REVISITING SWITCHING AND PERSISTENCE IN STEM MAJORS

Elaine Seymour

Center for STEM Learning,

University of Colorado at Boulder

This work is supported by the National Science Foundation (DUE-1224637) and the Alfred P. Sloan Foundation (Award No.: 2012-6-05). Any opinions, findings, conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation or the Alfred P. Sloan Foundation.

Questions To Be Addressed

- How have STEM persistence-related issues changed?
- What problems (old or new) remain to be addressed?
- What are some priorities for our efforts to enable persistence?

Talking about Leaving Revisited (TALR) Research Team Contributors

University of Colorado Boulder, Center for STEM Learning:

Persistence study team:

Elaine Seymour, Anne-Barrie Hunter, P.I., Heather Thiry, Dana Holland, Raquel Harper

Institutional and SALG data analyst:

Tim Weston

National data analysts:

Joseph J. Ferrare, University of Kentucky

You-Geon Lee, University of Wisconsin, Madison

Switching and Persistence: Then and Now

Original study: CIRP data analyzed by HERI, 1993.Patterns of persistence and switching from declared or intended majors by 1991:

Overall STEM switching rate = 44%

Range by disciplines: 38% in engineering to 63% in math/statistics.

Gender. Losses higher for women (52%) than for men (41%).

Losses similar in engineering (37% for women; 38% for men) but with much smaller numbers of women entrants than today.

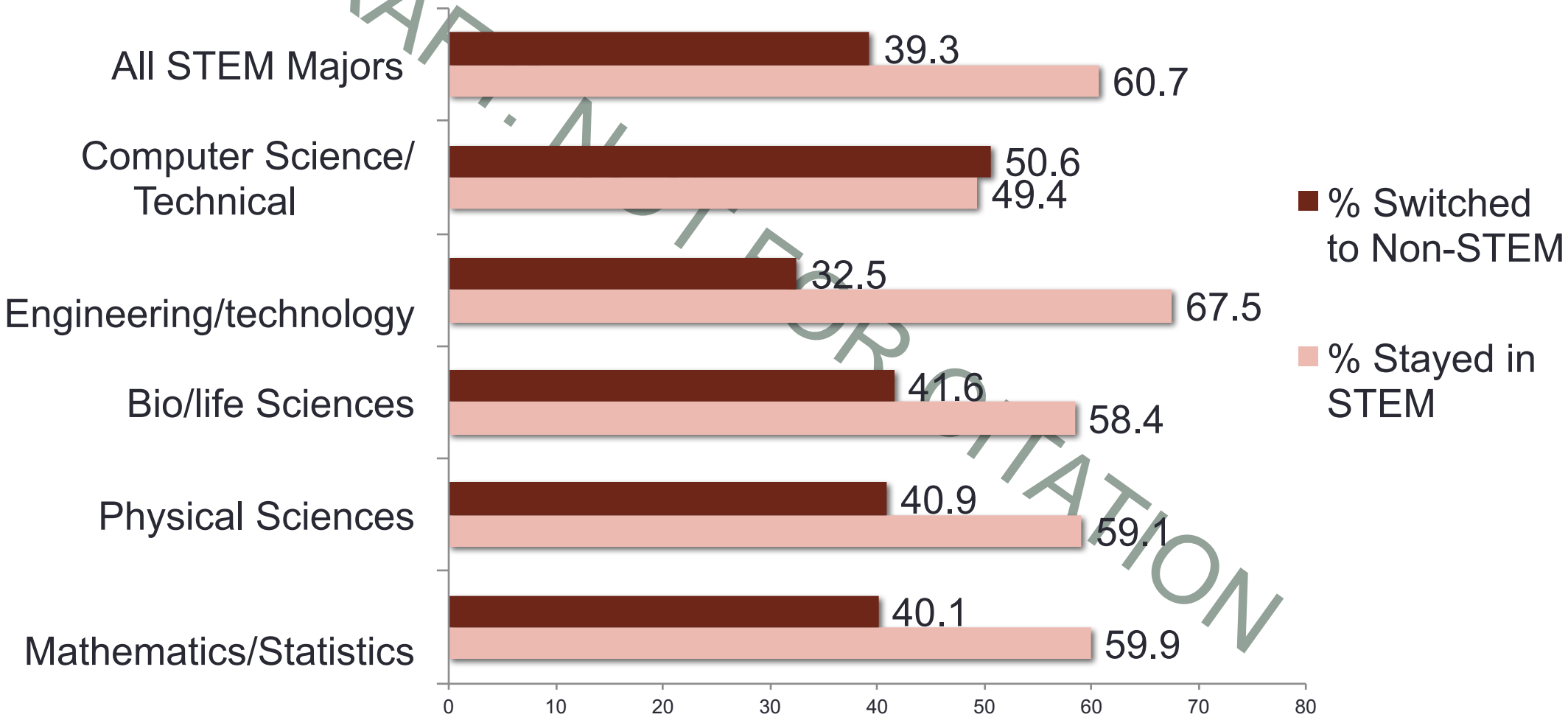
Race/ethnicity (from NACME data):

