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Supporting STEM Transfer Students

Dr. Jennifer Marie Duis, Northern Arizona University

Augsburg College, Chemistry, B.S., 1999 University of Colorado—Boulder, Organic Chemistry, M.S., 2002 University of Northern Colorado, Chemical Education, Ph.D., 2008 University of British Columbia, Chemistry Teaching Laboratory Optimization with CWSEI, Postdoctoral Fellow, 2008—2011 Assistant Professor, Department of Chemistry & Biochemistry, University of Northern Arizona, Flagstaff, AZ, August 2011—Present

Dr. Nena E. Bloom, Center for Science Teaching and Learning, Northern Arizona University

University of Michigan, Natural Resources, B.S., 1991 University of California, Davis, Plant Protection & Pest Management, M.S., 1997 Northern Arizona University, Curriculum & Instruction, Ed.D., 2015 Evaluation Coordinator, Northern Arizona University, Flagstaff, AZ, 2007-Present.

Mr. Alexander R Ollerton, Northern Arizona University

Central Arizona College, AA 2011 Central Arizona College, AS 2011 Northern Arizona University, Advanced Chemistry, B.S. - in progress Northern Arizona University, Undergraduate research assistant, 2015-present Northern Arizona University, FYLI TA, 2015-present

Aspiring Grdauate Student

Dr. Derek L Sonderegger, Northern Arizona University

Derek Sonderegger is an Assistant Professor in the Department of Mathematics and Statistics at Northern Arizona University. His research interests include Occupancy Models, permutation methods for gene expression data, and Bayesian computing. His teaching interests in statistics pedegogy include bootstrap methodology for introductory courses and undergraduate data science in general.

Vanessa Fitz-Kesler, Northern Arizona University

Elizabethtown College, BS, Biology, 1990 Northern Arizona University, Post degree Elementary Education Certification, 1997 Current position: Northern Arizona University, Center for Science Teaching & Learning: Evaluation Assistant, 2014-present

Dr. Pauline L Entin, Northern Arizona University

Vice Provost for Academic Affairs, 2014-present, Northern Arizona University, Flagstaff, AZ Associate Dean for Academic Affairs, 2010-2014, College of Engineering, Forestry and Natural Sciences, Northern Arizona University, Flagstaff, AZ Assist/Assoc/Full Professor, Biological Sciences, Northern Arizona University, 2001-present Post-Doctoral Fellowship 1997-2000 Physiology, University of California, San Diego Ph.D. 1997 Physiology, Cornell University, Ithaca, NY B.A. 1991 Biology, Brown University, Providence, RI

Supporting STEM transfer students

Abstract

First-year students are the primary target of support services, housing resources, and scholarships at universities. However, this can leave students who transfer in from a community college or another institution at considerable disadvantages. Furthermore, transfer students intending to pursue Science, Technology, Engineering, & Math (STEM) degrees may lack important introductory courses (prerequisites such as calculus and general chemistry) and can struggle to get courses transferred appropriately, slowing down degree progression. We are now in the second year of implementing a program that includes a peer-mentored semi-residential learning community, a co-convened seminar course, and NSF-funded scholarships (Transfers to Graduates in Engineering, Math and Sciences) to support transfer students in the College of Engineering, Forestry, and Natural Sciences at Northern Arizona University. Voluntary survey data, primarily from the first year of program implementation, is used to describe the STEM transfer student experience and examine possible qualitative and quantitative impacts of the implemented program. The current results of outreach to local community colleges are also described.

