

# Future of Education for STEM Talented Adolescents

July 10, 2013

John T. Almarode, Ph.D.

James Madison University

Rena F. Subotnik, Ph.D.

American Psychological Association

Edward Crowe, Ph.D.

The Woodrow Wilson Foundation

Robert H. Tai, Ed.D.

University of Virginia



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Study Research Goals

***Overarching Research Question:*** What is the impact of participation in a selective science, mathematics, and technology (SMT) schools or Talent Search (TS) programs on completion of an undergraduate STEM major or concentration?

***Sub-research question 1:*** What are the characteristics of the SMT school, TS, and/or the participants associated with this outcome?

***Sub-research question 2:*** Do these characteristics differentially affect subgroups within the SMT schools and TS programs?



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Study Description: Participants

2004-2007 graduates of 25 selective SMT schools:  $n = 3,510$

Comparison group of same age peers who attended a Talent Search program and enrolled in mathematics or science classes during the summer:  $n = 603$

## Gender

Males		Females	
SMT	1,579 (46.8%)	SMT	1,797 (53.2%)
Comparison	257 (44.6%)	Comparison	319 (55.4%)



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Study Description: Participants

## Other Demographics

<i>n</i> = 4,113	
Hispanic Origin	170 (4.1%)
Caucasian	2,859 (69.5%)
African American	173 (4.2%)
Asian	931 (22.6%)
American Indian/Alaskan Native	40 (1.0%)
Native Hawaiian/Pacific Islander	13 (0.3%)
Other	157 (3.8%)
English as Primary Language	3,249 (79.0%)



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

## How many attended a specialized SMT high school?

<i>n</i> = 4,113	
Attended a Specialized SMT High School	3,526 (85.7%)
Did Not Attend a Specialized SMT High School	587 (14.3%)



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# How many attended a specialized SMT high school?

<i>n</i> = 4,113	
Attended a Specialized SMT High School	3,526 (85.7%)
Did Not Attend a Specialized SMT High School	587 (14.3%)

3,526 > 3,510



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



# School Model Descriptions

- ◆ **Residential:** Draws from an entire state. All students reside on campus. ( $n = 8$ )
- ◆ **Half-Time:** Students attend a regional center for SMT courses daily. ( $n = 7$ )
- ◆ **Full-Time Commuter:** Whole school is SMT and draws from local metropolitan population. ( $n = 4$ )
- ◆ **School-within-School:** An academy within a regular high school. ( $n = 6$ )



# School Model Descriptions

<i>n</i> = 3,526	
Residential ( <i>n</i> = 8)	1,220 (34.6%)
Half-Time ( <i>n</i> = 7)	818 (23.2%)
Full-Time Commuter ( <i>n</i> = 4)	843 (23.9%)
School-within-School ( <i>n</i> = 6)	645 (18.3%)



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



# Study Research Goals

## ***Overarching Research Question:***

What is the impact of participation in a selective science, mathematics, and technology (SMT) schools or Talent Search (TS) programs on completion of an undergraduate STEM major or concentration?



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Completion of a STEM Degree

- ▶ 49.8% percent of specialized SMT high school graduates completed a STEM undergraduate degree.
  - ▶ School w School: 58.3%
  - ▶ Residential: 51.7%
  - ▶ Half-Day: 48.4%
  - ▶ Full-Time Commuter: 42.3%
- ▶ 53.4% percent of comparison group completed a STEM undergraduate degree.
- ▶ According to the National Science Foundation, 22.6% of students entering college graduate with a STEM undergraduate degree.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Percentage of Female Participants Completing STEM degrees (by discipline)

SMT		TS	
Male	57.8%	Male	61.9%
Female	46.1%	Female	50.5%

	SMT	TS	NSF
Bio & BioMed	33.1%	26.3%	5.4%
Physical Science	9.3%	10.0%	0.9%
Engineering	11.0%	12.2%	1.4%
Mathematics	6.0%	6.9%	0.7%



# Logistic Regression ( $n = 3,761$ )

**Dependent Variable:** STEM Related Major or Concentration

**Independent Variable:** Attendance at a Specialized SMT High School

	B	S.E.	Sig.	Odds Ratio	95% CI
Attendance at a Specialized SMT High School	-0.097	0.097	ns	0.907	[.750, 1.097]
Gender (Females)	-0.454	0.067	***	0.635	[.558, .724]
Hispanic Origin	-0.643	0.181	***	0.526	[.369, .750]
Race/Ethnicity	0.731	0.349	*	2.077	[1.047, 4.118]
English as Primary Language	-0.150	0.129	ns	0.861	[.669, 1.108]
Immigrant Status	0.201	0.125	ns	1.222	[.956, 1.562]
Parental Education	0.243	0.098	*	1.276	[1.054, 1.544]
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Logistic Regression ( $n = 3,761$ )

**Dependent Variable:** STEM Related Major or Concentration

**Independent Variable:** Attendance at a Specialized SMT High School

	B	S.E.	Sig.	Odds Ratio	95% CI
<b>Attendance at a Specialized SMT High School</b>	<b>-0.097</b>	<b>0.097</b>	<b>ns</b>	<b>0.907</b>	<b>[.750, 1.097]</b>
Gender (Females)	-0.454	0.067	***	0.635	[.558, .724]
Hispanic Origin	-0.643	0.181	***	0.526	[.369, .750]
Race/Ethnicity	0.731	0.349	*	2.077	[1.047, 4.118]
English as Primary Language	-0.150	0.129	ns	0.861	[.669, 1.108]
Immigrant Status	0.201	0.125	ns	1.222	[.956, 1.562]
Parental Education	0.243	0.098	*	1.276	[1.054, 1.544]
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Results

