Why we are still Talking about Leaving

Presented by
Elaine Seymour

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A five-year mixed-methods research study in six institutions by the E&ER team, plus two collaborating studies.

- **Institutional Study** STEM Field-switching patterns using 1,437,806 transcripts and attribute data for 45,565 students.
- **Interview study**: in-depth semi-structured interviews and focus groups with 346 STEM switchers, persisters and relocators with high math scores: Av: 680 SAT; 28.5 ACT.
- **Student Assessment of their Learning Gains (SALG)** online end-of-course survey in 71 STEM foundation courses.
- **Classroom observation** study using the Teaching Dimensions Observation Protocol (TDOP) instrument in the same courses as the SALG survey: led by J. Farrare, University of Washington.
- Study of “DFWI” rates at 32 institutions: the impact of weed-out courses on persistence for particular student demographics: Andrew Koch and Brent Drake, the Gardner Institute.
Who switches?

National and Institutional Estimates of STEM Switching: Tim Weston
What proportion of students switch nationally?


- 28% switch from a STEM to a non-STEM major
- 20% leave school altogether

Switching from STEM to non-STEM majors has fallen from the 1990’s:

  from 44% (original CIRP data) to 28% (NCES)

Caveat: Comparisons with the 1997 TAL study are complicated by changes in HERI’s sampling methods.
From Tim Weston’s Transcript Analysis: which students are at highest risk?

• Higher rates of switching in Math (24%) & Biology/Life sciences (20%). Lowest rates in engineering (8%)

• **Women** switch at higher rates than men (18% v. 11%)

• Under-prepared students from families with lower socio-economic status (indicated by a PELL award) or are a first-generation college student.

The risk for all women is enhanced for **women of color in this group**. Woman of color with below average ACT/SAT math scores are also at high risk.

• Students with low SAT/ACT math scores switch at much higher rates: lowest quartile v. highest (25% v. 7%).

• **High performing students** whose leaving is associated with receiving one poor grade

• As are **women** who receive a poor grade, an incomplete/withdrawal (or even a single C grade) in an SFC course

• **Students at all math levels** switch at higher rates if they receive even one DFWI in a foundation course: no DFWI (12%), one DFWI (23%), two DFWIs (33%)
17% of persisting seniors had switched to a different STEM major

In a process of exploring and refining goals and interests

Discovery of new fields within STEM

Finding a better fit for interests, and career aspirations
Risk assessed by Regression Analysis: transcript data from six institutions: over 45,000 students and 1.5 million records:

Regression simultaneously weighs multiple factors and finds the independent contribution of each variable

- Predictor variables included: race/ethnicity, gender, grades, incompletes, GPAs and math scores

- **Students’ racial/ethnic groups as an independent variable did NOT predict STEM switching**

- Other factors--SAT/ACT math score, GPA, DFWIs and gender-- all predicted switching better than race/ethnicity

- However: there was significant interaction between gender and race/ethnicity such that being a **woman of color** did significantly predict switching:

  African-American and Hispanic women switched at much higher rates than both their male counterparts and White or Asian students
Anne-Barrie Hunter
The ‘Problem Iceberg’

Switchers and Persisters suffered from the same kinds of problems

• Contributory Causes of STEM Switching and Relocation and the ongoing problems of Seniors who Persist.

• Comparison of Findings from the Interview studies of TAL and TALR
‘The Problem Iceberg’
Findings from the Interview Studies compared: TAL (1997) and TALR (2019)

All 19 of the contributory causes of switching found in TAL were also found in TALR, but with changes in relative ranking. There were also 5 new issues.

As in the original study, switchers experienced more of the same kinds of problems that also negatively affected persisters and relocators.

Students’ problems derived from aspects of their STEM learning experiences remained dominant.