Science and math: students of color losses = 65% (white 37%)

Engineering: students of color losses = 64.4% (white = 31.6%)

Half of students of color who left engineering dropped out of college.

NOW. Ferrare and Lee: Patterns of Persistence in and Switching from Declared STEM Majors by 2009 for Beginning Postsecondary Students (BPS)



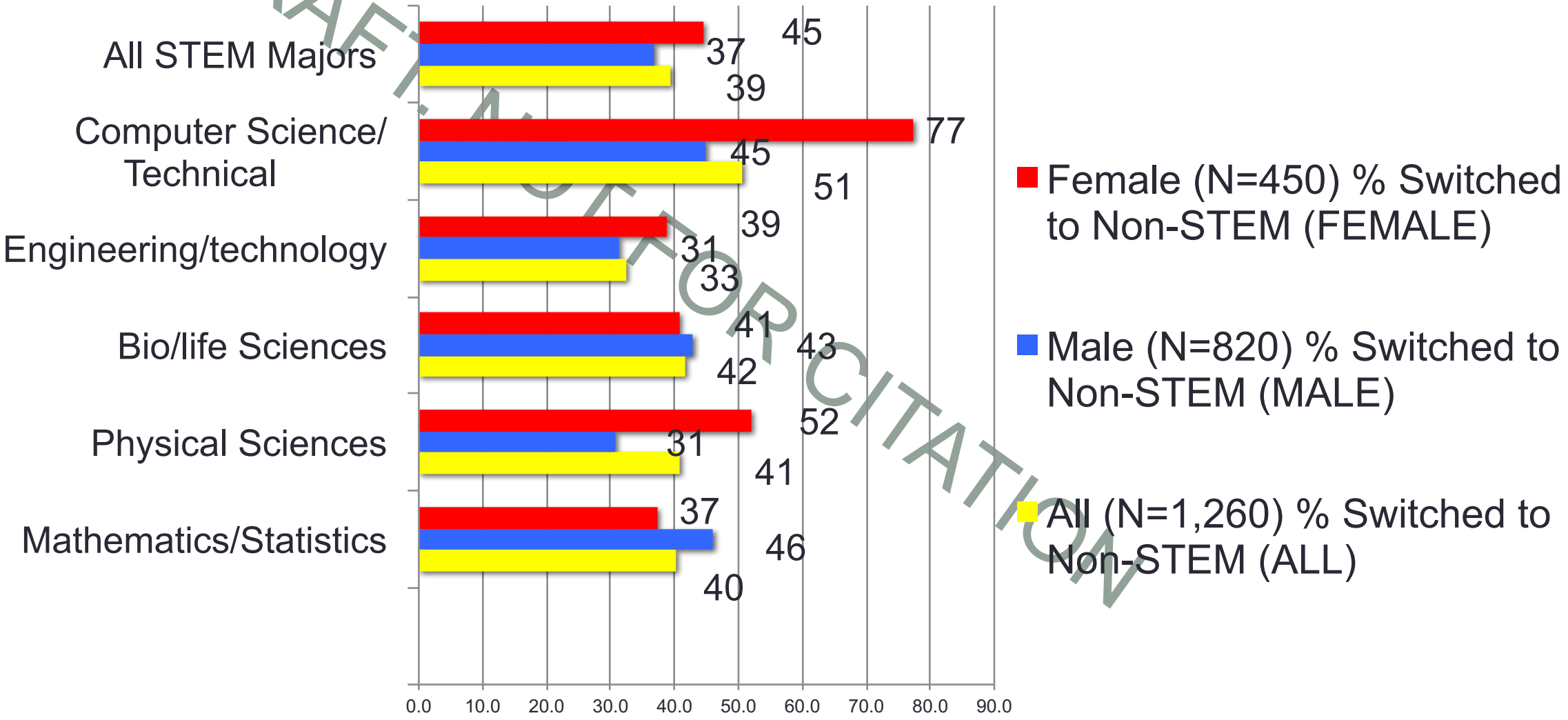
Then and Now

- The overall switching rate appears to have dropped from **44.1% to 39.3%**
- The percentage of STEM switchers into non-STEM majors has dropped in all STEM majors.
- It now ranges from 32% - 51% rather than 38%-63% in 1991.
- Switching has dropped:
  - In engineering: from 38% to 33%
  - In physical sciences: from 51% to 41%
  - In biology/life sciences: from 51% to 42%