- ◆ Students who graduated from a specialized SMT high school were no more likely to report that they earned a STEM related major or concentration than those respondents that participated in the Talent Search programs.
- ◆ Females were 36.5% less likely and those reporting Hispanic origins were 47.4% less likely to report that they earned a STEM related major or concentration.
- ◆ Those respondents reporting that their parents/guardians earned at least a bachelors degree were 27.6% more likely to report that they earned a STEM related major or concentration.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



# Results

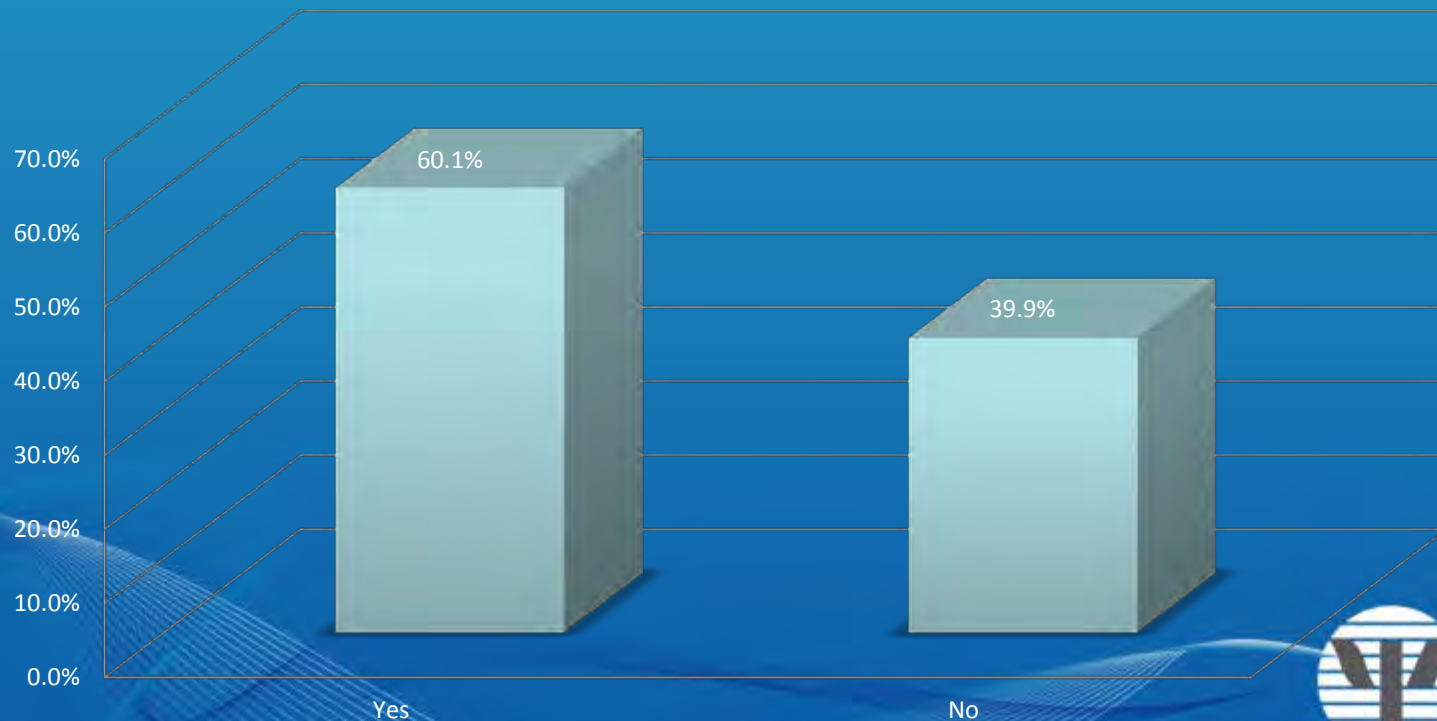
- ◆ Students who graduated from a specialized SMT high school were not more likely to report that they earned a STEM related major or concentration than those respondents that participated in the Talent Search programs.
- ◆ Females were 36.5% less likely and those reporting Hispanic origins were 47.4% less likely to report that they earned a STEM related major or concentration.
- ◆ Those respondents reporting that their parents/guardians earned at least a bachelors degree were 27.6% more likely to report that they earned a STEM related major or concentration.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