TALR: Increased complexity in the array of each student’s concerns.
Unchanged: Negative effects of STEM classroom learning experiences

- **STEM instructor pedagogy**
  - 96% all switchers, 74% of persisters

- **STEM curricular design**
  - 85% switchers, 56% of persisters

- **Under-preparation**
  - 64% switchers, 34% of persisters

- **Conceptual difficulties**
  - 80% all switchers, 42% of persisters

- **Difficulty getting timely help**
  - 80% all switchers, 31% of persisters

- **Losing interest**
  - 60% of all switchers, 61% switchers

All 6 problems contributed to weed-out course losses:
35% switching decisions in both studies
Marked Change TAL → TALR

**Loss of confidence**
- 23% to 61% in switching decisions
- 79% all switchers
- 44% persisters

**Competitive class climate**
- 14% to 52% in switching decisions
- 81% all switchers
- 42% persisters

**Finding an aptitude for a non-STEM field**
- 10% to 76% in switching decisions
- 76% all switchers
- 6% of persisters

*Effects greatest among women of all races/ethnicities, and men of color.*

*Rank change*
- 16th in TAL
- 1st in TALR
Financial and Career Concerns have increased since the 1990’s

Financial problems in completing a STEM degree

Switchers: 30% TAL 70% TALR
Persisters: 23% TAL 48% TALR

Increased need to work
Affected 70% switchers & 49% Persisters
Working over 20 hours per week distinguished switchers from persisters

Move to a major offering better career prospects

Rejecting future STEM careers and lifestyles

Instrumental moves into other majors to further career goals

Switchers
27% TAL 54% TALR

Switchers
29% TAL 58% TALR

Switchers
7% TAL 26% TALR
• Convergence in men’s and women’s accounts
  *Both described the same 17 factors as concerns*

• Convergence in the accounts of students of color and white students
  *Each group described the same 16 factors as concerns*

• Few accounts of:
  overt sexist behavior or overt racist behavior, from instructors or peers
  *But more reports of racist micro-agression*
Heather Thiry: from the Interview study
The Impact of K-12 Preparation on Switching

• Nearly 20% of switchers stated that preparation issues contributed to their switching decision

Who struggled the most with preparation issues?
• Life sciences majors (61%)
• Women of color (44% of all underprepared switchers)
• First-generation college students (42%)
However, many Students Struggled with Preparation for STEM Majors

- SoC Switchers: 73%
- White Switchers: 60%
- SoCPersisters: 41%
- White Persisters: 31%
Under-preparation in K-12 education

What does it look like?

• Lack of rigor in K-12 STEM education
• Lack of access to higher-level STEM courses in HS
• Tracking practices
• Lack of subject-credentialed teacher
STEM Learning Experiences and their Consequences:

Alignment of results from three of our studies: student interviews, SALG surveys and classroom Observation
What teaching methods did the students experience?

- 99% of switchers reported STEM instructors mainly used non-interactive forms of lecturing
- 57% of persisters reported mainly lecture-style teaching

Similar results were reported by the SALG survey and the Observation study (‘chalk talks’ and ‘slide shows’)

26% of switchers and 33% of persisters reported interactive lectures
Interview Study (Raquel Harper): STEM Learning Experiences and their Consequences: Poor-Quality STEM Teaching

- 78% of all students expressed frustrations with poor quality teaching, curriculum design, and assessment practices
- 96% of switchers were negatively affected
  - 48% reported poor teaching key reason for switching
- 72% of persisters were negatively affected
  - 92% of persisters of color reported problems with teaching
### How students defined poor quality teaching

<table>
<thead>
<tr>
<th>Definition of Poor Teaching</th>
<th>Switchers</th>
<th>Persisters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disorganized Teaching; poor preparation, structure, content sequencing, concept building</td>
<td>64%</td>
<td>43%</td>
</tr>
<tr>
<td>Delivering content at inappropriate level and at too fast a pace for absorption and application</td>
<td>49%</td>
<td>27%</td>
</tr>
<tr>
<td>Intimidating and distancing behavior by instructors: unapproachable, rude, dismissive re questions and in office hours</td>
<td>34%</td>
<td>33%</td>
</tr>
<tr>
<td>Inadequacies in presentation: lacking in illustration, application; conceptual links, made interesting topics dull</td>
<td>30%</td>
<td>38%</td>
</tr>
<tr>
<td>Disengaged teaching: little or no class interaction with students; little group work</td>
<td>30%</td>
<td>22%</td>
</tr>
<tr>
<td>Evident that valued research over teaching</td>
<td>21%</td>
<td>22%</td>
</tr>
</tbody>
</table>
Why weed-out courses are dysfunctional for STEM education.

