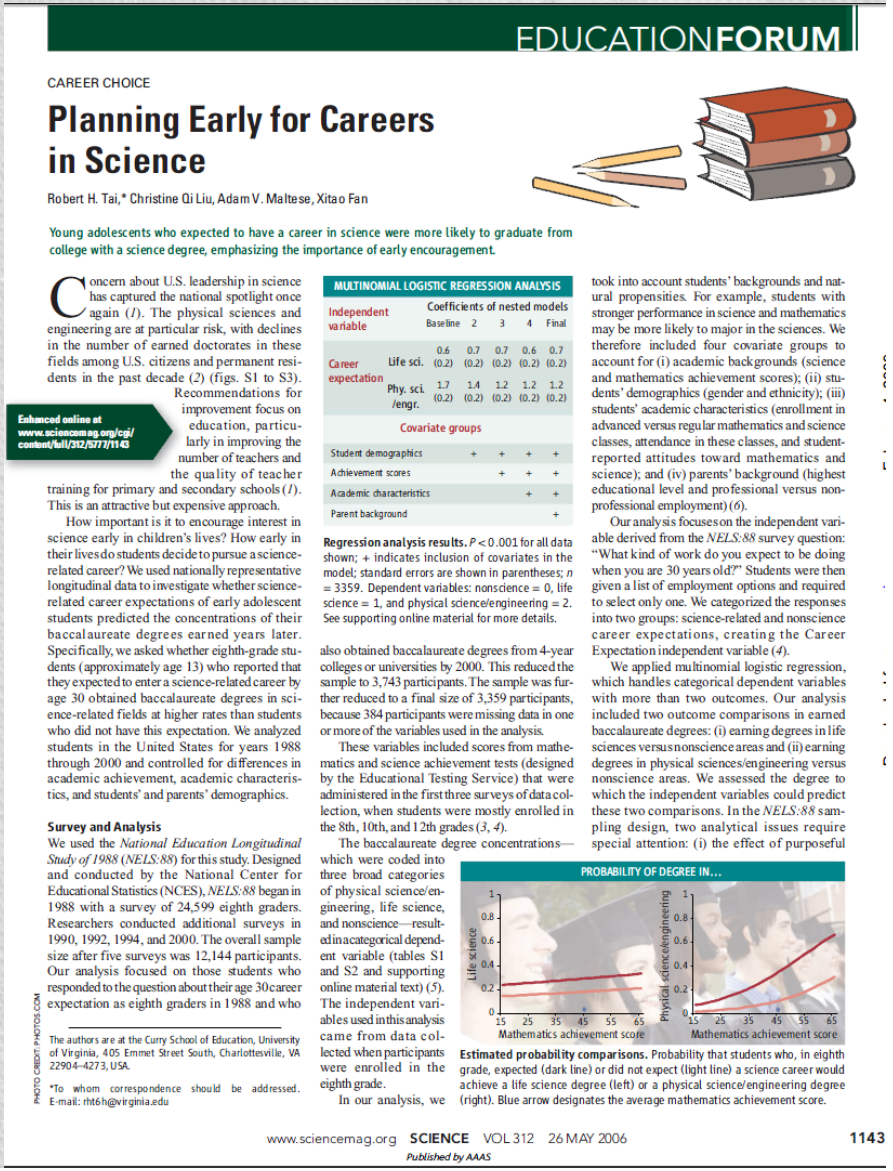
2013 15th Annual Chicago Symposium Series on Excellence in Teaching Mathematics and Science: Research and Practice

University of Virginia
Curry School of Education

Generating Interest among Students

An analysis of longitudinal data for 3300+ students spanning 12 years from ages 14 – 26 suggests that 8th graders with an interest in science are 2-3 more likely to earn degrees in STEM-related disciplines than those who do not report a similar early interest.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science.* 312, 1143 – 1144. doi: 10.1126/science.1128690



EDUCATIONFORUM

CAREER CHOICE

Planning Early for Careers in Science

Robert H. Tai,* Christine Qi Liu, Adam V. Maltese, Xitao Fan

Young adolescents who expected to have a career in science were more likely to graduate from college with a science degree, emphasizing the importance of early encouragement.

Concern about U.S. leadership in science has captured the national spotlight once again (*1*). The physical sciences and engineering are at particular risk, with declines in the number of earned doctorates in these fields among U.S. citizens and permanent residents in the past decade (*2*) (figs. S1 to S3). Recommendations for improvement focus on education, particularly in improving the number of teachers and the quality of teacher training for primary and secondary schools (*1*). This is an attractive but expensive approach.

Enhanced online at www.sciencemag.org/cgi/content/full/312/5777/1143

How important is it to encourage interest in science early in children's lives? How early in their lives do students decide to pursue a science-related career? We used nationally representative longitudinal data to investigate whether science-related career expectations of early adolescent students predicted the concentrations of their baccalaureate degrees earned years later. Specifically, we asked whether eighth-grade students (approximately age 13) who reported that they expected to enter a science-related career by age 30 obtained baccalaureate degrees in science-related fields at higher rates than students who did not have this expectation. We analyzed students in the United States for years 1988 through 2000 and controlled for differences in academic achievement, academic characteristics, and students' and parents' demographics.

Survey and Analysis

We used the *National Education Longitudinal Study of 1988* (*NELS:88*) for this study. Designed and conducted by the National Center for Educational Statistics (NCES), *NELS:88* began in 1988 with a survey of 24,599 eighth graders. Researchers conducted additional surveys in 1990, 1992, 1994, and 2000. The overall sample size after five surveys was 12,144 participants. Our analysis focused on those students who responded to the question about their age 30 career expectation as eighth graders in 1988 and who also obtained baccalaureate degrees from 4-year colleges or universities by 2000. This reduced the sample to 3,743 participants. The sample was further reduced to a final size of 3,359 participants, because 384 participants were missing data in one or more of the variables used in the analysis.

These variables included scores from mathematics and science achievement tests (designed by the Educational Testing Service) that were administered in the first three surveys of data collection, when students were mostly enrolled in the 8th, 10th, and 12th grades (*3*, *4*).

The baccalaureate degree concentrations—which were coded into three broad categories of physical science/engineering, life science, and nonscience—resulted in a categorical dependent variable (tables S1 and S2 and supporting online material text) (*5*). The independent variables used in this analysis came from data collected when participants were enrolled in the eighth grade.

In our analysis, we took into account students' backgrounds and natural propensities. For example, students with stronger performance in science and mathematics may be more likely to major in the sciences. We therefore included four covariate groups to account for (i) academic backgrounds (science and mathematics achievement scores); (ii) students' demographics (gender and ethnicity); (iii) students' academic characteristics (enrollment in advanced versus regular mathematics and science classes, attendance in these classes, and student-reported attitudes toward mathematics and science); and (iv) parents' background (highest educational level and professional versus nonprofessional employment) (*6*).

Our analysis focuses on the independent variable derived from the *NELS:88* survey question: "What kind of work do you expect to be doing when you are 30 years old?" Students were then given a list of employment options and required to select only one. We categorized the responses into two groups: science-related and nonscience career expectations, creating the Career Expectation independent variable (*4*).