Caveats:

- CIRP data includes undeclared majors; BPS data does not.
- BPS data includes CS/Technical. In 1993, CIRP data did not
- Small unweighted sample sizes (italics in table). Treat with caution.

Ferrare and Lee. Patterns of Switching from Declared Majors by 2009 for BPS students in STEM who began their postsecondary education in a bachelor's program, by Gender.



Changes in STEM Switching by Gender: Comparisons of TAL-1 CIRP Data and TALR 2009 BPS Data

Overall: Switching rates of women reduce by ~ 8% and men by ~ 2%

- **The switching rates of women *drop in*:**

  Math/statistics 35%: 72% to 37% (men: 54% to 46%)

  Bio-sciences 16%: 57% to 41% (men: 46% to 43%)

- **They are *similar* in:**

  Engineering 2%: 37% to 39% (men: 38% to 31%)

- **They *increase* in:**

  Physical sciences 8%: 44% to 52% (men: 54% to 31%)

  Computer sciences 8%: 69% to 77% (men: 46% to 45%)

Patterns of Switching from Declared Majors by 2009 for BPS Students in STEM who began their postsecondary education in a bachelor's program by Race

Original STEM Major (2003 ~ 04yr)	Black (N=140)	Hispanic (N=130)	Others (N=60)	Asian (N=110)	White (N=910)
	% Switched to Non-STEM	% Switched to Non-STEM	% Switched to Non-STEM	% Switched to Non-STEM	% Switched to Non-STEM
Mathematics/Statistics	29	*62*	28	0	*48*
Physical Sciences	*70*	*61*	*48*	*2*	32
Bio/life Sciences	*47*	*51*	35	28	37
Engineering/technology	*40*	33	34	23	30
Computer Science/ Technical	*53*	*71*	*55*	*44*	36
All STEM Majors	**48**	**45**	**38**	**24**	**34**

Notes. All percentages are weighted for the study's sampling design. *Italic* indicates relatively small unweighted sample sizes, so that interpretations should be cautious.

Structured Disadvantages

- Ferrare and Lee explain these racial disparities in terms of socio-economic and educational disadvantages.
- Switchers of color:
  - Have lower admission test scores
  - Are less likely to have taken calculus or to have earned college credits during high school
  - Work more and need more financial support to attend college.

The Persistence Study is also addressing the effects of structured disadvantages on student performance, including poorer quality high school education.

The Persistence Study: an intentional sample of Switchers and Non-switchers

346 students interviewed at six of the original study sites:

- **96 switchers** (28%) and **250 non-switchers** (72%) with entering math scores of 650+SAT or 28+ ACT
- A sub-set of non-switching seniors who were selected by their low "math readiness" scores
- Samples were subdivided by sex, race/ethnicity, and discipline (biology, math, physics, chemistry, engineering & computer science)
- Overall, women = 64%, men = 36%
- students of color of both sexes = 36%

THEN. TAL1: What Factors Contributed to Switching Decisions? The "Problem Iceberg" (see Table and Summary of Findings)

- **The most common problems contributing to switching decisions were shared by non-switchers.**
- Seven factors were cited by one-third of both switchers and non-switchers:
  - Loss of interest in the discipline
  - Poor teaching by STEM faculty
  - Pace and load of course demands
  - Developed interest in a non-STEM major
  - Chose STEM major for reasons that proved inappropriate
  - Inadequacies in advising and counselling
  - Inadequate high school preparation

The STEM switching process

- Push factors: Problems in pre-college and college experiences that make it difficult to persist with an original major (and career aspiration)

- Pull factors: What draws students to alternative majors and career options, largely while struggling with problems in their STEM majors.

- Pragmatic/instrumental considerations that make original choices seem less feasible or attractive than available alternatives

NOW: What Factors Contribute to Switching Decisions?