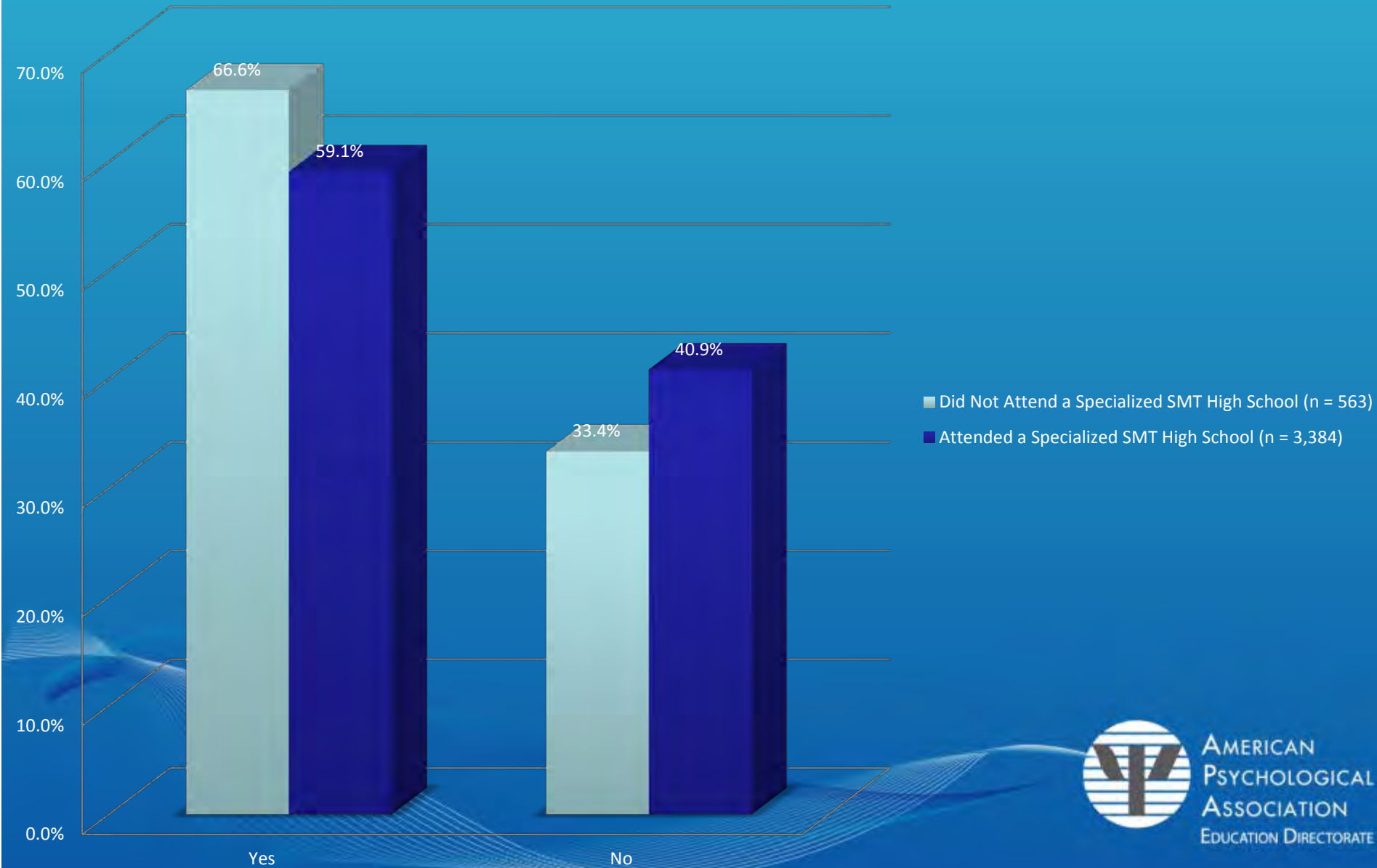
# Instead of parental/guardian education, what about parental/guardian career?

Are or were either of your parents/guardians in a career that involves direct technical knowledge of STEM?  
n = 3,947



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Are or were either of your parents/guardians in a career that involves direct technical knowledge of STEM?



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Logistic Regression ( $n = 3,752$ )

**Dependent Variable:** Attend a Specialized SMT High School

**Independent Variable:** Parent or guardian in a career that involves direct technical knowledge of STEM

	B	S.E.	Sig.	Odds Ratio	95% CI
<b>Parent/Guardian Career in STEM</b>	<b>0.026</b>	<b>0.105</b>	<b>ns</b>	<b>0.804</b>	<b> [.835, 1.262]</b>
Gender (Females)			Included		
Hispanic Origin			Included		
Race/Ethnicity			Included		
English as Primary Language			Included		
Immigrant Status			Included		
Parental Education			Included		
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Logistic Regression ( $n = 3,752$ )

**Dependent Variable:** STEM Related Major or Concentration

**Independent Variable:** Parent or guardian in a career that involves direct technical knowledge of STEM

	B	S.E.	Sig.	Odds Ratio	95% CI
<b>Parent/Guardian Career in STEM</b>	<b>0.261</b>	<b>0.073</b>	<b>***</b>	<b>1.298</b>	<b>[1.126, 1.496]</b>
Gender (Females)			Included		
Hispanic Origin			Included		
Race/Ethnicity			Included		
English as Primary Language			Included		
Immigrant Status			Included		
Parental Education			Included		
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Results

- ◆ Those respondents reporting that their parents/guardians are or were in a career that involves direct technical knowledge of STEM were 29.8% more likely to report that they earned a STEM related major or concentration.
- ◆ Students who graduated from a specialized SMT high school were not more likely to report that they earned a STEM related major or concentration than those respondents that participated in the Talent Search programs.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



# Three Possible Interpretations

1. Throw up our hand; specialized SMT high schools do nothing to increase the flow of students into the STEM pipeline or pathways.
2. Specialized SMT high schools serve as incubators for talented adolescents with a proclivity for STEM related disciplines.
3. Talent Search programs are more than just a comparison group, but a fifth model for talented adolescents with a proclivity for STEM related disciplines.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