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Background – Importance of transfer students in STEM

Organizations from the federal government to individual businesses have called for expansion of the STEM-qualified workforce. In a 2010 report, the President's Council of Advisors on Science and Technology stated that "The U.S. economy needs a large and increasing supply of workers who can routinely use scientific, technological, engineering, and mathematical knowledge and skills in their jobs; this knowledge fuels innovation and entrepreneurship."[1] Whereas nationally there is an increased emphasis on STEM graduates and a specific goal of doubling undergraduates in STEM fields from 200,000 to 400,000 by 2020,[2] "the number of (bachelor's) degrees awarded in science, engineering and computer-related fields declined in Arizona while holding steady nationally"[3]. In the field of engineering specifically, the number of jobs is estimated to grow by about 11% but the number of high school students planning to enter this field is remaining stable.[4] There is a critical need to expand the STEM workforce through increasing graduation numbers. Furthermore, rates of attrition in undergraduate engineering are a persistent concern.[4] Recruiting and retaining STEM students through community college and other transfer pathways to the university level may be an important key to increasing bachelor's degree completion in these areas.

More than 40% of all STEM graduates (bachelors or masters) enter four-year institutions as transfer students, and the percentage is even higher for Hispanic (51%) and American Indian/ Alaska Natives (45%) science or engineering degree earners.[5] In particular, vertical transfer to four-year universities provides an important access point for many underserved students, including low-income, first-generation, and racial/ethnic minority students, who represent a large percentage of community college students. [6] Transfer students thus provide an important pool to diversify engineering and other STEM fields and to fulfill STEM workforce needs.[7] However, many STEM transfer students have academic, social and/or psychological challenges as they adjust to campus life[8,9] or may suffer credit loss,[10] which can delay graduation or lead to attrition. Some studies indicate that students who transfer can experience "transfer shock", including lower grade-point averages (GPA's) in their first year of transferring.[11] However, those who make it past "transfer shock" are likely to graduate with similar GPAs to students who began their education at the institution.[11] Therefore, the early transfer period is a critical time for transfer student persistence.

Although not specific to STEM transfer students, a number of theories have been developed to explain student persistence in undergraduate degrees. Tinto's model of student integration[12] is widely used and posits that persistence in undergraduate degrees occurs when students are integrated both socially and academically into the undergraduate institution. Critics have suggested that this integration is not just the responsibility of the student but rather that the institution shares responsibility in the successful integration of students into college.[13] Tierney suggests that social capital, frameworks that enable groups, are an important factor for persistence in higher education, and institutions can help develop such capital by providing networks.[14] These networks are aligned with student academic success through activities such as advising, mentoring or access to professional networks at the university level. Over the decades many institutions have developed programs for undergraduate persistence in order to develop capital and foster integration into university life.

Certain programs have been found helpful to support successful transfer, including orientation, advising, and mentoring programs, although less is known about how these programs help STEM transfer students specifically.[9] In a study of women transfer students in STEM, persistence was improved by the presence of a helpful professor, advisor or peer transfer support.[15] The success of these activities can be explained because they help students develop social and cultural capital. However, while many orientation and retention efforts are available to support freshmen development of social capital, few initiatives are available for transfer students to ease their transition into university.

Study Purpose

The purpose of this study was to identify STEM transfer students' experiences as they transition into a university setting at NAU and study how participation in a scholarship and support program impacted this transition as compared with STEM transfer students who were not in the program. The research questions guiding the study presented in this paper are:

1. What do STEM transfer students experience as they become STEM majors at NAU?

2. Are there differences in the utilization of co-curricular and professional resources between students participating in a transfer-specific program and non-participants?

3. What has been learned from community college outreach efforts?

Learning Communities

Learning Communities (LCs) originated in the 1920s at the Experimental College at the University of Wisconsin and have now been adopted by many institutions to support freshman undergraduates in a wide variety of models.[16] At Northern Arizona University (NAU) the membership of each freshmen residential LC is comprised of 20-30 students who are housed together in an on-campus dormitory with a designated faculty advisor and an undergraduate peer mentor. Each LC sponsors six to seven extra-curricular events per semester, funded through a University-provided budget of approximately $15 per LC student, and holds regular LC group and individual meetings run by the peer mentor. Students in academic major-based LCs are enrolled in the same section of one or more of courses relevant to that major. NAU offers approximately 30 freshmen residential LCs focused on a wide variety of majors and interests, including eight related to College of Engineering, Forestry, and Natural Sciences (CEFNS) fields, with one specifically for engineering majors. Non-residential LC's are also available at NAU. In addition to the new semi-residential Transfer-GEMS LC described in this paper, ten college-based non-residential LCs for sophomores and beyond have also been recently developed.[17]