Elaine Seymour
Anne-Barrie Hunter
Tim Weston
E&ER, University of Colorado:

in collaboration with:
Brent Drake
Drew Koch
Gardner Institute:
How students identified weed-out courses.

From the Interviews and SALG surveys: Constructed vs. Intrinsic ‘hardness’

**Course structure**
- Far too much material is covered too quickly
- Incoherent organization of content. Missed steps and explanations
- Rote learning and memorization rather than conceptual learning

**Teaching**
- Dull content delivered exclusively in lecture mode
- Teacher indifference to whether students follow or understand
- Learning alone. Finding help is essential but difficult to get.

**Testing & grading**
- Assessments misaligned with content and understanding
- Highly competitive class culture created by steeply-curved grading
35% switching decisions in both TAL and TALR derived from weed-out course experiences

TALR: also cited by 43% of all switchers & 18% of persisters

A structured, normalized process of student wastage:

Talking about Leaving (1997, TAL)

“They do the usual speech: ‘Look to the right of you; look to the left of you. Forty percent of you won’t be here next year’. I think that’s the standard speech at every university.” African-American man, persisting senior in engineering

Talking about Leaving Revisited (2019, TALR)

“During welcome week, the associate dean came in and told us, ‘The people sitting next to you are probably not going to be here by the time you graduate...They were deliberately trying to get rid of the weakest link and, for a while, that’s what we felt like.” White woman, switcher from math to economics
In TAL and TALR: Despite variations in the achievement levels of incoming students across institutions and cohorts, switching rates following weed-out courses were consistent over time.

• “It doesn’t matter how good the students are that enter. They are going to come up with the requisite number of Cs and Ds. There’s no sense trying to help students to understand things and do well. The mentality is, ‘We mark down and fail 30%’”
  White man, high math persisting senior in chemical engineering

• “Every single class, it was, ‘Let’s try and cut off another row of students.’ You come in used to high school teachers that want to figure out how to get you to understand something. That changes to, ‘Last man standing will make it into the major.’”
  White man, high math switcher from engineering to economics
Tim Weston identified ‘Severe’ Foundational Courses (SFCs) and their Consequences from student transcript data

SFCs: Required introductory courses where student transcript data for multiple years showed:

- More than 20% of students did not pass or complete (DFWI)
- Typically, large (over 100 students)
- Most are in the first year; but some are in 2nd or 3rd years.

Weston also identified:

- Which groups of students received poor grades, incompletes or withdrawals
- How many students who switched had received none, one or two poor grades during their first year.
SFCs by discipline

- Biology, 10%
- Calculus, 22%
- Chemistry, 22%
- CS, 16%
- Math, 24%
- Engineering, 4%
- Physical Sci., 4%

Large, Introductory, DFWI>20%, Multiyear.
(N = 68)
DFWIs predicted switching from SFCs

Receiving a DFWI in an SF course predicts switching even when student characteristics (gender, math ability level), institution, discipline and other variables are held constant.

Dividing the students in FSCs into FOUR standardized math ability levels.

Across the four math levels, switching rates from SFCs were:
• 23% for students who receive one DFWI
• 33% for students with two DFWIs.

Although students with higher standardized math scores switch less than those with lower scores,

Students at all math ability levels often switched when receiving one DFWI
Comparing switching effect of one vs. zero DFWI scores by gender at 4 math levels

- Risk increases proportionally for both men and women at each math score level
- But: Students with higher math scores still switch out at higher rates if they receive one DFWI
- Women receiving one DFWI are more prone to switch than men at each math score level
Losing high-performing students:

Among students with GPAs of 3.5 – 4.0:
12% switched out of STEM, including 7% with math scores in the highest quartile
10-14% switched after 1 or 2 poor grades or 1-2 incompletes in a weed-out class
In all three studies we found: students who switch following a weed-out (SFC) course are not a random group.