We applied multinomial logistic regression, which handles categorical dependent variables with more than two outcomes. Our analysis included two outcome comparisons in earned baccalaureate degrees: (i) earning degrees in life sciences versus nonscience areas and (ii) earning degrees in physical sciences/engineering versus nonscience areas. We assessed the degree to which the independent variables could predict these two comparisons. In the *NELS:88* sampling design, two analytical issues require special attention: (i) the effect of purposeful

MULTINOMIAL LOGISTIC REGRESSION ANALYSIS

Independent variable		Coefficients of nested models				
		Baseline	2	3	4	Final
Career expectation	Life sci.	0.6 (0.2)	0.7 (0.2)	0.7 (0.2)	0.6 (0.2)	0.7 (0.2)
	Phy. sci. /engr.	1.7 (0.2)	1.4 (0.2)	1.2 (0.2)	1.2 (0.2)	1.2 (0.2)
Covariate groups						
Student demographics		+	+	+	+	
Achievement scores			+	+	+	
Academic characteristics				+	+	
Parent background					+	

Regression analysis results. $P < 0.001$ for all data shown; + indicates inclusion of covariates in the model; standard errors are shown in parentheses; n = 3359. Dependent variables: nonscience = 0, life science = 1, and physical science/engineering = 2. See supporting online material for more details.

Estimated probability comparisons. Probability that students who, in eighth grade, expected (dark line) or did not expect (light line) a science career would achieve a life science degree (left) or a physical science/engineering degree (right). Blue arrow designates the average mathematics achievement score.

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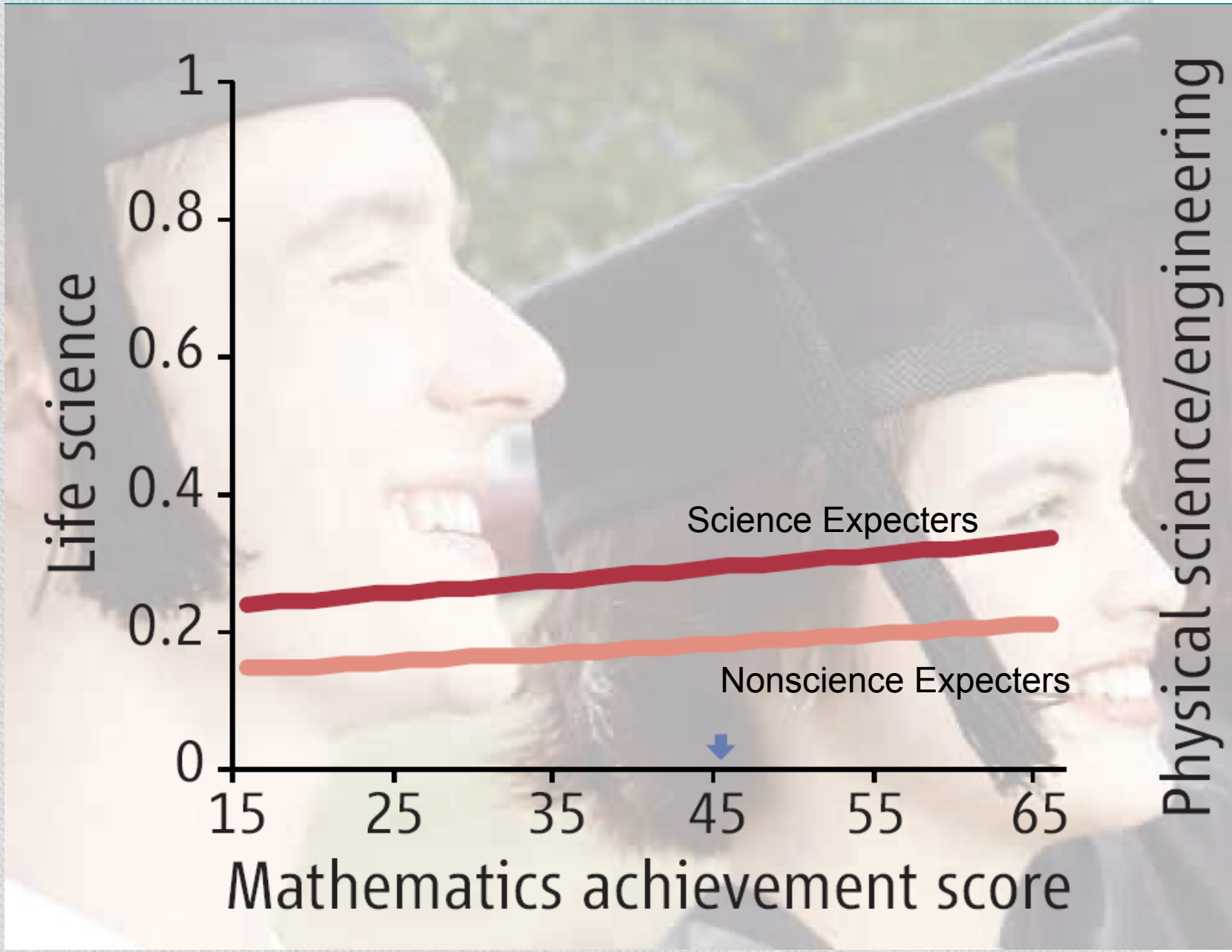
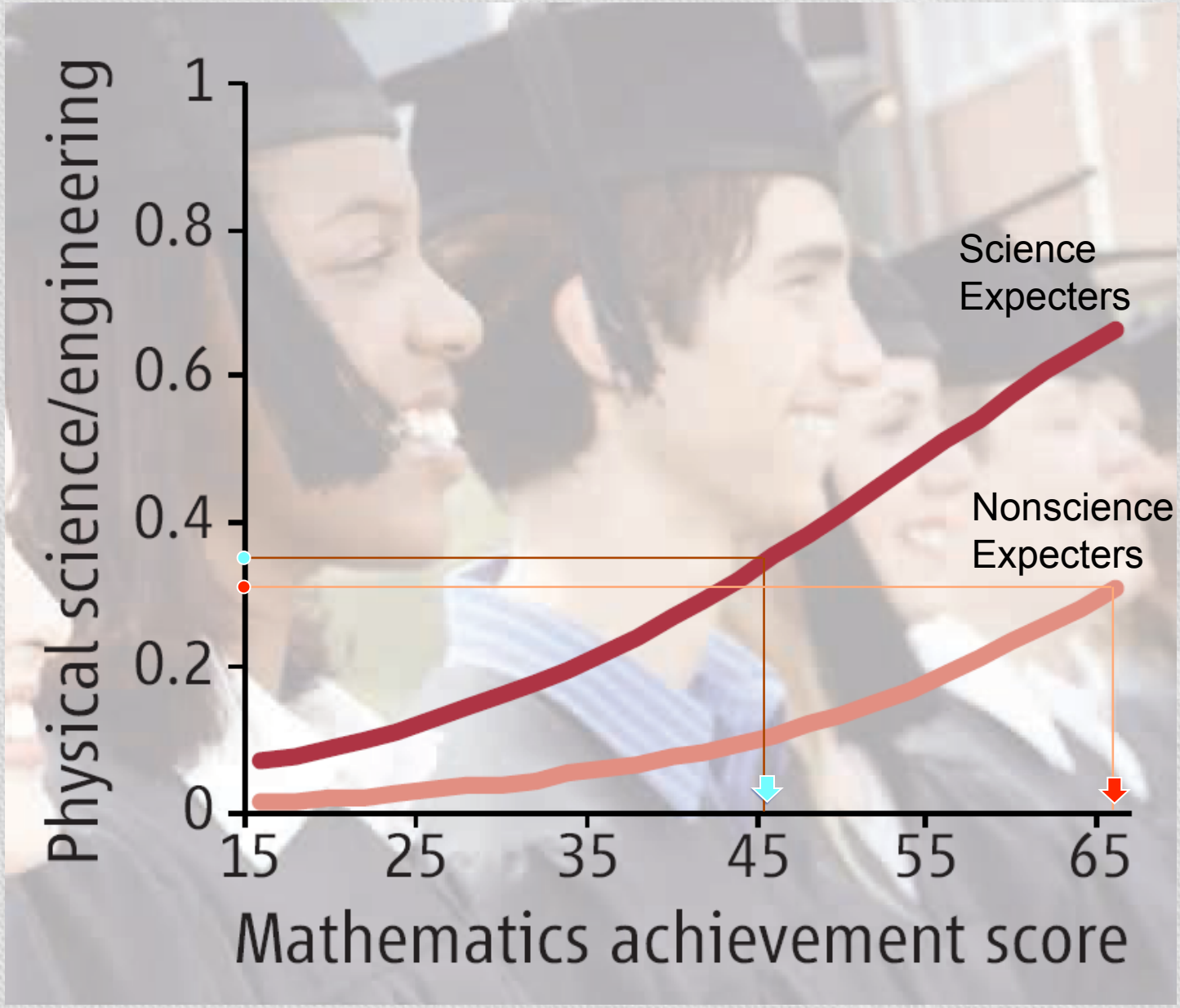