Factors Contributing to Students' Decisions to Switch to non-STEM Majors or to Different STEM Majors	*% Switchers (N=96)*	*% Non-switchers (N=250)*
Negative effects of STEM culture	66%	24%
Issues with grades	61%	14%
Lack of/loss of interest in STEM	61%	5%
Under-informed choice of STEM major	50%	6%
Negative impact of STEM curricular design	45%	14%
Difficulties transitioning to greater demands required by college-level courses*	43%	5%
Negative impact of STEM teaching practices	41%	9%
Negative impact of STEM weed-out gateway courses contributes to switching and relocation*	33%	15%
STEM major is too narrow, wants to broaden education	26%	2%
Difficulties getting or seeking appropriate, timely help	21%	8%
Career-related reasons	21%	2%
Poor high school preparation	20%	3%

** Not broken out in TAL1*

NOW: What Factors Contribute to Switching Decisions?

Factors Contributing to Students' Decisions to Switch to non-STEM Majors or to Different STEM Majors	*% Switchers (N=96)*	*% Non-switchers (N=250)*
All negative teaching and learning experiences: lacks sense of belonging, poor curricular experiences; poor quality teaching, and weed-out effects	86%	36%

What is Similar or Different about the Two Sets of Findings?

Problems with STEM students' learning experiences continue to dominate as contributors to STEM majors' switching decisions (86%)

10 individual switching contributors can be directly compared with TAL-1 findings.

In 6 of them, the percentage of STEM switchers who cite them is larger than it was 20 years ago:

- Negative effects of STEM culture
- Issues with grades
- Lost/loss of interest in STEM
- Under-informed choice of STEM major
- Negative impact of curricular design
- Negative impact of STEM teaching practices

In the final tabulation we will set factors prompting switching within the concerns of all switchers and non-switchers. We have added a column not shown in TAL of factors that prompted relocation of non-switchers into other STEM majors.

High School Deficiencies and College Transition

Both in TAL-1 and TALR: Under-preparation creates switching risks.

Heather Thiry reports:

- 20% switchers identified inadequate preparation as a factor in switching decisions--rising to 36% when combined with transition difficulties
- Deficiencies not identified & addressed quickly lead to early switching

Under-preparation includes:

- Inadequate disciplinary knowledge (esp.in chemistry and calculus)
- Being unaccustomed to conceptual, abstract thinking
- Poor study habits and time management skills
- Not knowing how to navigate college as a system (1st generation issue)

Life science majors stand out as students who struggle most with under-preparation issues.

Structured Disadvantages

Students of color, low socio-economic status, & 1st. generation students from under-resourced high schools are at enhanced risk.

School deficiencies include:

- lack of access to higher-level STEM courses, including AP and IB courses
- poor teaching, lack of rigor, and tracking practices in K-12 science and math.

Students often do not know they are under-prepared until they enter college. Even talented students find it difficult to catch up quickly enough to survive.

92% of all switchers reported *difficulties in transition to college*:

- heavy workload and fast pace of intro. STEM courses,
- expectation of increased independence in learning,
- impersonal teaching methods experienced in large classes,
- difficulties in adjusting to the study skills and effort required
- Not finding timely help with academic difficulties

21% of switchers reported difficulty in getting appropriate help. 10% of switchers had difficulties in navigating the college system at all (Thiry)

Largely arising from limited social capital among first generation students, these problems are exacerbated by disciplinary under-preparation. They include:

- Knowing about or finding appropriate resources
- Feeling uncomfortable or intimidated in seeking help
- Services used proved unhelpful

Difficulties in accessing available support services because of work commitments, time, or other constraints. Most affected:

- Women of color
- First-generation college students.

*The quality and effectiveness of departmental and campus-wide **student support systems** are critical in showing students how to navigate their early semesters to avoid critical losses and discouragement.*

The Role of Choice of Major in Switching and Persistence

- TAL1: ***Under-informed choice of majors or careers (14%)*** **created a switching risk**
- TALR: 5**0%** ***of switchers left, in part, due to under-informed choice***.

A well-grounded, driving interest in the major and related careers supports persistence.