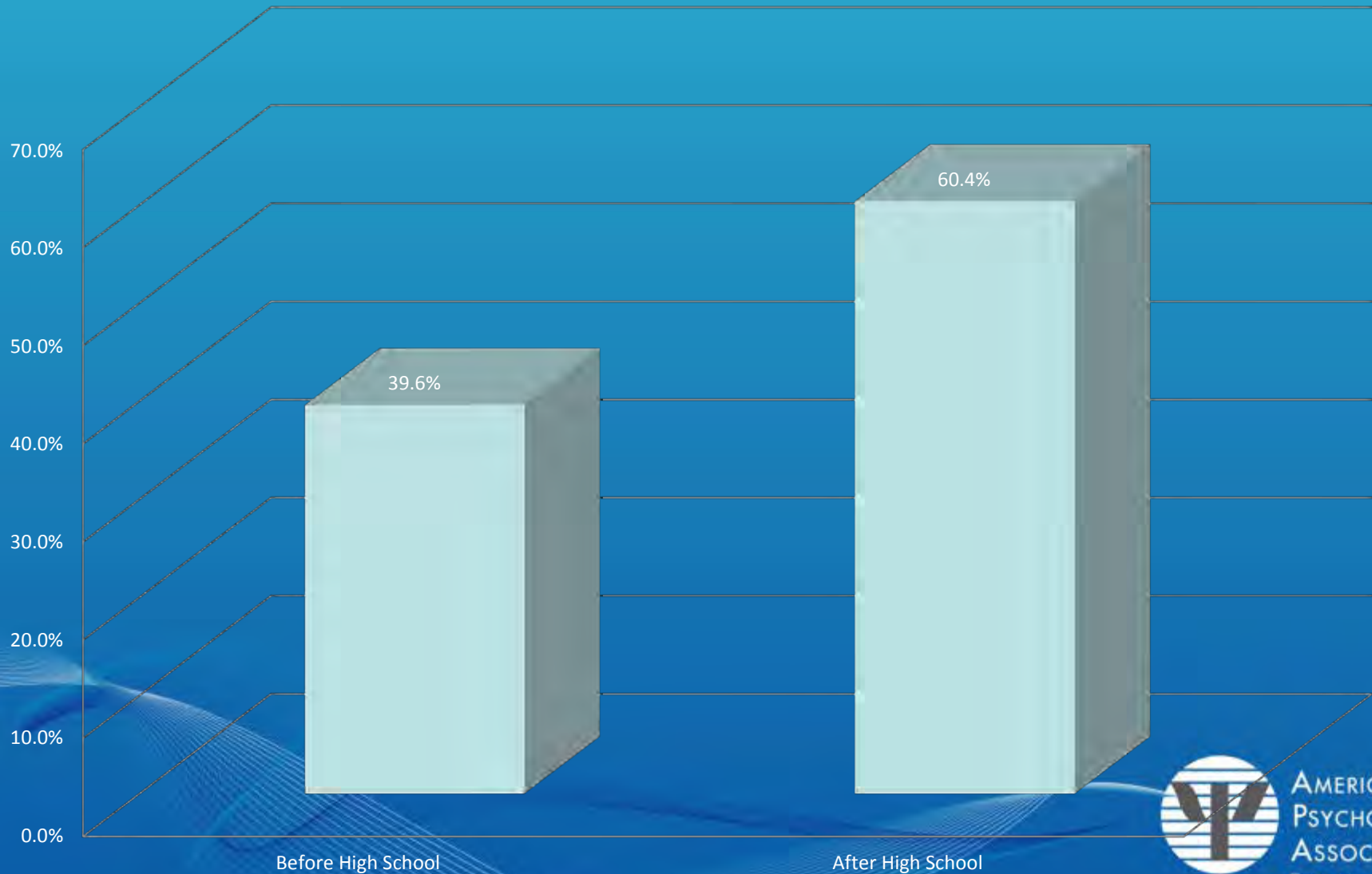
- ~~1. Throw up our hands, specialized SMT high schools do nothing to increase the flow of students into the STEM pipeline or pathways.~~
2. Specialized SMT high schools serve as incubators for talented adolescents with a proclivity for STEM related disciplines.
3. Talent Search programs are more than just a comparison group, but a fifth model for talented adolescents with a proclivity for STEM related disciplines.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