1
0.8
0.6
0.4
0.2
0
Life science
Science Expecters
Nonscience Expecters
15
25
35
45
55
65
Mathematics achievement score
Physical science/engineering

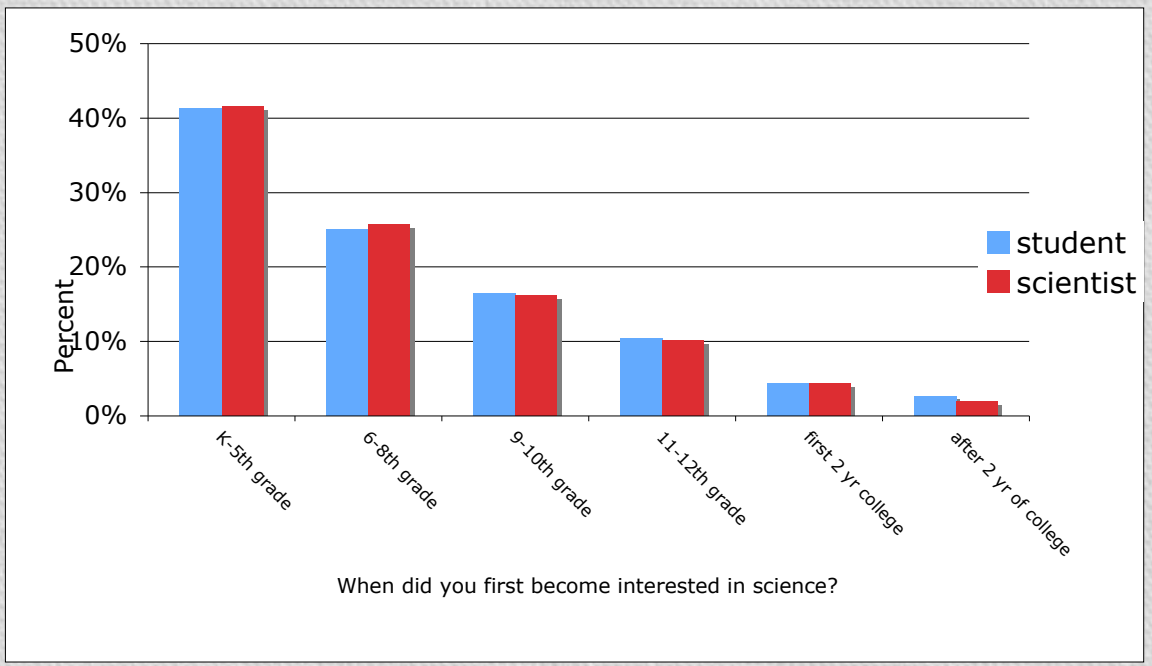

Physical science/engineering
1
0.8
0.6
0.4
0.2
0
15
25
35
45
55
65
Mathematics achievement score
Science Expecters
Nonscience Expecters

When do scientists and graduate students say they first became interested "science"?

70% of scientists and 69% of graduate students reported developing their interest in science in Grades K-8

24% of both scientists and graduate students in Grades 9 - 12

6% of scientists and 7% of graduate students in College



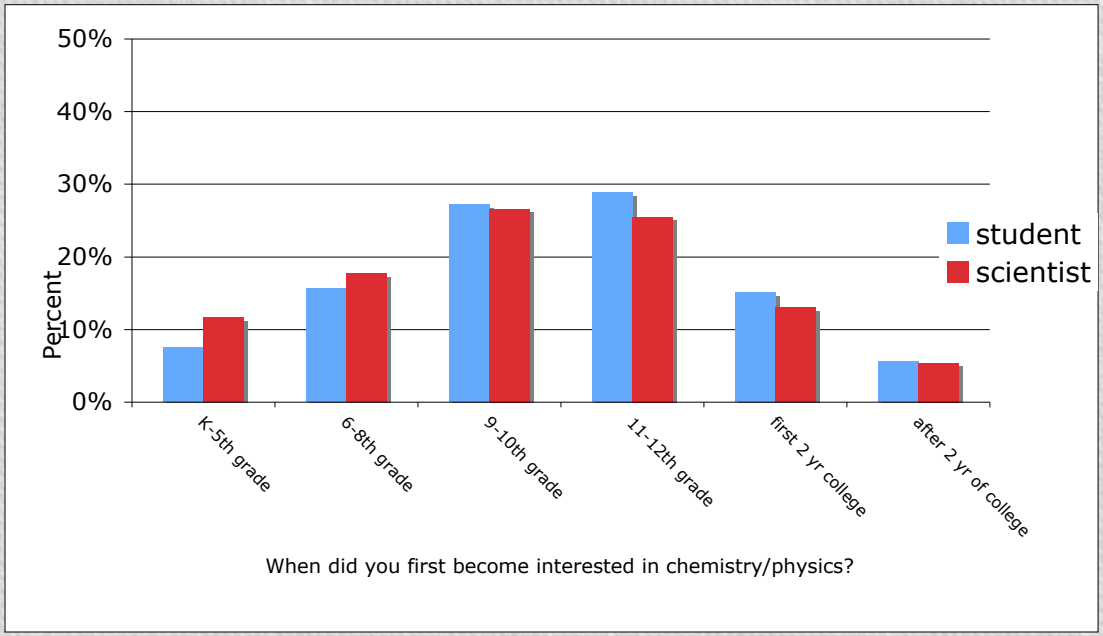
*Data from Project Crossover (NSF REC 0440002), PI R. H. Tai, University of Virginia

When do scientists and graduate students say they first became interested their career discipline?

29% of scientists and 23% of graduate students reported developing their interest in chemistry/physics in Grades K-8

52% of scientists and 56% of graduate students in Grades 9-12

18% of scientists and 21% of graduate students in College



*Data from Project Crossover (NSF REC 0440002), PI R. H. Tai, University of Virginia

Interest appears to play an important role in student engagement in a subject area.

How might we conceptualize the development of interest?

Hidi, S. & Renninger, K. A. (2006) The four-phase model of interest development. *Educational Psychologist*, 41 (2), 111 – 127.

The Four-phase Model of Interest Development (Hidi & Renninger)

Phases	Description and Characteristics
Triggered Situational Interest	Sparked by environmental or text features such as incongruous, surprising information
Maintained Situational Interest	Held and maintained through **meaningfulness of tasks and/or personal involvement**
Emerging Individual Interest	Positive feelings, stored knowledge, and stored value
Well-developed Individual Interest	More positive feelings, stored knowledge, and stored value over other interests Typically self-generated, but benefits from external support

Marks, H. (2000) Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American Educational Research Journal*, 37 (1), 153 – 184.