Under-informed choice is a particular problem in Engineering (Heather Thiry):

- 18 under-informed students with high math SAT or ACT scores switched out of engineering majors and had difficulty finding a new major
- Some felt pressured into engineering because of their aptitude and interest in math
- Lack of incoming knowledge about engineering was compounded by a lack of real-world focus in early required courses, which diminished initial curiosity

Parental Influence on Women's Choices (TALR)

TALR: a shift to **parental approval of STEM majors and careers for daughters.**

- **Daughters are expected to work and support themselves**, and choose a career path to enable this.
- **Norms of "appropriate" careers for girls have gone**. The "supported wife" of the 1950's era is now seen as unrealistic by women and their parents.
- **These trends appear in STEM women's accounts of:**
  - Forced choices under parental pressure
  - Parents discounting non-STEM aspirations
  - Strong parental preference for careers perceived--sometime erroneously--as high-paying.
  - Unsupportive parental attitudes towards difficulties in STEM majors and negative responses to switching decisions

Grades and Identity: Issues for Women?

- TALR: Some students have difficulty in overcoming an internalized perfectionism that ties identity to high scores.
- Growth in competitiveness about grades among high school girls continues in college. Women who link their identity to high grade maintenance can be at risk in STEM majors
- Inability to disentangle identity from grades creates switching risks and ongoing difficulties for women who persist
- In addition: High school grades achieved with modest effort, promote high performance expectations among parents and a sense of entitlement in students—likely to be thwarted in STEM majors
- Men seem more able to let go of high self-demands and settle for grades that are good enough to keep going in their major (But not all men!)

Sexism and Racism: A changed environment

We note a marked decline in the overt sexist and racist behavior reported in TAL1.

TAL1 Common Experiences:

- Male STEM faculty conveyed to women that they were unwelcome in their classes.
- Rudeness and hostility from male class peers was a daily experience that was largely unchecked by male faculty—especially in engineering and the physical sciences.

All students in the TALR study were asked, had they experienced or observed bad behavior by faculty or peers? We found few examples, and often had to explain what we had originally found. Interviewees were amazed and horrified.

TALR Common Experiences:

- Easy relationships both between the sexes and races,
- Stressed the importance of tolerance and inclusivity.
- Campus and department atmosphere as open and welcoming.

We did, however, observe more subtle forms of racism.

The Unintended Consequences of Weed-out Classes

TAL1: Found that weed-out practices contribute to switching decisions

TALR: More precisely focused on **which** students are more likely to switch because of their experiences in weed-out classes, and **why**

(Departments do not appear to collect data on the demographics of students that are "weeded out")

Hypotheses:

- Gatekeeper classes (notably, chemistry, physics, and calculus) have disproportionate negative effects on students who are non-white, of low socio-economic status and are first generation college students, especially from under-resourced high schools
- Losses are notable in majors "serviced by" weed-out classes. Most negatively affected by weed out experiences are: women in life sciences (also most affected by poorer preparation), and men in engineering.

Weed-out Consequences

Inadequate HS Preparation: May be too great to overcome where weed-out classes are encountered early. What can help?

A policy of late declaration. Advisors steering under-prepared students around such courses until their skills have been built. (Some students survive by doing this, including community college.)

Finding Alternative Pathways to STEM Goals: Weed-out classes redirect some students away from STEM disciplines into majors that enable higher GPAs. This increases students' chances of acceptance into competitive STEM graduate programs. (Raquel Harper)

High-Achieving Students may Lose Interest:

As noted in TAL1, high-achieving students may lose their incoming interest through boredom induced by weed-out course approaches to teaching content. Some multi-talented students who have viable alternative interests switch into them. (Dana Holland)

Does STEM Switching Still Matter?

Shortage, shortfall, or a waste of talent?

- As in TAL1, our interview data document permanent damage to switchers that has economic, career, and personal dimensions
- Joe Ferrare and You-Geon Lee's analysis of BPS data adds to our understanding of switching as permanent wastage:

  Switchers from *all* majors—not only STEM—are less likely to complete bachelor's degrees than those who persist in their original major

  - Among STEM switchers, only 48% complete any bachelor degree within six years
  - Risks are greatest among first-generation, black, and Hispanic students
  - Men are less likely to graduate after switching majors than women
  - Men are more likely than women to drop out of college, rather than switch majors

The creation of "at risk" STEM majors: System effects that perpetuates wastage of talented students.

Dominant, ongoing problems with the quality of STEM undergraduate education intersect with :

- Inadequate high-school preparation, including under-resourced high schools that exacerbate other structural disadvantages
- Consequent student difficulties in college transition
- Under-informed or forced choices of major
- Imbalance between performance scores and student identity
- Failure to receive appropriate and timely help with difficulties
- Perpetuation of an institutionalized weed-out system that may unwittingly discard students that STEM disciplines might prefer to keep.