Introducing a Comprehensive Model for Researching STEM Transfer and Survey Tool

Within and outside of the scholarship in STEM fields, there is an acknowledged lack of research-based evidence about how we can effectively broaden the diverstiy of students in STEM, improve transfer rates in STEM from two- to four-year institutions, and prepare students for careers in STEM despite an acknowledged importance of doing so. In part, this can be attributed to a lack of "tools" that allow us to study upward transfer in STEM. The issue of upward transfer in STEM represents an area of both opportunity and challenge, as STEM career fields are rapidly expanding, and many of these job openings will require students to have a four-year degree. Supporting students who begin at two year colleges has important implications related to this.

The STEM Transfer project, "Expanding STEM Talent through Upward Transfer" (NSF DUE-1430642) aims to not only illuminate upward transfer in STEM fields, but also create data collection tools that allow this work to continue beyond the project's lifetime. The first step in doing this is to create a framework within which the factors that we wish to study can be understood, providing a lens through which we can look and in turn describe what we see. It serves as the cornerstone for what we describe in our studies, and can also help others make sense of what they discover as they too try to simplify a complex process in order to better serve students in their goals related to success in STEM careers.

Though our model is a "first of its kind" in attempting to capture the most salient factors associated with transfer in STEM (see Figure 1), it's important to recognize, as Sir Isaac Newton once did, that "if we have seen further, it is by standing on the shoulders of giants." Indeed, the model is shaped and influenced by Social Cognitive Career Theory (SCCT)–Lent, Brown, and Hackett's (1994, 2000) extension of Bandura's (1986) work in Social Cognitive Theory. This research brief is intended to 1) introduce the model, 2) explain a bit about what it means and how it was formed, 3) briefly explain how one of the instruments (a survey) was created, and 4) provide connections to how it can be used in a practical sense. In future editions, we will highlight various elements of this model, using illustrations from the STEM Transfer project as well as other relevant literature.

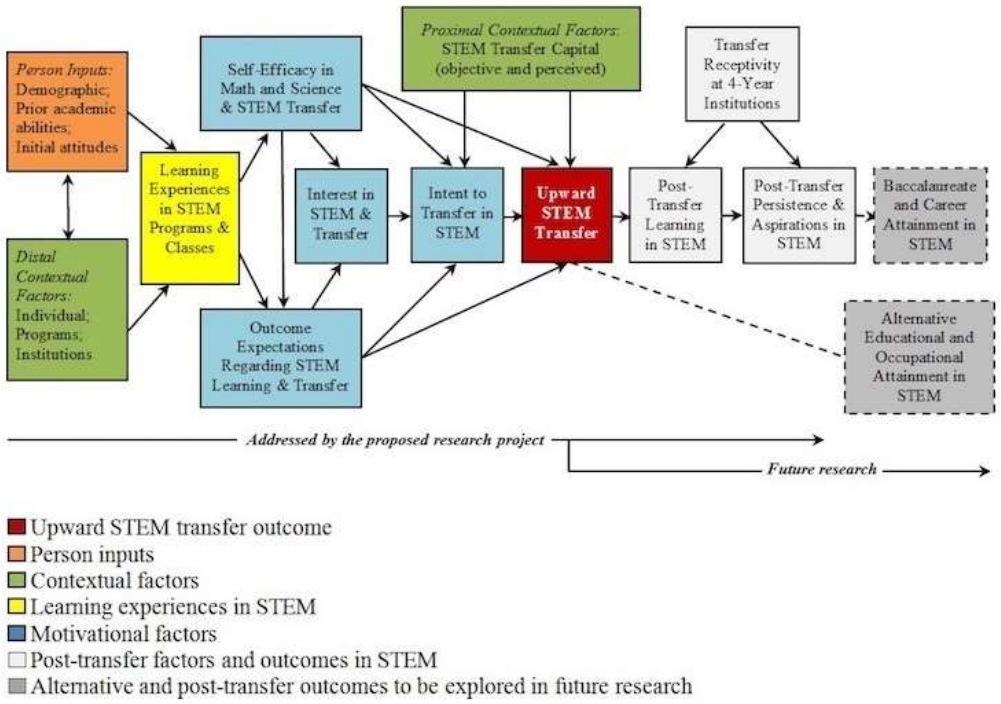

Figure 1. The STEM Transfer Model proposed and described in Wang (2017).