A large body of research, including data from NAU, supports a variety of positive outcomes from LCs. The psychosocial effect of 'belonging' is a key benefit. LCs help students build academic and social support networks, described as social capital by Tierney, and reduce the sense of anonymity that can arise in a large lecture class.[18, 19] In addition, LC members have been shown to be more engaged with higher class attendance and participation than non-members[18, 20] and have increased retention rates.[21, 22, 23] Others have demonstrated that LC students had higher

GPAs, more units completed per semester and lower dropout rates.[24] Although traditionally offered for freshman, Townsend & Wilson's work suggests the guidance of a learning community could also aid in integrating transfer students both socially and academically.[9]

Context

NAU is a high-research public institution with a current student body of over 29,000. Located in a small city of approximately 68,000 people, NAU is the smallest of the three public universities in Arizona and the only one located in a rural area, approximately two hours from metro Phoenix. Nineteen percent of the student population identifies as Hispanic or Latino, 3% Native American, and 3% African American, all groups typically underrepresented in science fields. Nearly 59% of the university population is female and over one-third are first-generation college students. CEFNS has well-established units for academic advising, and general and specialized programs for academic support, such as Supplemental Instruction (a tutoring program) and the Multicultural Engineering Program (a program including tutors, success coaches, workshops, monthly newsletter and study lounge developed to enhance academic performance of students and support underrepresented student populations in engineering programs, https://nau.edu/cefns/engineering/multicultural/).

A number of STEM majors are offered at the Flagstaff campus in CEFNS, including biology; environmental science; astronomy; chemistry; computer science; civil, electrical, environmental, and mechanical engineering; geology; mathematics; and physics. NAU's engineering programs have been rated such that NAU is one of the top non-Ph.D. granting Engineering schools by US News[25] and are accredited by the Engineering Accreditation Commission of ABET. In addition, NAU ranks second in the nation for awarding bachelor's degrees in engineering to Native Americans,[26] fifth in the nation for physical sciences, and eleventh in the nation for awarding bachelor's degrees in biological sciences to this group.[27] Additionally, NAU is 50th in the nation for graduating Hispanics in all disciplines.[28]

Approximately 36% of new NAU students are transfer students, with the majority transferring from Arizona community colleges. Transfer students are defined as students who enter the institution having completed more than 12 college credit hours since graduating from high school. NAU has partnerships with 19 Arizona community colleges through a program called 2NAU, which allows a student to be admitted to NAU while completing an associate's degree at a partner community college. Transfer students are starting to be recognized by NAU as one with specialized needs. To meet these needs, NAU implemented Transfer and Commuter Connections, a program committed to providing support and services for students who commute to campus and transfer students that have switched to the Flagstaff campus, in 2014.

Transfer GEMS

In 2013 NAU was awarded a National Science Foundation Scholars to Graduates in Science, Technology, Engineering, or Mathematics (S-STEM) grant #1260138 to develop Transfers to Graduates in Engineering, Mathematics and Science (Transfer-GEMS), a program for incoming transfer students with declared STEM majors. The purpose of this program is to provide both competitive, financial need-based scholarship support and a semi-residential LC to foster a successful transition from community college or another university to NAU. The LC provides

students with an undergraduate community peer mentor, faculty and staff mentors, and academic coaching. Scholarship recipients have priority for the limited number of residential LC spaces on campus, though many Transfer-GEMS LC members (scholarship awardees or otherwise) do not live in these reserved suites. Additionally, participation in a seminar course, designed to provide students with the skills and routines necessary to obtain a Bachelor of Science degree, is required of, but not limited to, scholarship recipients during the first semester. This course also provides the students with professionalism skill training, career development and guidance for success in STEM careers. Transfer-GEMS' ultimate goal is to increase the number of transfer students graduating from CEFNS with STEM majors and decrease their time (number of semesters) to graduation.