- **"Authentic" learning associated with life outside the classroom has strong positive connection with student engagement**

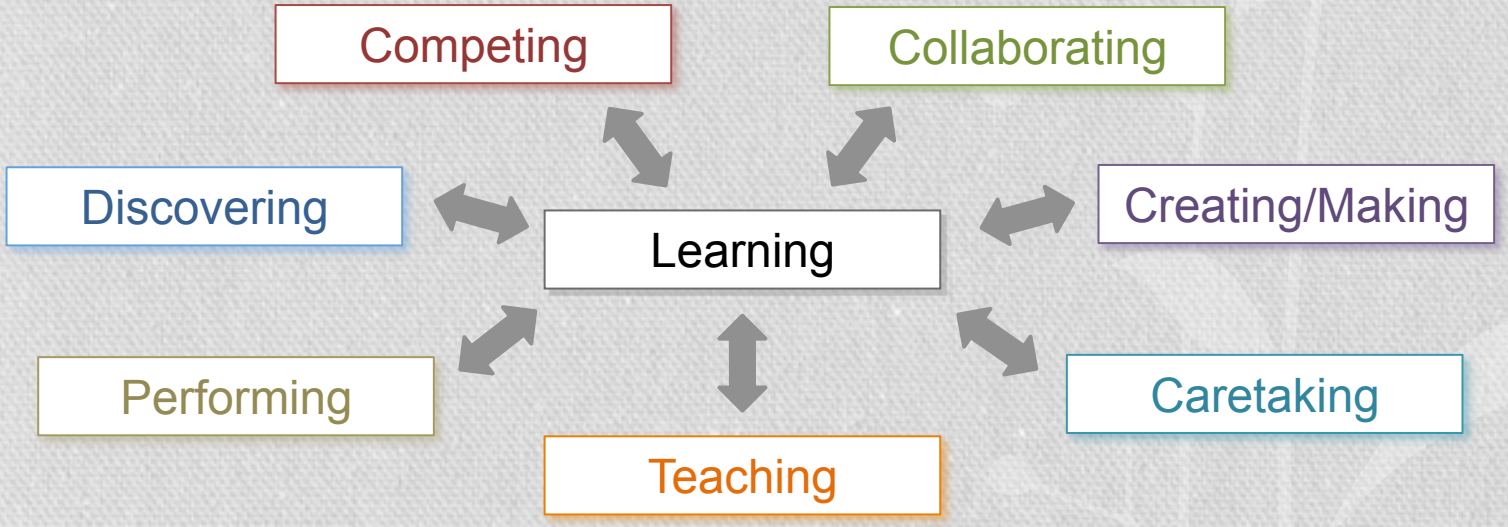
Hulleman, C. S. & Harackiewicz, J. M. (2009). Promoting performance and interest in high school science classes. *Science, 326, 1410 - 1412.*

- **Connecting learning to students lives has a measureable impact on performance and interst among students**

FOCIS

Framework for Observing Children's Interactions with Science
is a typology of learning activities

(Originally developed for K-12 learning environments, there are some applications for instruction in higher education)



Creating/Making

- When I see old bottles or boxes, I like to imagine making them into useful things

Teaching

- Helping my classmates learn new things is fun for me

Collaborating

- Working with others is more fun than working alone

Performing

- I feel comfortable when I am in front of a crowd

Competing

- Activities are more fun when I get to compete

Caretaking

- I like taking care of plants and animals

Discovering

- I like figuring things out

Exploratory Study

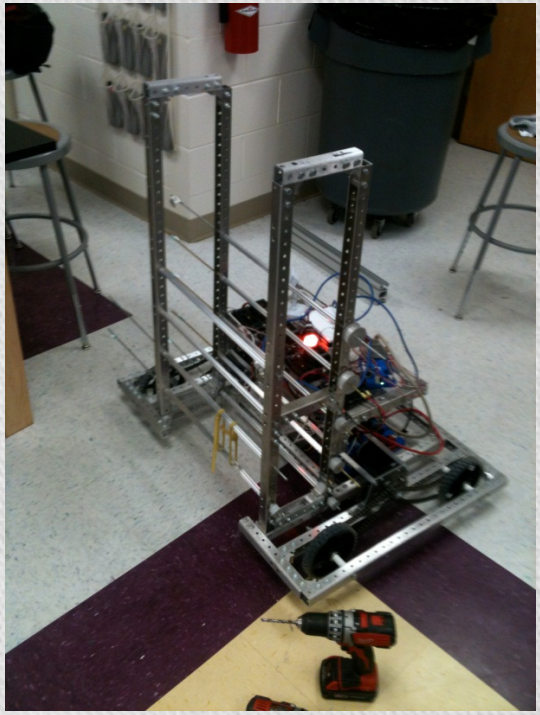
Method

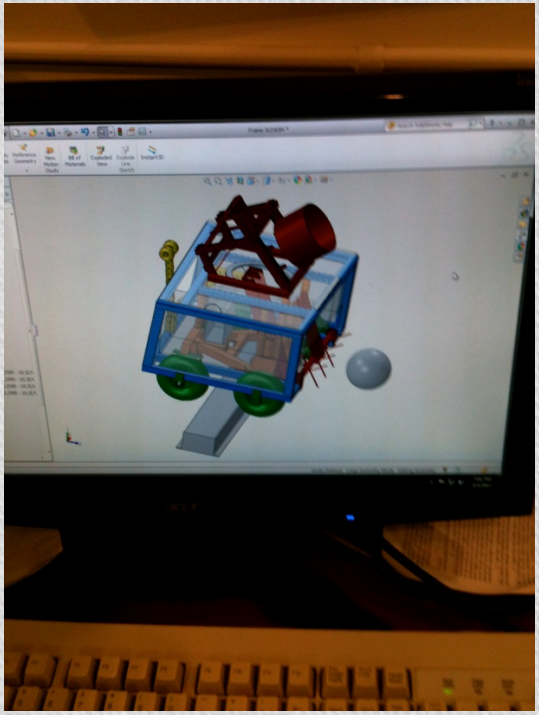
- Observed 12 FRC teams across Midwest, New England, and Central and Southern Atlantic regions.
- Conducted over 65 interviews with mentors and students.