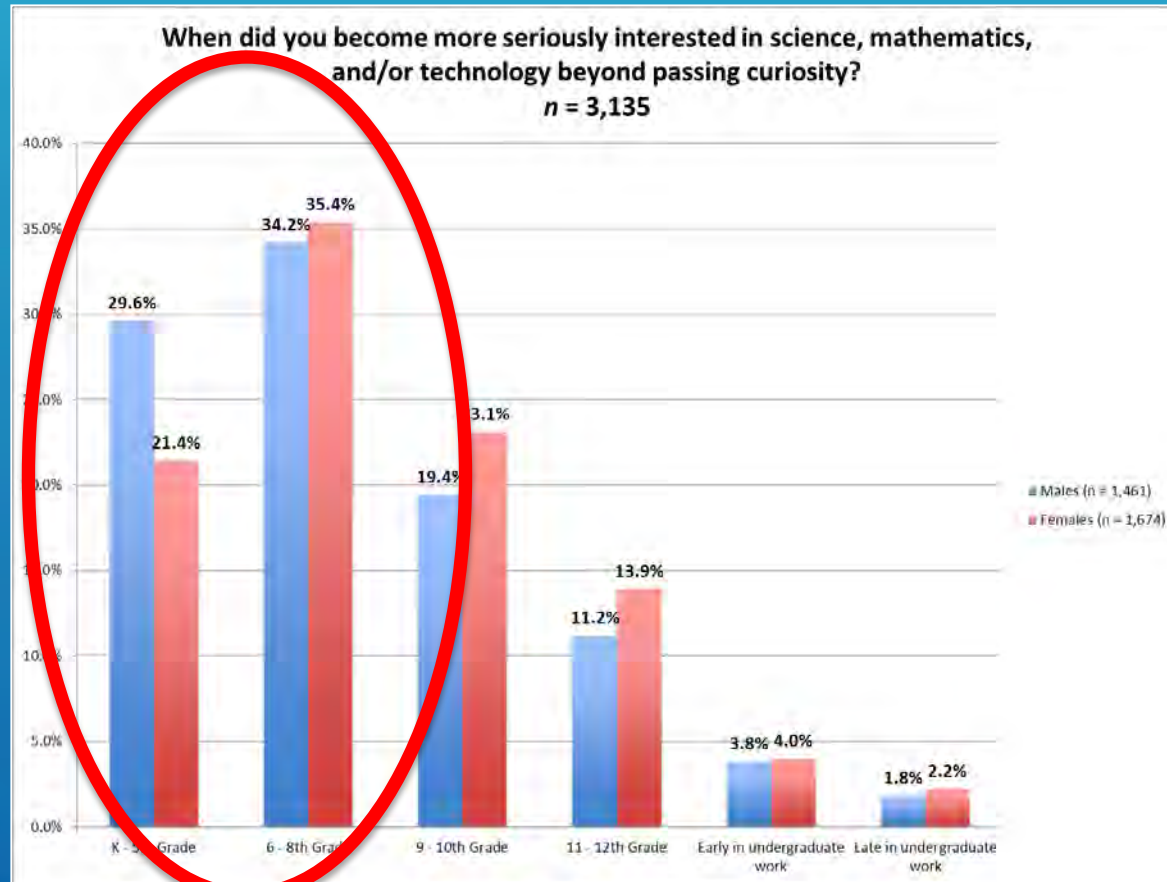
# When did you first become interested in topics related to your eventual college major or concentration?

n = 3,642



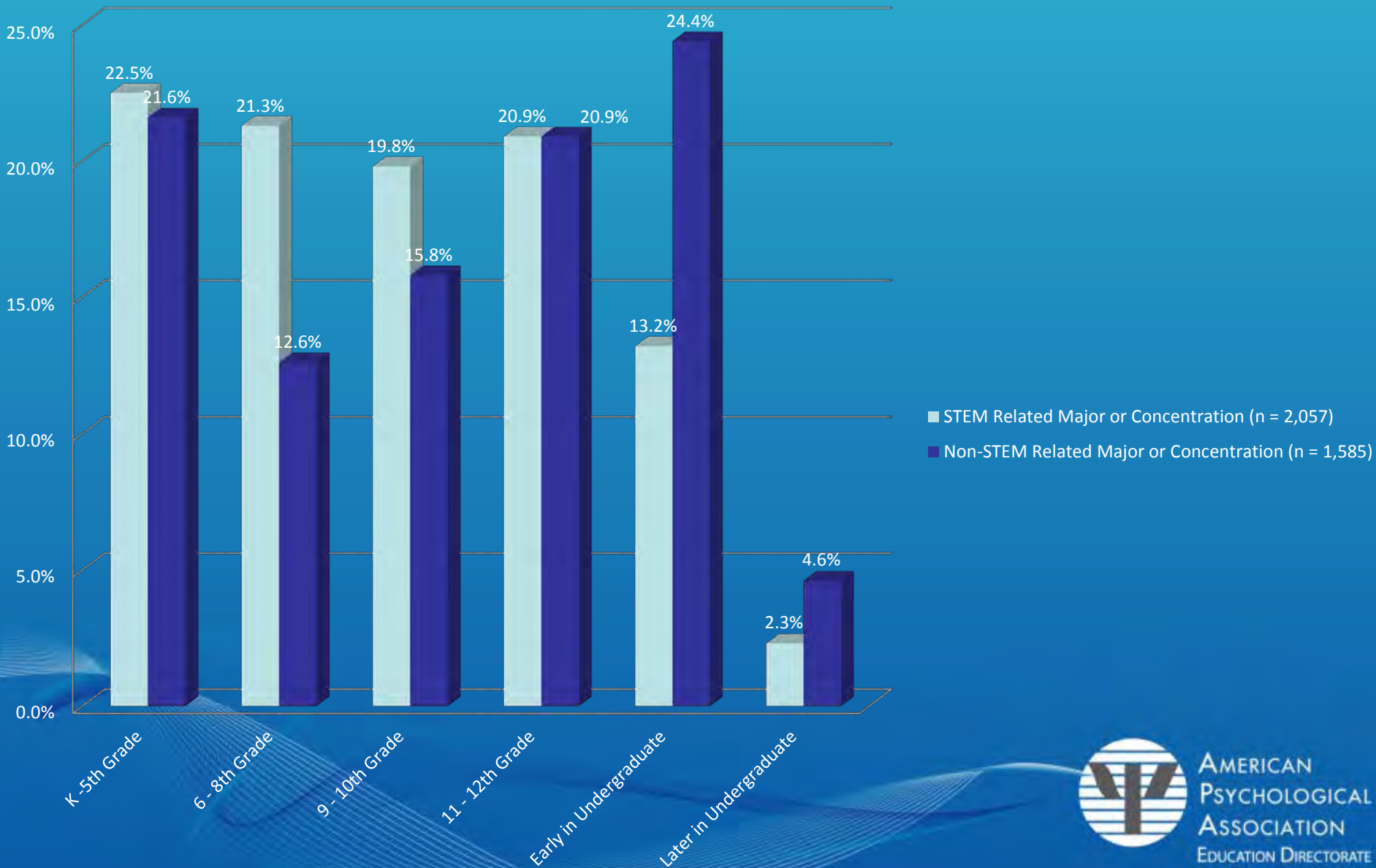
AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Interest, Not Choice of Major