In Fall 2014, 349 STEM transfer students entered CEFNS out of 2,782 new transfers to NAU. Of these, 26 in some way joined the Transfer-GEMS program. Fifty-seven students switched into CEFNS during the year, for a total CEFNS transfer population for the 2014-2015 school year. This is the first cohort of three total that will be supported by the current grant, with 14 scholarships to be awarded in each of the subsequent groups. Transfer-GEMS cohort participation for the 2014-2015 academic year (AY) is further illustrated in Figure 1. From this point will we refer to those participating in the program as "Transfer-GEMS" and all other CEFNS transfer students as "Transfers".

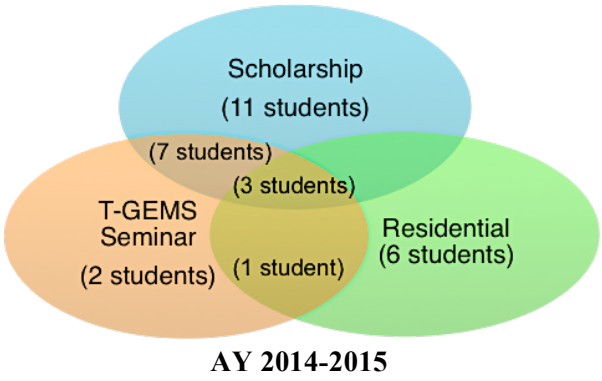

Figure 1. Transfer-GEMS Cohort 1 participation diagram.

Theoretical Framework

The overarching theoretical framework of this project is linked to Bourdieu's[29] cultural capital framework, that the "relevant knowledge, information, skills, and resources that individuals can gain that are as valuable as monetary resources" and his theory of social capital, made up of social 'connections'.[30] Bourdieu's framework suggests that access to relevant knowledge, information resources and networks about how to successfully attain a Bachelor's degree provided through the Transfer-GEMS learning community and seminar course can provide valuable capital to STEM transfer students and should smooth their transition to university. This project is also informed by Bandura's self-efficacy theory, i.e. an individual's motivations and beliefs that they can achieve their goals.[31] Leptien's work suggests that learning communities can provide supports for each of Bandura's self-efficacy domains (mastery experiences, vicarious experiences, social persuasion, and somatic/emotional influences) for transfer students.[31]

Methods

This study employed survey research to identify the experiences of CEFNS transfer students. Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population.[32]

Survey Participants

Four hundred and six transfer students in CEFNS were contacted through email in Spring 2015 by an administrative unit on campus and asked to participate in an online survey. Sixty-six of these students provided informed consent to participate in the survey research and completed at least one-third of the survey questions (a response rate of 16%). Demographics of the sub-sample of students who responded to the survey are detailed in Tables 1 and 2. The overall average Fall GPA of survey respondents was 3.23 (SD = 0.77), with Transfer-GEMS respondents having a mean GPA of 3.31 (SD =0.58) while Transfer respondents had a mean GPA of 3.21 (SD = 0.83). However, the mean GPAs for these two, relatively small samples are not significantly different.

Table 1. Ethnicity of CEFNS survey respondents

Ethnicity	Transfer-GEMS respondents *n*=17		Transfer respondents *n* = 48	
	Number	Percentage	Number	Percentage
American Indian/ Alaska Native	1	6%	4	8%
Asian	0	0%	1	2%
Black/ African American	2	12%	0	0%
Hispanic/ Latino	4	24%	9	19%
Pacific Islander	0	0%	1	2%
International	0	0%	1	2%
Not Specified	0	0%	1	2%
Two or More	0	0%	2	4%
White	10	59%	29	60%

Table 2. Gender and first-generation status of CEFNS survey respondents

Gender	Transfer-GEMS respondents *n*=17		Transfer respondents *n* = 48	
	Number	Percentage	Number	Percentage
Male	9	53%	26	54%
Female	8	47%	22	46%
First-Generation College Status	9	53%	23	48%

Note that majors were represented differently in these two groups, Transfer-GEMS versus Transfer respondents (see Table 3).