Themes

- Student and Mentor Perception of 4-H
  - Community Outreach
- Team Operations
  - Start Up
  - Recruitment
  - Fundraising

FRC Build Season

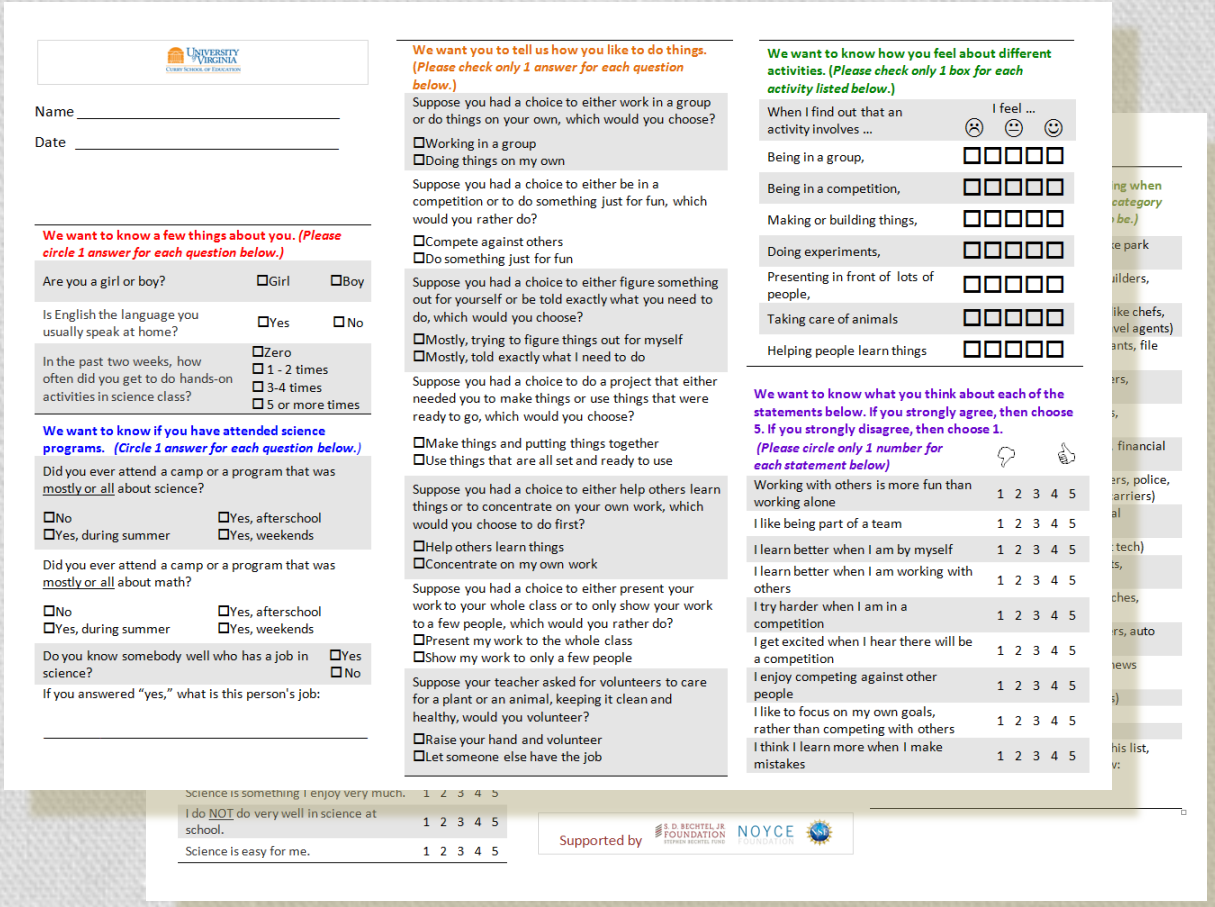




FRC Competition Season

Surveyed students at Camp Invention®

- Camp Invention® is operated by InventNOW ®, a non-profit organization in Akron, Ohio.
- Annually, Camp Invention® has 1100 5-Day summer programs enrolling over 77,000 students
- We developed a survey for FOCIS to asset students' preferences for learning activities.
- In this pilot study, we surveyed 17 sites enrolling 465 participants in Grades 4 - 6 from 10 states



University of Virginia Curry School of Education

Name _____

Date _____

We want to know a few things about you. ***(Please circle 1 answer for each question below.)***

Are you a girl or boy?	☐Girl	☐Boy
Is English the language you usually speak at home?	☐Yes	☐No
In the past two weeks, how often did you get to do hands-on activities in science class?	☐Zero ☐1 - 2 times ☐3-4 times ☐5 or more times	

We want to know if you have attended science programs. ***(Circle 1 answer for each question below.)***

Did you ever attend a camp or a program that was mostly or all about science?

☐No ☐Yes, afterschool
☐Yes, during summer ☐Yes, weekends

Did you ever attend a camp or a program that was mostly or all about math?

☐No ☐Yes, afterschool
☐Yes, during summer ☐Yes, weekends

Do you know somebody well who has a job in science? ☐Yes ☐No

If you answered "yes," what is this person's job:

_____

We want you to tell us how you like to do things. ***(Please check only 1 answer for each question below.)***

Suppose you had a choice to either work in a group or do things on your own, which would you choose?
☐Working in a group
☐Doing things on my own

Suppose you had a choice to either be in a competition or to do something just for fun, which would you rather do?
☐Compete against others
☐Do something just for fun

Suppose you had a choice to either figure something out for yourself or be told exactly what you need to do, which would you choose?
☐Mostly, trying to figure things out for myself
☐Mostly, told exactly what I need to do

Suppose you had a choice to do a project that either needed you to make things or use things that were ready to go, which would you choose?
☐Make things and putting things together
☐Use things that are all set and ready to use

Suppose you had a choice to either help others learn things or to concentrate on your own work, which would you choose to do first?
☐Help others learn things
☐Concentrate on my own work

Suppose you had a choice to either present your work to your whole class or to only show your work to a few people, which would you rather do?
☐Present my work to the whole class
☐Show my work to only a few people

Suppose your teacher asked for volunteers to care for a plant or an animal, keeping it clean and healthy, would you volunteer?
☐Raise your hand and volunteer
☐Let someone else have the job

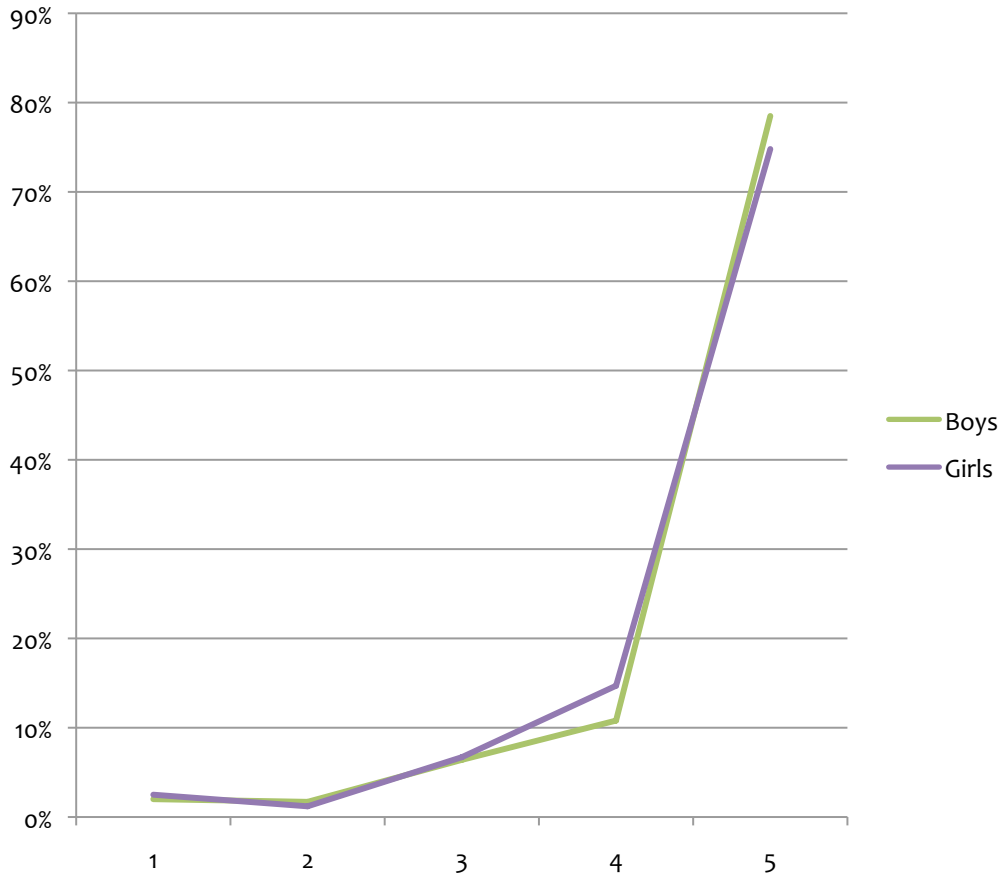
We want to know how you feel about different activities. ***(Please check only 1 box for each activity listed below.)***