We categorize the elements that contribute to a person's educational outcomes in terms of individual, motivational, and contexual factors, and learning experiences. Taking these elements together can help shape a holistic view of how students experience college in general and navigate upward transfer in STEM in particular.

Individual factors, or "person inputs", are demographic and socioeconomic, but also include abilities, shaped by prior academic and life experiences as well as attitudes.

Contextual factors consist of both background (*distal*) elements as well as those that are central (*proximal*) to STEM transfer. Distal contextual factors might be related to the program or institution in which a student is enrolled, or may be more individual. Examples include whether or not a student is working (and how many hours a student works), whether s/he has financial or emotional support, and the specific early experiences a student has that might cause him or her to continue to pursue a STEM degree. Proximal factors, for the purpose of this model, focus on policies and practices that support student transfer in STEM. These are categorized as "STEM transfer capital", and include policies and practices such as accurate information about transfer, support for transfer, articulation agreements–or set pathways for transfer, as well as interactions that students have with others around transfer (including faculty, peers, and advisors).

With regards to learning experiences, in particular, we focus on early behaviors and academic effort from students in STEM coursework as a possible critical area where students might find their calling in

STEM. Further, active learning experiences are important for engaging students in the problem solving and analytic thinking inherent in STEM subject areas, which in turn helps motivate students toward transfer in STEM.

Among the motivational factors we consider, cognitive-personal factors driving students' choices related to academic and career development include their outcome expectations (what will happen if…), interests, goals (intent) and importantly, their self-efficacy (belief in one's own abilities). In general these beliefs and intentions are held by individuals, based on learning experiences and life circumstances.

Post-transfer–after a student makes the leap to a 4-year college setting, institutional support is still needed in order to help students achieve success, and this is also indicated in the framework.

With this framework established, a series of survey instruments was developed as a longitudinal tool, and one of them–a baseline survey–has been validated by our research. This survey allows for the study of what influences transfer students moving from 2-year colleges to 4-year colleges in STEM fields, and it went through extensive panel review, piloting, and testing. This was done by both consulting design experts, and performing a pilot test followed by exploratory factor analysis. Lastly, cognitive interviews were conducted with students at 2-year colleges to verify that the survey was readable and that students were interpreting items in the way we imagined. The fully developed survey consists of 103 survey items, and readers who are engaged with institutional research should feel free to use this instrument (http://stemtransfer.wceruw.org/survey.html)–just be sure to provide the proper citation. Further, if you are curious about additional details related to the development of the survey, be sure to read the STEM Transfer Project's soon to be published paper covering its development in *The Review of Higher Education*: (Wang, X., & Lee, S. (accepted). Investigating the psychometric properties of a new survey instrument measuring factors contributing to upward transfer in STEM fields. *The Review of Higher Education*.)

Practically speaking, the STEM Transfer project goes a long way toward helping educational leaders, institutional researchers, and support staff at both 2-and 4-year institutions, and instructors and students themselves understand some of the nuances of the transfer process, in turn leading to greater student success in completing transfer in STEM fields. In simply reviewing this framework, there are many areas to consider related to where to focus attention. Keep in mind that while we aim to shed light on pathways, each student's story is unique and deserves to be understood, and this framework gives us a home base from which we can anchor our studies as we continue to explore the complexities inherent in this diverse topic area.

Additional studies within the STEM Transfer project address ways in which individual stories contribute to our understanding, and future postings will detail each one. We explore the ideas of aspirational momentum (and variations across gender and race), look at academic momentum and early experiences in STEM, delve into how intent and action can be reconciled in reviewing course-taking patterns, review social capital and factors related to first-year success, focus on the role of life experiences and women in STEM, and dig deeper into active learning and how STEM learning may differ from other subject areas. Lastly, our *pièce de resistance*, as it were, is our culminating study, "The Road to Becoming a Scientist" in which we create a tapestry of ideas related to STEM transfer based on student interview and survey data.

References and Works Cited:

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Lent, R.W., Brown, S.D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice and performance. *Journal of Vocational Behavior, 45*(1), 79-122.

Lent, R.W., Brown, S.D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*(1), 36-49.

Wang, X. (2017). Upward transfer in STEM fields of study: A new conceptual framework and survey instrument for institutional research. *New Directions for Institutional Research*, *2016*(170), 49-60. doi:10.1002/ir.20184

Wang, X., & Lee, S. (accepted). Investigating the psychometric properties of a new survey instrument measuring factors contributing to upward transfer in STEM fields. *The Review of Higher Education*.