Table 3. Primary academic plan of transfer student survey respondents

Primary Academic Plan	Transfer-GEMS respondents *n*=17		Transfer respondents, *n* = 48	
	Number	Percentage*	Number	Percentage*
Engineering	8	47%	17	35%
Environmental Science/ Geology	1	6%	8	17%
Forestry	2	12%	4	8%
Biology	3	18%	14	29%
Chemistry	2	12%	4	8%
Physics/Astronomy	1	6%	1	2%
Mathematics	0	0%	0	0%

*Percentages were rounded to the nearest whole number.

Data Collection

An annual survey was conducted in March 2015 with students who had transferred into CEFNS from outside of NAU in Fall 2014. Survey questions were developed from the literature about learning communities and new college students (ex. reference 21) and asked about students' transfer experiences, academic-oriented supports they were interested in and supports they utilized, finances and social supports. Questions were fixed-response Likert scale, and open-ended. The approximately 100-question survey was administered primarily online (though several Transfer-GEMS participants were unable to complete the survey on-line and therefore completed the survey on paper) with multiple gift card drawings as incentives. A nearly identical survey was conducted the previous academic year in order to collect a baseline of the transfer student experience prior to Transfer-GEMS program implementation.

Face and content validity of the survey was established through interviews with transfer students and checks of the survey questions by transfer students who had been employed as student mentors. Additionally, the research team, which contributed to survey question development, includes faculty from several different CEFNS departments, a former CEFNS advisor, and a current CEFNS transfer student.

Data Analysis

Survey responses were analyzed as a whole for all CEFNS transfer student respondents as well as comparisons made between Transfer-GEMS participant responses (n=17) and Transfer responses (n=48). Open-ended responses were examined through constant comparative analysis.[33] Fixed response question answers were on a four- or five-point Likert scale and responses were summed into sub-scales representing use of: academic enrichments, academic supports, peer/social supports, confidence and intention to complete an advanced degree. Descriptive statistics were calculated using frequency counts and percentages. Inferential statistics were conducted to compare means between Transfer and Transfer-GEMS groups using two-sample t-tests. A parallel analysis using non-parametric permutation-based tests had identical inferential results, and we conclude the results are robust against the violations of continuity and normality of the response scale.

Results

Transfer Experience

To answer research question 1 (What do STEM transfer students experience as they become STEM majors at NAU?) survey instrument data was considered in its entirety. Students responded to questions about transferring credits, financial aid, orientation and other issues.

Advising. Although a majority of transfer students (62%) were satisfied with their previous community college advising, a number expressed frustration about getting the appropriate advice. Students commented that more advising help from both community college advisors and NAU advisors, as well as better communication between the groups would make the transfer process easier. As one student commented:

> *"More informed advisers at the community college* [would be helpful]. *The way my degree transferred was not correct. I was not aware that there was a step I missed in getting my AGEC* (Arizona General Education Curriculum certificate) *transferred.*"

Another student commented, "*I think that there could be more support from the [NAU] advisor side in the idea of knowing transfer credits and what classes to take*."

Students also commented that the transfer process would have been easier if their transfer credits were evaluated in a timelier manner so they could register for the appropriate courses.