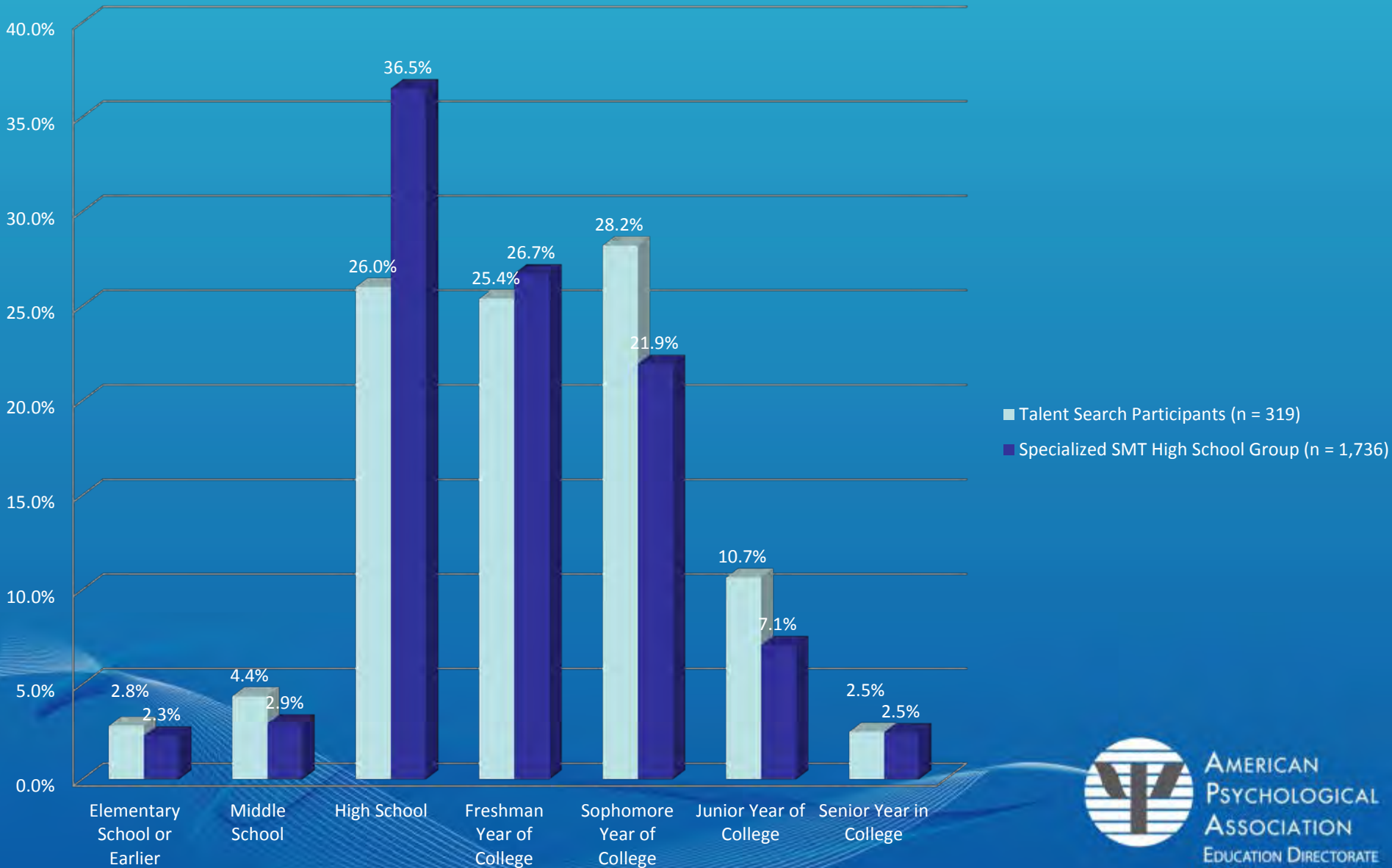
AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# When did you first become interested in topics related to your eventual college major or concentration?





