Why we are still Talking about Leaving

Script for Presentation by Elaine Seymour on March 23rd 2021

TITLE SLIDE 1:

Thank you to my long-time colleague, Dr. Pratibha Varma Nelson, and to my hosts--the Center for Teaching and Learning and the STEM Education Innovation and Research Institute--for your invitation to share some of the data from our 2019 study "Talking about Leaving Revisited: Persistence, Relocation and Loss in STEM Education" I hope that this selection from our findings will be of use to you in deciding what strategies might be most appropriate for your own initiatives to improve quality and access in STEM education.

SLIDE 2: A five-year multi-methods study

Our research team, Ethnography & Evaluation Research (E&ER) at the University of Colorado at Boulder, together with two collaborating teams, undertook a large multi-methods 5-year study that enabled us to triangulate findings from five data sources. Our sample sites were six institutions of different types that had also participated in our original "Talking about Leaving" study in the 1990s. So, we were able to make comparisons of our findings over time. The first four of the studies (shown on-screen) were conducted at our six study sites; the fifth study analyzed institutional data from 32 institutions participating in a Gateway Course improvement program run by the Gardner Institute. My work focused on the student interview study, but I am also presenting here the work of other team members.

SLIDE 3: Who Switches?

My colleague, Tim Weston, who conducted the institutional records analyses, began by estimating the extent of STEM field-switching into non-STEM majors nationally and at our six sample institutions.

SLIDE 4: What proportion of students switch nationally

The most recent estimates, stemming from two large national data sets, indicate some improvement over the 1990's switching rates—from 44% to 28%. This may

well reflect the nation-wide effort over the last two decades to actively address the causes of STEM losses. However, there is a further loss of 20% of STEM entrants who leave, not only their intended STEM major, but college altogether. So, the national STEM persistence rate is around 52%. The causes of the 20% loss rate are as yet, unknown. However, as we shall later see, the Gardner study findings offers some clues.

SLIDE 5: Transcript study: which students are at highest risk?

From Tim Weston's institutional transcript analysis of over 45,000 students and 1.5 million records, we learn which STEM students are at highest switching risk.

- Majors in math and the life sciences
- Women more than men
- Students from lower socio-economic and first-generation families who are the most likely to enter under-prepared and with lower math SAT/ACT scores---—especially women of color
- But also, high-performing students, particularly women, whose leaving is associated with receipt of an early poor grade
- And students at all math levels who receive a D or F grade, a Withdrawal or an Incomplete (DFWI). Switching is evident for 23% of students with one DFWI and rises to 33% with two.

I shall say more about what explains Tim's findings as we go along.

SLIDE 6: STEM Relocators

17% of STEM entrants relocate to other STEM majors and Heather Thiry's interview study analysis revealed these three main explanations for their moves. They were offered by our sample of seniors who had relocated to a different STEM major.

SLIDE 7: Risk assessed by Regression Analysis

We wanted to know whether and how race/ethnicity figured as a switching risk.

Tim's regression analysis of institutional data included a set of possible independent variables. He found that racial/ethnic group status—whether that of a specific group, or taken together—did not, in and of itself predict switching. Indeed, several other factors (SAT/ACT math scores, GPA, DFWIs and gender) all

predicted switching more accurately than did race/ethnicity. CONTINUED OVERLEAF

However, when race/ethnicity and being a woman were combined, they did significantly predict switching.

These findings may have particular relevance for efforts to improve STEM participation by students of color.

SLIDE 8: Anne-Barrie Hunter, The Problem Iceberg

I now want to turn to our student interview study conducted with 349 STEM switchers, persisters and relocators. Anne-Barrie Hunter's analysis of the text data generated by these semi-structured interviews established the contributory causes of switching and relocation decisions --also of the ongoing problems experienced by persisting seniors.

She also compared the extent of each kind of problem with those described by students in the original TAL study.

To describe these findings, we used the metaphor of an iceberg because switchers and persisters reported the same kinds of problems. Where these problems prompted switching, they were the tip of a larger unseen part of the 'iceberg' of the same issues reported by students who stayed.

SLIDE 9: TAL and TALR compared

A core of 19 contributory causes of switching were found in both the original and current studies, but with changes in their relative ranking. No switcher in either study ever left for a single reason and the mix of reasons for switching varied notably by gender, race-ethnicity, and level of high school preparation. In the new study, there was also increased complexity and an increase in the number of each student's concerns. But, as beforel, switchers described rather more of the same problems that also troubled persisters.

SLIDE 10: Unchanged: Negative effects of STEM classroom learning experiences.

The frequency of these six problems (that were all related to aspects of students' learning experiences in STEM courses) were unchanged since the first study. And,

as before, these problems inter-relate and build on each other. Five of them were also described by persisting seniors.