Orientation. Similar to Spring 2014 findings (data collection the AY prior to Transfer-GEMS program implementation), almost half the students (47%) would have liked an in-person orientation designed for transfer students. A number of students expressed the need for more guidance on academic progressions. One student commented that the transfer experience would have been easier if they were to have known: *"Which classes from my community college would have counted towards my degree at the university."*

Campus Life. About half of the transfer students identified that they were familiar or very familiar with social activities at NAU. Over two-thirds of respondents had participated in an NAU sponsored social activity, although most students had participated in these activities monthly or less frequently. However, this level of participation appears greater than AY 2013-2014 (pre-Transfer-GEMS) survey respondents, as 51% of these respondents indicated *never* having participated in social activities at NAU. More than three-quarters of the current respondents were satisfied with social activities provided by NAU. Communications about social activities from NAU's Transfer and Community Connections group appeared important for getting students involved, particularly for Transfer-GEMS participants.

Financial Aid. Many transfer students (43%) were unfamiliar with financial aid, though it appears those involved with Transfer-GEMS were better informed (only 18% indicated "unfamiliar" with financial aid information). Additionally, one quarter of the transfer student respondents report struggling to manage school and living expenses. As one student commented, "*I am tired of stress if I am going to make rent or not and it affects my studies when I have to job search all day every day with no feedback*."

Satisfaction. Transfer students were satisfied overall with academic supports/enrichment. Both groups were satisfied with academic supports offered by NAU (90%). Both groups were satisfied with academic opportunities related to majors (85%). Almost all students from both groups felt they were doing well academically.

Transfer-GEMS Experience

To answer research question 2 (Are there differences in the utilization of co-curricular and professional resources between students participating in a transfer specific program and non-participants?) means were calculated for each group and compared. These means are detailed in Table 4.

Table 4. Means for Transfer Survey Instrument Subscales

Subscale	Transfer-GEMS Students		Transfer Students	
	Mean	SD	Mean	SD
Number of academic enrichments used (0-10 points)	5.06	2.87	2.68	2.29
Number of academic supports used (0-6 points)	4.00	1.41	2.37	1.40
Frequency of use of social/peer supports (0-35 points)	24.29	5.84	22.23	4.79
Level of confidence (0-35 points)	26.88	4.86	25.17	5.31
Level of advanced degree (1=Masters or higher; 2=Bachelors or lower)	1.41	0.51	1.36	0.49

For use of academic supports, there was a significant effect for participation, $t(61) = 4.08$, $p < .0001$, with Transfer-GEMS using more academic supports than Transfers. Supports included supplemental instruction, advising, learning community, and others. Although fewer non-participants had used academic supports, these students were interested in these supports, as 70% of this group responded that they would like to use at least one of the identified supports.

For use of academic enrichments, there was a significant effect for participation, $t(59) = 3.39$, $p < .001$, with Transfer-GEMS using more academic enrichments than Transfers. These enrichments included participating in professional meetings, career fairs, student professional organizations, and/or themed or major-focused programs, talks, and/or presentations. Similar to findings reported above, although fewer Transfers had used academic enrichments, these students were interested, as 80% of this group responded that they would like to use at least one of the identified enrichments.

For some constructs there was no difference between Transfer-GEMS and Transfers. Analysis indicated that there was no statistically significant difference about their confidence, including their ability to succeed academically and to graduate on time. There was also no statistically significant difference between the groups in their intention to complete an advanced degree, or use of social/peer support to study together, encourage each other to attend class, etc.