When I find out that an activity involves ...	I feel ... ☹ 😐 ☺
Being in a group,	☐☐☐☐☐
Being in a competition,	☐☐☐☐☐
Making or building things,	☐☐☐☐☐
Doing experiments,	☐☐☐☐☐
Presenting in front of lots of people,	☐☐☐☐☐
Taking care of animals	☐☐☐☐☐
Helping people learn things	☐☐☐☐☐

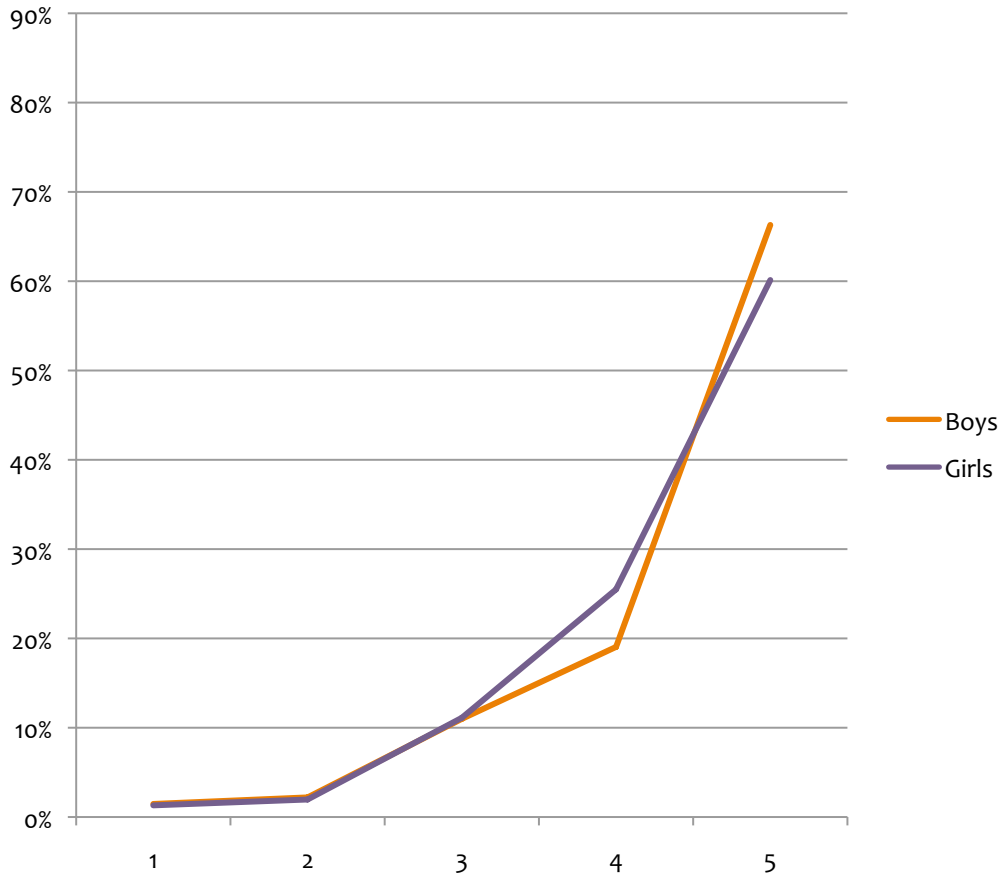
We want to know what you think about each of the statements below. If you strongly agree, then choose 5. If you strongly disagree, then choose 1.
(Please circle only 1 number for each statement below)

	👎 1 2 3 4 5 👍
Working with others is more fun than working alone	1 2 3 4 5
I like being part of a team	1 2 3 4 5
I learn better when I am by myself	1 2 3 4 5
I learn better when I am working with others	1 2 3 4 5
I try harder when I am in a competition	1 2 3 4 5
I get excited when I hear there will be a competition	1 2 3 4 5
I enjoy competing against other people	1 2 3 4 5
I like to focus on my own goals, rather than competing with others	1 2 3 4 5
I think I learn more when I make mistakes	1 2 3 4 5
Science is something I enjoy very much.	1 2 3 4 5
I do NOT do very well in science at school.	1 2 3 4 5
Science is easy for me.	1 2 3 4 5

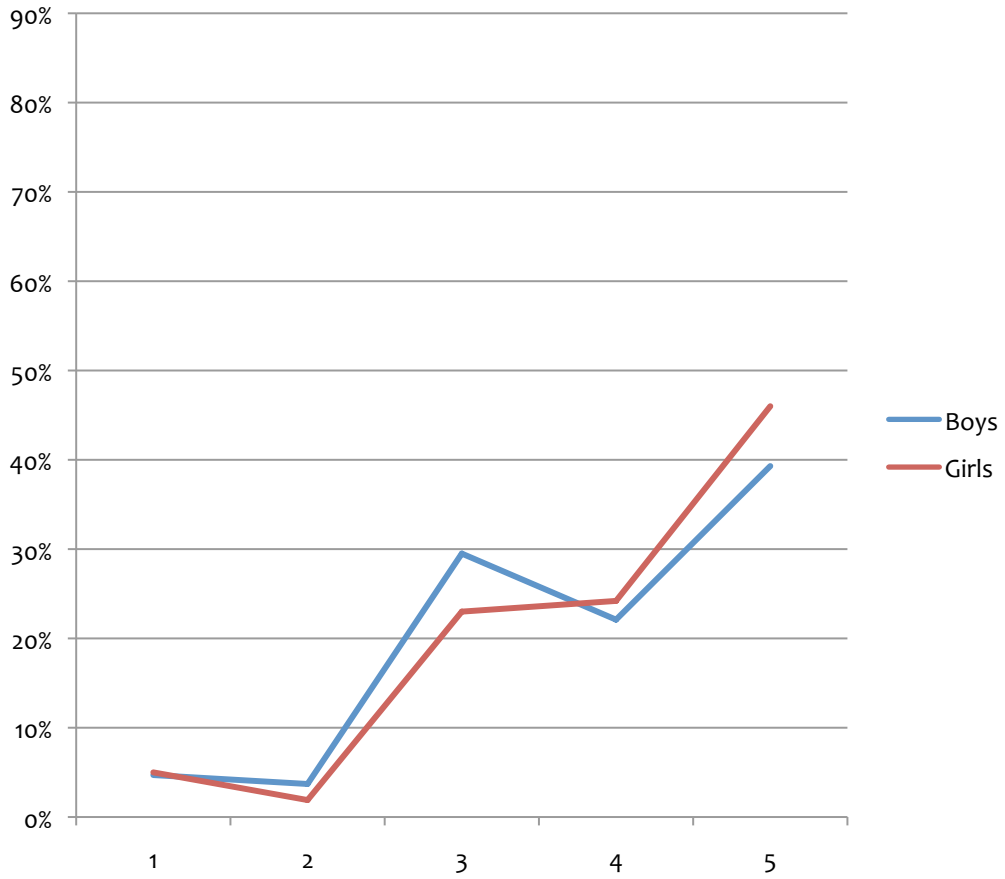
Supported by S. D. Bechtel, Jr. Foundation · Noyce Foundation · NSF