In Weston’s (TALR) Institutional records study: Switchers from SFCs differ from persisters by a set of intersecting factors that include gender, race/ethnicity, and socio-economic status.

The risks of switching are greater for:

• Women than men.
• Students from lower socio-economic status families (indicated by PELL awards) and first-generation college students:

The risks are greater for all women in these groups

At greatest risk: women of color, especially those with below average ACT/SAT math scores.
Gardner Institute Gateway study:
Drew Koch and Brent Drake

- 32 participating colleges and universities
- Enrollment ranging between 13,000 and nearly 100,000 students
- 1.2 million student records analyzed

*Defined “weed-out” courses in the same way as Tim Weston’s study*
- Foundational (required, introductory)
- Large enrollment (within or across sections)
- High DFWI rates

**STEM weed-out courses identified:**
General Biology, General Chemistry, College Algebra, and College Calculus I.
What distinctive patterns of grades and DFWIs are evident in weed-out courses: Race/Ethnicity

![Rates of D, F, W, and I Grades by STEM Gateway Courses and Race/Ethnicity](image_url)
Distinctive patterns of grades and DFWIs evident in weed-out courses by First-generation college and Pell Grant Eligibility Status

Rates of D, F, W, and I Grades for STEM Gateway Courses by First-Generation and Pell Grant Eligibility Status

<table>
<thead>
<tr>
<th>Course</th>
<th>First-Gen. DFWI Rate</th>
<th>Non-First-Gen DFWI Rate</th>
<th>Pell DFWI Rate</th>
<th>Non-Pell DFWI Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Biology</td>
<td>34.0%</td>
<td>29.0%</td>
<td>28.8%</td>
<td>26.9%</td>
</tr>
<tr>
<td>General Chemistry</td>
<td>32.8%</td>
<td>32.4%</td>
<td>28.3%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Math – Algebra</td>
<td>38.7%</td>
<td>31.5%</td>
<td>31.7%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Math – Calculus</td>
<td>36.8%</td>
<td>33.4%</td>
<td>29.9%</td>
<td>28.3%</td>
</tr>
</tbody>
</table>
Receiving a DFW or I in just one SF foundation course was related to the decision to leave the institution, even when the student was otherwise in good academic standing.

These students were not dismissed from their institution. They chose not to return to the institution the following year.

This finding makes a significant contribution to our understanding of why 20% of students who enter STEM majors leave college without a degree in any major—a form of loss whose causes are under-studied.
Findings from the two institutional studies concur:

- A student’s chances of passing STEM weed-out courses and persisting to graduation are greatly diminished by structured disadvantages of gender, race/ethnicity, family income and educational preparation.

- These risks are evident when examined singly but greatly increase when they occur in combination.
Chapter 7, TALR: Interview study findings on how and why four significant groups of students are lost in the weed-out process

- Interested, capable, but socio-economically and educationally-disadvantaged students that include students of color.
- Students with high ability who are disappointed with the quality of weed-out course science.
- Students with career aspirations other than careers in STEM disciplines.
- Women of all races and ethnicities in all three categories.
Our data contradict any belief that weed-out practices select only those who are best fitted to continue in a STEM major and discard only those who are not.
Where are we going next?

All systems of behavior rest on beliefs

STEM weed-out systems have persisted for many years and are found internationally. Thus, we presume that:

- They are perpetuated because they perform valued functions;
- Beliefs about their necessity are taught and reinforced in the process of professional socialization.
Our new study:

We want to learn what system of beliefs sustain weed-out course practices.

What STEM faculty believe about:

• The **functionality** of teaching in ways that weeds out a consistent high proportion of course entrants.

• The **characteristics** of those who enter and leave these courses.

• The **capacity to ‘do science’** or become a scientist.

• The ways in which STEM disciplines must be **learned**.

• Their **responsibility to their discipline**—versus that of their institution.