P*roblems with poor teaching in STEM courses* ranked third (at 36%) of all reasons for switching. They were of concern to almost all (90%) switchers and were cited by three-quarters (74%) of persisters.

As before, students distinguished problems with pedagogy from those with STEM curricular design. The main curriculum design issues were content overload, over-fast pace of delivery, and poor alignment between course elements (e.g., between the content of course and labs; and between course and assessment content).

Note that all six student learning experience problems contributed to weed-out losses which were of precisely the same rate **(35%)** as in the original study. (I will expand on this finding a little later.)

SLIDE 11: Marked changes since TAL

There was an upward shift both in loss of confidence and problems with class cultures which appear to have become more competitive over time. Intense status competitions among peers, encouraged by steeply-curved grading practices, encourage isolation and failure to develop a sense of belonging that we found to be greatest among women of all races and ethnicities, and men of color.

We documented finding an aptitude for a non-STEM major in both studies but now it has risen to first place. It was typically part of a push-pull process-- the end-result of finding viable alternatives while losing the struggle to stay in an originally-preferred STEM discipline. It was rarely the realization of a true passion. High-academic performers who accounted for roughly one-quarter (26%) of all STEM switchers often moved away from STEM majors out of disappointment with the quality of their education experiences. These were often multi-talented students who were able to pursue other interests and options—as was reflected in their pursuit of multiple majors and minors in both STEM and non-STEM disciplines.

SLIDE 12: Financial and Career Concerns have increased since the 1990's.

They are of several kinds:

1. Financial problems in completing a STEM degree emerged as a far more widespread concern than in the 1990's. As a factor in switching, financial concerns rose from 30% to 70%. They were also a serious concern for one-quarter (23%) of the persisters in the original study, but rose to half of persisters (48%) in the new study. Worry about large loans also affect career-related decisions.

For both switchers and persisters, there was an increase in the need to work while in school and also an increase in student working hours that:

- Created strains for 70% of switchers overall and for almost half of persisters.
- And they directly contributed to 10% of all switching decisions,

Where students worked for more than 20 hours per week, this, in itself, distinguished switchers from persisters

2. Career-related concerns were also found to be a more pressing influence on students' decisions in the current than in the original study.

   a. Almost double the number of switchers (54%) than the original one (27%) explained that they changed to a non-STEM major partly because it *offered better career opportunities.*

   b. And again, twice the number of switchers (58%) than in the first study (29%) cited as a reason for switching that they *rejected the future careers and lifestyles* to which they projected STEM majors would lead.

   c. Making instrumental, *system-playing moves into other majors as a means to further their career goals* was also a far more prominent strategy among switchers (notably high-performers) in the current study. 26% of all switchers sought or considered non-STEM majors by which they could achieve their particular career goals while graduating with higher GPAs

that would give them a competitive edge. This compares with only 7% of students in the original study.

SLIDE 13: Here are some more positive changes found in the new study

There were marked convergences in the issues that were described BOTH by women and men and also by students of color and white students. Thus, fewer issues were specific to particular student groups. There were still group differences in what students struggled with, but they were less marked than in the first study.

Overt sexist and discriminatory behaviour that was common among male peers (and evident among some male instructors) in the first study had disappeared. Racism was less overt and white students strongly denounced this as unacceptable. However, students of color continued to report micro-aggressions.

SLIDE 14: From her analysis of the impact of K-12 under-preparation on switching, Heather Thiry found that arriving in college under-prepared contributed to almost 20% of switching decisions. It was highest among life-science majors, women of color and first-generation college students.

SLIDE 15: FIGURE: However, the consequences of under-preparation affected both switchers and persisters but was greater among switchers. In both groups, the problem was more marked among students of color.

SLIDE 16: What creates K-12 under-preparation?

- Intellectually unchallenging math and science teaching focused on memorization.
- Little or no preparation for higher-level conceptual thinking or application of knowledge.
- 61% of switchers had taken at least one AP or IB science course but discovered in foundation courses that they had been taught at a lower level than most of their peers.
- The root cause was often that *no subject-credentialed teachers* were available. CONTINUED OVERLEAF

- Some women, students of color and first-generation students traced their lack of mastery back to elementary or middle school where they were placed in lower tracks or not encouraged to pursue math and science.

These K-12 educational inequalities created struggles in adjustment that were compounded by the structure of introductory STEM courses—to which we now turn.

SLIDE 17: STEM Learning Experiences and their Consequences (Raquel Harper)

Our information comes from three of our studies—

- Student accounts from interviews,
- Results from the SALG surveys in which students assessed the degree to which aspects of their foundation courses had (or had not) enabled their learning, and
- Results from the same foundation courses in the Observation study (led by our collaborator, Joe Ferrare, using the Teaching Dimensions Observation Protocol--TDOP)

SLIDE 18: What teaching methods did the students experience?