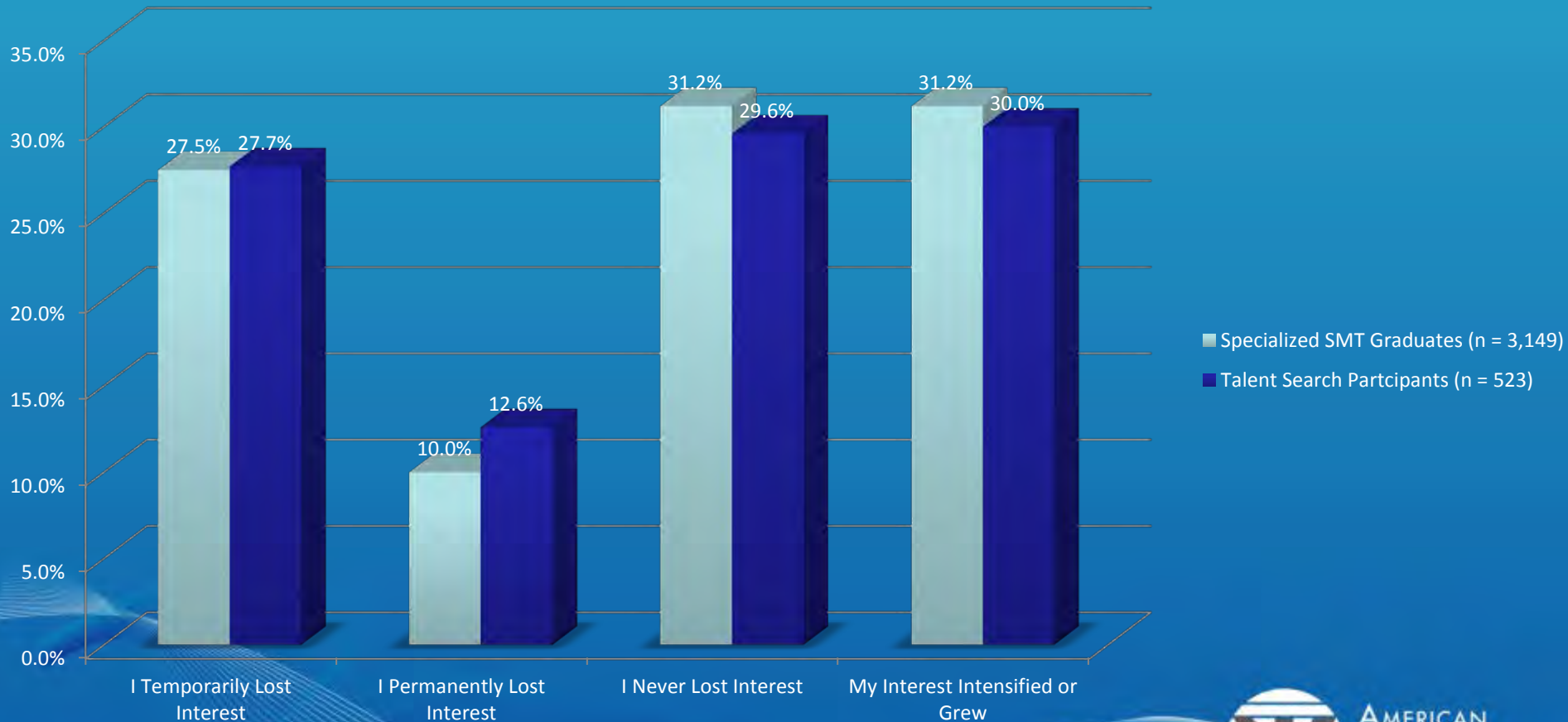
# Timing of Selection of Major for those Graduating with STEM Related Majors or Concentrations by Study Group



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



## With regard to your interest in science, mathematics, and/or technology, which of the following apply?



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Logistic Regression ( $n = 3,321$ )

**Dependent Variable:** STEM Related Major or Concentration

**Independent Variable:** Never Lost Interest

	B	S.E.	Sig.	Odds Ratio	95% CI
<b>Never Lost Interest</b>	<b>0.498</b>	<b>0.221</b>	<b>*</b>	<b>1.645</b>	<b>[1.066, 2.539]</b>
Gender (Females)			Included		
Hispanic Origin			Included		
Race/Ethnicity (American Indian/Alaskan Native)			Included		
English as Primary Language			Included		
Immigrant Status			Included		
Parental Education			Included		
Parent/Guardian in STEM			Included		
Early Interest			Included		
Attendance to SMT HS			Included		
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# Logistic Regression ( $n = 3,321$ )

**Dependent Variable:** STEM Related Major or Concentration

**Independent Variable:** Intensified Interest

	B	S.E.	Sig.	Odds Ratio	95% CI
<b>Intensified Interest</b>	<b>1.621</b>	<b>0.261</b>	<b>***</b>	<b>5.060</b>	<b>[3.032, 8.445]</b>
Gender (Females)			Included		
Hispanic Origin			Included		
Race/Ethnicity (American Indian/Alaskan Native)			Included		
English as Primary Language			Included		
Immigrant Status			Included		
Parental Education			Included		
Parent/Guardian in STEM			Included		
Early Interest			Included		
Attendance to SMT HS			Included		
Constant			Included		