Community College Outreach

To answer research question 3 (What has been learned from community college outreach efforts?) we identify how this outreach has been attempted, current results, and future plans. Until Spring 2016, outreach to Arizona's community and tribal colleges had been primarily via email and phone calls. Informational flyers for the Transfer-GEMS scholarship program as well as a link to the CEFNS webpage with access to the scholarship application were sent to all STEM faculty and advising staff at each community or tribal institution. Only minimal responses were received and distribution of the information could not be evaluated. Few of the students who applied to the program reported learning about the Transfer-GEMS program through their previous institution. Most Transfer-GEMS applications came following direct email outreach from Transfer-GEMS staff to admitted transfer students. Beginning in January of 2016, in-person visits to as many statewide community and tribal colleges as possible were made in conjunction with our Office of Undergraduate Admissions Transfer Visit Day events. These events included tabling in high traffic areas and a scheduled information session at each institution. When possible, CEFNS and Transfer-GEMS program information was also provided individually and in-person to STEM faculty and advising staff at each institution. Identifying key faculty and leadership at these locations is fairly easy via examination of their websites, and most have been receptive to meeting with Transfer-GEMS staff while they are visiting the respective community or tribal college campus. It is hoped that these in-person meetings, during which information about the Transfer-GEMS program as well as NAU's offerings and transfer pathways, will result in better communication and future partnerships. Additionally, although Arizona State University and University of Arizona are the primary institutions Maricopa and Pima County community college students will transfer to. Nevertheless, we have still received a warm reception from these community colleges, with faculty showing an interest in exploring NAU transfer pathways and sharing NAU information with their students.

Discussion

To broaden and diversify the number of STEM bachelor's degree recipients, including engineering bachelor's degree recipients, transfer students are an important target for recruitment and retention. Our study is aimed at understanding the experiences of STEM transfer students and the effects that an intervention aimed at transfer students has on student experiences. We begin by summarizing the results we found and then discuss them in terms of social and cultural capital frameworks as well as the opportunity to improve our understanding of transfer students' experiences.

When looking across all transfer respondents, it is apparent that transfer students have unmet needs surrounding the transfer and transition process. Students identified the need to have more information about credit transfer, finances and campus life, and would have liked a transfer-student-specific, in-person orientation. These responses indicate students need more access to capital, knowledge and resources about the transfer process and university life. Initial attempts to meet these needs at NAU have resulted in an updated online transfer student orientation, which was piloted in Spring 2015 and went live for AY 2015-2016. Additionally, *optional* in-person, half-day long orientations will be offered to transfer students entering in Fall 2016 (http://nau.edu/admissions/after-you-apply/orientation/transfer-enrollment/). It will be interesting to see whether there is any impact on students' stated desire for an in-person orientation.

However, despite these unmet transfer and transition process needs, during the first year of Transfer-GEMS implementation the CEFNS transfer student respondents appear to have strong self-efficacy about their abilities to graduate.

The design of the Transfer-GEMS program is to provide knowledge of STEM-major-specific and general academic campus resources as well as social networks through a seminar course and through a LC. We found a statistically significant difference in the use of both academic enrichments and supports by Transfer-GEMS students as compared with Transfer students. This suggests Transfer-GEMS students have more access to these academic resources, including supports and enrichments, than Transfer students. Rather than identifying integration as the sole responsibility of the student, as critics of Tinto's model contend, the Transfer-GEMS seminar and LC support academic integration through shared responsibility between the students and the institution.[13] A possible mechanism for this integration is by providing students capital through early knowledge and resources that may be otherwise delayed or inaccessible if they were not in the program. For instance, the Transfer-GEMS students learned about tutoring sessions, resume development, received peer and other academic mentoring, and other supports and enrichments in their first semester of transferring. Although it is too early to identify if early access to this capital, during the traditional period of "transfer shock" will relate to persistence in their STEM degree program, other studies have identified the importance of such transfer supports for persistence.[11] Even though Transfer students were utilizing fewer academic supports and enrichments than Transfer-GEMS students, the high percentage of these students who wanted to utilize these resources suggests that these types of supports would meet a critical need for transfer students. Thus it would appear that Transfer-GEMS may be providing students better access to or awareness of desired resources that Transfer students have not managed to discover on their own, despite the current availability of these resources on campus.