Findings from the three studies were in alignment in highlighting the dominance of non-interactive forms of lecturing. The Observation study found two distinct lecturing forms that Ferare labelled 'chalk talks' (illustrated in this photo) and 'slide shows'.

However, interactive lectures were reported in some courses by one quarter of switchers and one-third of persisters—though less often in first-year courses.

SLIDE 19: From the Interview data, Raquel Harper distilled the nature and consequences of what both switchers and persisters described as poor quality teaching, curriculum design and learning assessment practices. The proportions of students describing both negative learning experiences and their consequences were, as you see here, high

- (78%) across the whole student sample.
- Notably, 72% of persisters and 92% of persisters of color reported problems with teaching

- 48% of switchers cited their STEM learning experiences as a key reason for switching.

SLIDE 20: How students defined poor quality teaching

When we asked students to explain what they meant by poor quality teaching, here is how both switchers and persisters categorized its dimensions.

Four of their categories focused on inadequacies in course structure, presentation, and delivery--what the students labelled 'disorganized', 'disengaged' and 'dull' teaching.

But the other two categories focused on intimidating attitudes and distancing behavior towards students who asked questions or approached instructors for clarifications.

There is similarity between persisters and switchers in several of the appraisal categories: Persisters who were better-prepared than many switchers had less difficulty with the level, content overload, and fast pace of foundation courses, and reflected that later courses were better prepared and presented.

SLIDE 21 Why weed-out courses are dysfunctional for STEM education

I now focus on a set of STEM educational practices that have changed least (since our original study) in their nature and consequences--both for students and, we would argue--for STEM disciplines.

In findings from four of our component studies, we were able to identify-- **both** by their **characteristics** and their **consequences**--a sub-set of (largely foundational) courses commonly referred to by students, faculty and advisers as 'weed-out' courses—a term that is **reputational, traditional, pervasive**, and **entirely unofficial.**

SLIDE 22: How students defined weed-out courses.

Students' characterization of weed-out course structure, teaching, testing and grading methods converged on the distinction that students made between content that was conceptually 'hard' by its intrinsic nature, and content that was made harder than it needed to be by the manner in which it was taught. Here we

show some of the elements of 'constructed' hardness that were described as dominant in courses that students identified as 'weed-out'.

As I have outlined, some of these characteristics were identified in other courses. But it is in weed-out courses that they were experienced in their most extreme forms. For example, the problems created by steeply-curved and manipulated grading practices were cited as the main source of cut-throat competition that contributed to many switching decisions.

SLIDE 23: A structured, normalized process of student wastage.

These practices may also account for the consistency over time in the 35% of switching decisions that derive from weed-out course experiences. They were also cited as a problem by switchers overall, and, in retrospect, by persisters.

The two speakers here—a persister and a switcher speaking over twenty years apart-- typify a commonly-expressed student assessment of these courses as reflecting a pre-determined, normalized process of student wastage.

SLIDE 24: Switching rates are consistent over time

These two speakers—one a switcher, the other a persister, and both high-math score students—comment that pre-set failure rates do **not reflect variation** in the calibre of incoming students by institutions or cohorts—a phenomenon that we first noticed in the original study.

SLIDE 25: We also have Objective definitions of weed-out course characteristics

Tim Weston in the E&ER team, and our colleagues, Drew Koch and Brent Drake at the Gardner Institute, worked independently to identify weed-out courses from markers that were evident in their samples of institutional records. These two student transcript studies converged on a comparable set of identifiers that distinguished weed-out courses from other STEM foundational courses.

Here, Tim Weston uses the term, 'Severe' Foundation Courses (SFCs) to distinguish weed-out courses from other STEM introductory courses. He found that 'severe' foundation courses were distinctive in that more than 20% of their students received a D or F grade, withdrew from the course or registered an 'incomplete' (i.e. a DFWI). These courses are also 'required' for particular majors. They are typically large, and mostly (though not always) in the first or second

year. He also identified which groups of students received DFWIs and the pattern of grades for switchers in the first year.

SLIDE 26: SFCs by Discipline

Using these criteria, Tim Weston grouped his sample of 68 SFCs by their disciplines. The highest numbers of students receiving a DFWI were courses in calculus, chemistry and computer science. Individual courses in these disciplines had much higher DFWI rates than their disciplinary averages. For instance, at one of our study sites, in *Calculus for Biological Scientists*, 29% of the students received a DFWI as also did 45% in *Calculus for Physical Sciences.* This course had the highest rate of students leaving any introductory STEM course at all six institutions.

SLIDE 27: Tim Weston also found that DFWIs in a SF course Predict Switching even when student characteristics, institution, discipline and other variables are held constant.

He divided students in SFCs into FOUR standardized math ability levels.