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

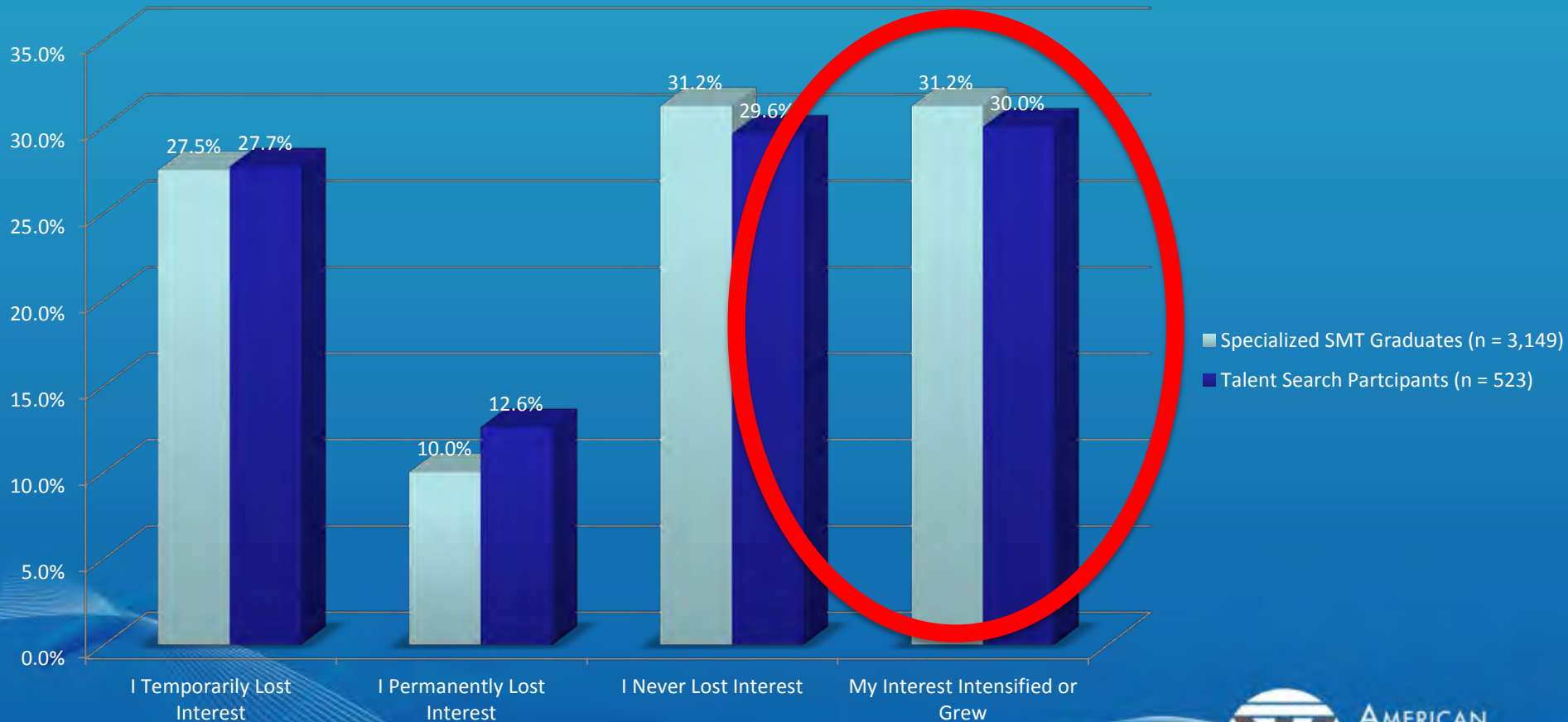
# Results

- ◆ Those respondents reporting that they never lost interest in SMT subjects were 64.5% more likely to report that they earned a STEM related major or concentration.
- ◆ Those respondents reporting that their interest intensified or grew in SMT subjects were over 5 times more likely to report that they earned a STEM related major or concentration.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

## With regard to your interest in science, mathematics, and/or technology, which of the following apply?



# Participation in High School Research Projects

School within a School	56.3%
Half - Day	53.5%
Residential	34.2%
Comprehensive	33.3%
Comparison Group	13.3%

**Females:** nearly **2 times** the odds (1.95) of completing a STEM university degree compared to females who did not.

Overall, those who participated in high school research were nearly **2 times** more likely to complete a STEM degree.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE



# What is associated with this intensification or growth in interest?

1. Emphasis on Deep Conceptual Understanding
2. Connections to Other Content Areas
3. Laboratory Experiences
4. Hands On Experiences
5. Field Trips
6. Guest Lectures
7. Demonstrations
8. Internships
9. Allowed to Pursue Own Interests
10. Collaboration
11. Pace (Too Fast, Too Slow)
12. Level of Teacher Enthusiasm
13. Expertise of Teacher in STEM
14. Awareness of Careers
15. Reinforce Self-Confidence
16. Reinforce Interest



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

# What is associated with this intensification or growth in interest?

1. Emphasis on Deep Conceptual Understanding
2. Connections to Other Content Areas
3. Laboratory Experiences
4. Hands On Experiences
5. Field Trips
6. Guest Lectures
7. Demonstrations
8. Internships
9. Allowed to Pursue Own Interests
10. Collaboration
11. Pace (Too Fast, Too Slow)
12. Level of Teacher Enthusiasm
13. Expertise of Teacher in STEM
14. Awareness of Careers
15. Reinforce Self-Confidence
16. Reinforce Interest



# What is associated with this intensification or growth in interest?

1. Emphasis on Deep Conceptual Understanding
2. **Connections to Other Content Areas**
3. Laboratory Experiences
4. Hands On Experiences
5. Field Trips
6. Guest Lectures
7. Demonstrations
8. **Internships**
9. Allowed to Pursue Own Interests
10. Collaboration
11. Pace (Too Fast, Too Slow)
12. Level of Teacher Enthusiasm
13. Expertise of Teacher in STEM
14. **Awareness of Careers**
15. **Reinforce Self-Confidence**
16. **Reinforce Interest**



# Further Data Exploration

- ▶ Why a more intensive dose of talent development does not appear to be reflected in differentiated outcomes.
- ▶ SMT signature curricular factors explored so far affect the outcomes for SMT students but don't explain outcomes for comparison group.
- ▶ What can schools do to compensate for the contributions of parental cultural influence?
- ▶ Some SMT schools are more selective and science focused than others, irrespective of models; some percent of SMT students enroll because of overall school quality, not STEM focus.
- ▶ Follow-up interview study to unpack specific variables: persistors, high school research, and mentors.



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE

This material is based upon work supported by the  
National Science Foundation under  
Grant #0815421



AMERICAN  
PSYCHOLOGICAL  
ASSOCIATION  
EDUCATION DIRECTORATE