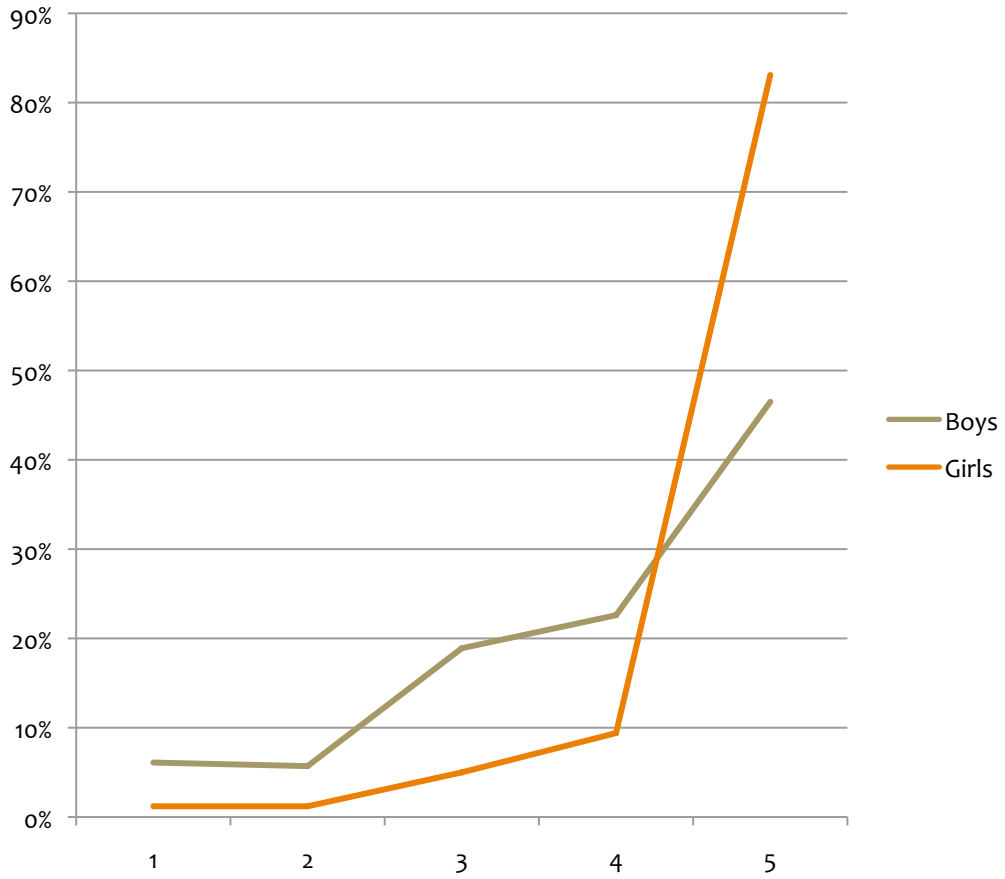
Creating/Making



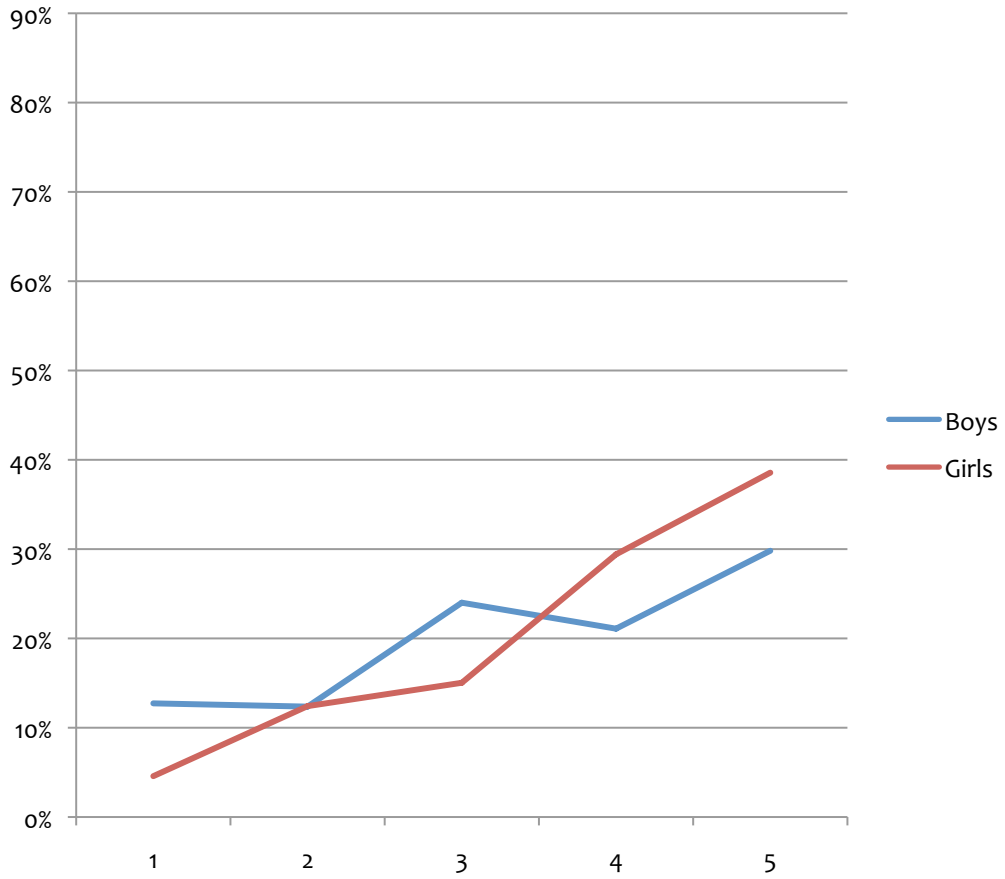
Discovering



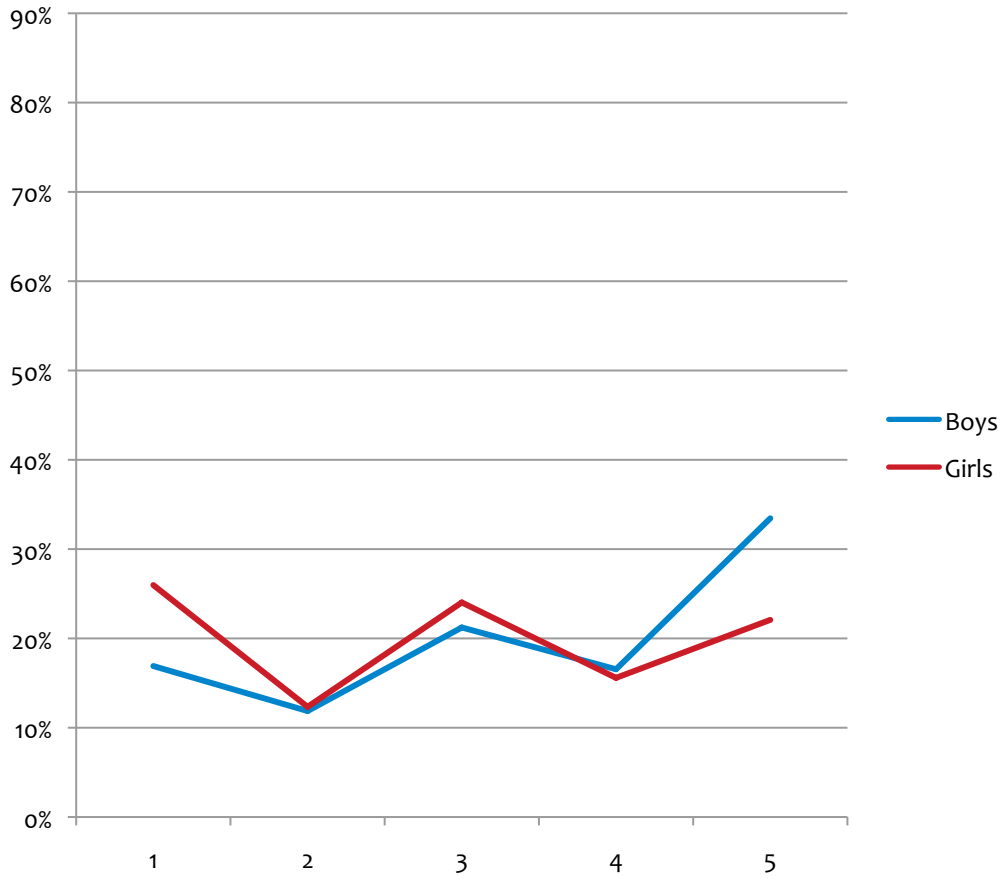
Collaborating



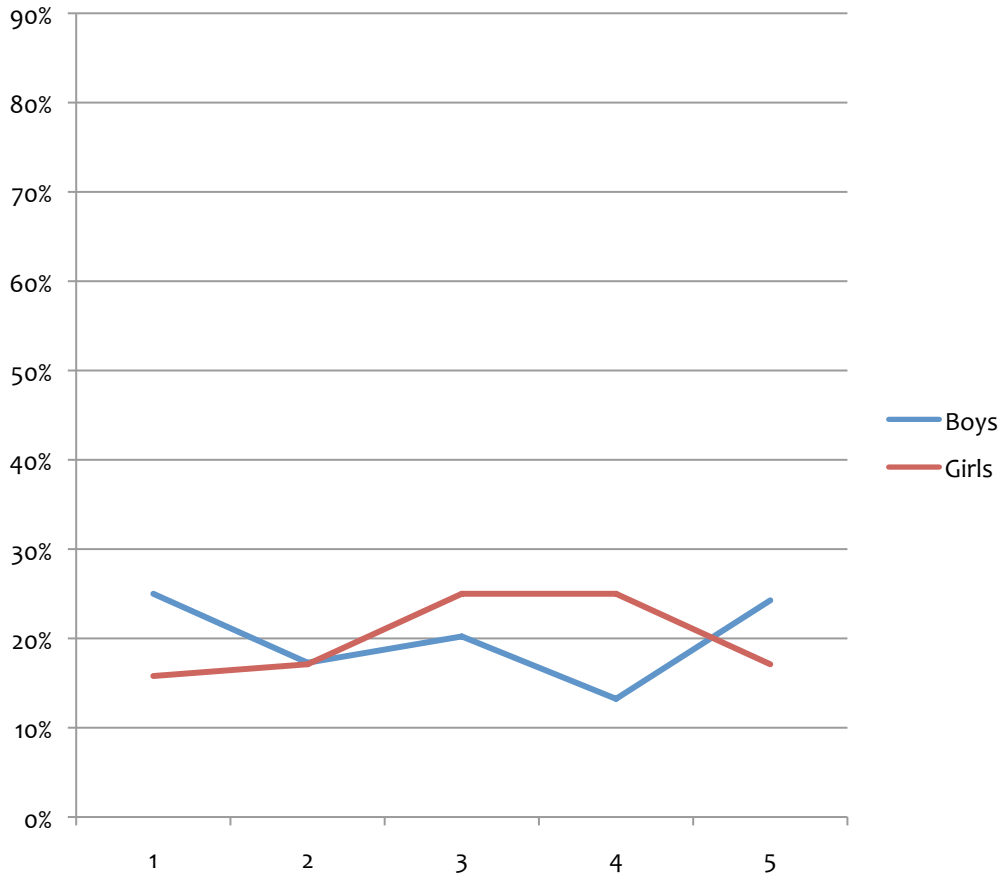
Caretaking



Teaching



Competing

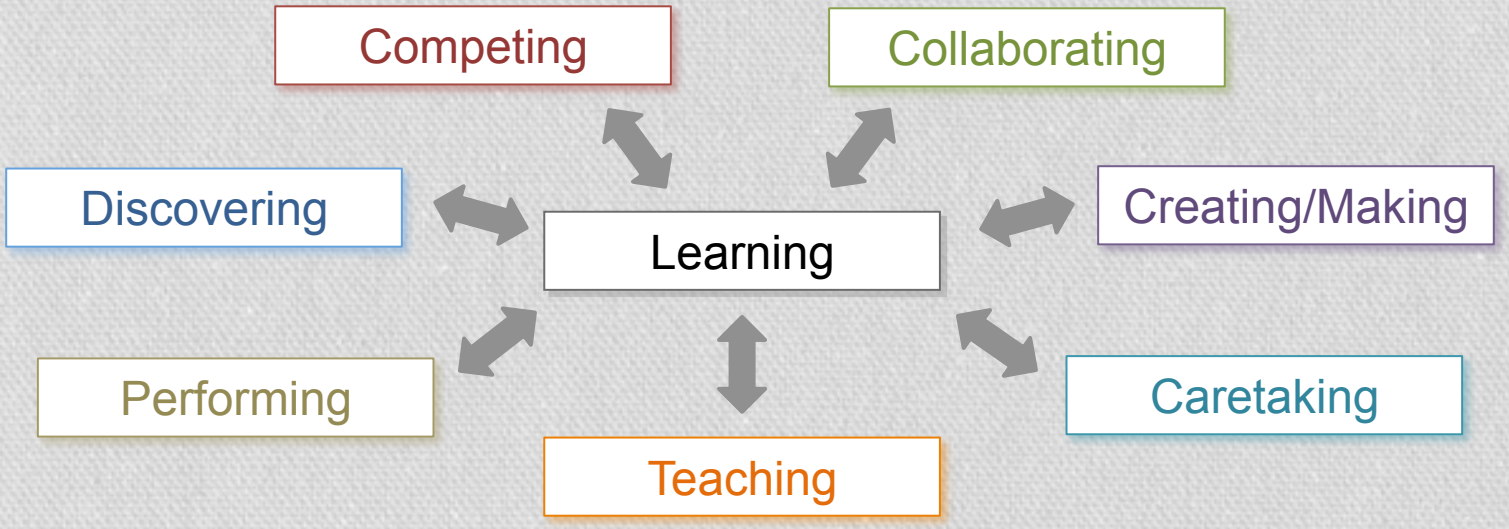


Performing

Among 465 4th – 6th Grade students who attended Camp Invention® in 2013 at the 17 study sites

- **Creating/Making, Discovering, Collaborating**, and **Caretaking** generally reported high or very high preferences among campers
- Preference response patterns for **Collaborating**, **Discovering**, and **Creating/Making** are very similar for both Girls and Boys
- **Caretaking** was rated **very high among Girls** compared to only **generally positive among Boys**
- **Teaching** were generally positive among Girls, but revealed a shallower slope among Boys
- **Competing** and **Performing** both reported "flat" response patterns for both Girls and Boys

FOCIS


Competing
Collaborating
Discovering
Learning
Creating/Making
Performing
Caretaking
Teaching

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Thank you

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SUPPLEMENTARY SLIDES