Across these four math levels, switching rates from SFCs were:

- 23% for students who received 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 just one DFWI

SLIDE 28: FIGURE: Comparing switching effect of one and zero DFWI scores by gender at four math levels

Here we see the four math ability levels disaggregated by gender to show the consequences for switching when students in each group received either one or no DFWI score. Although, as we might expect, the switching risk increases proportionately for both sexes as math score levels rise, the switching risk for women of just one DFWI which is 35% in the lowest math group is still 28% in the highest math score level. And women receiving just one DFWI are more prone to switch than men at each math score level. So, here Tim gives us the beginnings of an understanding that women are more at risk than men in weed-out courses and

that being a high math performer does not necessarily protect them from this risk.

SLIDE 29: Losing high performers

Tim examined the switching rates of students with GPAs in the 3.5 to 4.0 range and found that 12% of them switched out of STEM majors, including 7% in the highest math quartile. As noted, he further established that poor grades or incompletes were a significant factor in their leaving.

Thus, Tim Weston's findings suggest that weed-out course instructors who may believe that they are selecting for math (or other) abilities by the teaching and assessment methods that they use, would seem to be mistaken.

SLIDE 30: In all three studies we found that students who switch following weed-out courses are not a random group

Tim found that students who switch following weed-out courses also differ from persisters by a set of intersecting factors that include gender, race/ethnicity, and socio-economic status.

Students at highest risk are women overall and students from lower socio-economic families with women and women of color from these circumstances at highest risk.

SLIDE 31: The Gardner Institute Gateway study.

Our collaborators, Drew Koch and Brent Drake of the Gardner Institute independently conducted a parallel study of weed-out courses in their 32 participating institutions. They analyzed 1.2 million student records in four STEM courses that also had high DFWI rates and found a similar pattern of high DFWI rates by course discipline that Tim Weston also found.

SLIDE 32: FIGURE Distinctive patterns of grades and DFWI rates in weed-out courses by race/ethnicity

Examining students' DFWI rates in SFCs by their racial or ethnic group, the Gardner Institute analysis found significantly higher DFWI rates for particular racial and ethnic groups compared to both the DFWI course **average** and that for white students.

Here are the DFWI rates for four racial and ethnic student groups for weed-out courses in each of the four STEM disciplines included in their study. (general biology and chemistry, math-algebra and calculus).

SLIDE 33: FIGURE Both first-generation and Pell-grant eligible students had worse average DFWI rates than students from more educated and affluent families

Although not so large as the differences found for groups by race/ethnicity, students from families with **greate**r financial (and likely social) capital had a clear advantage in these courses over their peers from poorer families. This finding also aligns with that of Tim Weston.

SLIDE 34: Receiving a DFWI in just one weed-out course was related to the decision to leave not only the major but also the institution among students who were otherwise in good academic standing.

This finding contributes to the understudied phenomenon of the 20% loss rate among students who enter STEM majors but subsequently leave college without any degree.

SLIDE 35: Findings from the two Institutional Studies

Overall, a student's chance 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.

SLIDE 36: We do not have the time today to go further. But from our evidence in the interview data, (in **Chapter 7 of TALR)** we highlight how and why four significant groups of students are lost in the weed-out process

We have already identified the risks to:

- Working class students of all races and ethnicities who struggle with under-preparation from under-resourced schools and with the need to work to pay for college.
- Students of high ability who are disappointed with the quality of foundational courses, and often struggle with unaccustomed low grades, and to
- Women, and notably women of color, in both of these groups.

The group shown here that we have not yet mentioned are students with career aspirations other than majoring in STEM disciplines—often these are in health-related professions, and specialties in engineering, earth sciences, agriculture.

These students saw themselves as well-suited to their own major by their interest and career aspirations. However, particular, required weed out courses had blocked their intended career path.

As one disgruntled engineer put it. ”They are losing some really useful people and they don’t seem to know it.”

SLIDE 37: Like that student, we do not know whether STEM departments know from data which students are lost from their weed-out courses.

But 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.

SLIDE 38: Where are we going next? We are now planning a large interview study to learn what system of beliefs sustain weed-out course practices. They have persisted for many years and are found internationally. So, we assume that weed-out courses are viewed as performing valued functions, and that beliefs about how to teach them and why are transmitted to each new generation of young academics.

SLIDE 39: In our new study, we want to learn what system of beliefs sustain weed-out course practices--something that has not hitherto been documented.

Here are some of the beliefs that we would like to learn about.

This is a very practical endeavor--because efforts to encourage the uptake of research-grounded teaching strategies have to begin by acknowledging:

- How instructors conceptualize the learning process.
- And how difficult it is to migrate to student-focused or active learning methods when doing this may violate deeply-felt but perhaps unarticulated beliefs.

  I hope that this account of some of our work and findings will be useful to you.

  Elaine Seymour
  March 23, 2021