Social integration is another key factor identified for student persistence, particularly in engineering.[4] However, there was no statistically significant difference in Transfer-GEMS students' use of social supports compared to Transfer students. Current results do not suggest that the LC and seminar program are providing Transfer-GEMS students greater access to social supports than Transfer students. The Transfer-GEMS program activities also do not currently appear to affect confidence or academic/professional ambition. This may be due to the primarily non-residential nature of the Transfer-GEMS LC. It also may be due to the fact that because students are from a number of different STEM majors, they do not have greater access to social and peer support from Transfer-GEMS peers than they receive from their other classmates. Alternatively, it could be that the impacts from the Transfer-GEMS project related to social integration factors have already spread to benefit the larger transfer student population. This will be explored in future analyses of pre-Transfer-GEMS data. It is also possible that the relatively low response rate has prevented actual differences from being detected.

Limitations

There are a number of limitations to the methodology used to conduct this study, survey research, including low response rate. This is a particular problem when certain groups receive many requests to complete surveys.[34] This survey was one of a number of surveys sent by the larger administrative unit at NAU to assess undergraduate students' satisfaction with various components of college life, therefore survey fatigue could be a challenge. The vehicle for

dissemination was also a challenge. Although emailed electronic surveys have increased the time and ease of survey research, as compared with mailed surveys, increasingly undergraduates are not utilizing email as a form of communication. We hope to improve response rate by using popular forms of communication with undergraduates, such as Twitter and other forms of social media to send reminders, rather than just email.

Other limitations to survey research are the reliance on self-reported data (in which participants are not reporting their actual behaviors but rather their perceptions of their behaviors)[34] and the lack of thick, descriptive information available from qualitative studies, such as ethnographies or case studies. Additionally, despite recruitment efforts, majors were represented differently in Transfer-GEMS versus Transfer respondents (see Table 3), which may have contributed to differences in responses.

Conclusions

As engineering and other STEM fields look for ways to meet future workforce needs and diversify the professions, providing successful pathways for transfer student recruitment and retention strategies is essential. Our initial findings suggest curricular programs providing early access to academic enrichments and supports for STEM transfer students may be critically important to ease "transfer shock" of these students by providing capital.[11] Universities would be wise to invest time and resources to ensure their websites provide information specifically for transfer students, such as degree progression plans and course transfer guides, to not only attract transfer students to their STEM programs but, should these efforts increase applications and admissions, this may also increase the diversity of their student population[5] with students who are potentially more likely to complete degree programs[11] than first-time freshmen. Additionally, institutions should consider offering transfer students orientation in much the same depth that it does for first-time freshman as transfer students are similarly unfamiliar with the campus, course management and enrollment systems, academic services, common school acronyms, student clubs, welcome week activities, etc. in addition to potentially being underprepared for the rapid pace and high expectations of university STEM coursework. Any outreach or recruitment efforts that typically target lower level, introductory, and prerequisite courses (that transfer students may have completed prior to entering your university) should have a separate plan for reaching transfer students. In addition, it is important to offer transfer students sufficient financial support, by easy access to scholarship information through the institution's website or via targeted information to applicants as well as review of internal scholarship opportunities that may currently exclude transfer student applicants. Furthermore, individual departments may wish to add transfer student relevant information, links, or pages to their websites to ensure they are not missing potential students. Finally, this work begins to build the literature on STEM transfer students' support needs and which avenues of providing this support may yield the greatest returns.

Future Work

Future work in this area will determine if there is a differential persistence to graduation and/or academic success for Transfer-GEMS students over Transfer students. Another area for research will be to determine if Transfer students "catch up" to Transfer GEMS students in their

utilization of academic enrichments and supports, or if this early and targeted introduction to resources is critical.

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Bibliography

1. **U.S. Executive Office of the President,** "Prepare and Inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future," White House, Washington, DC (2010). https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf (accessed 02.05.16)
2. **Miller, C. D.,** "Business, Industry STEM Education Coalition Launched," available online at http://www.nationaldefensemagazine.org/archive/2010/June/Pages/BusinessIndustrySTEMEducationCoalitionLaunched.aspx (2010).
3. **Battelle Technology Partnership Practice**, "Measuring up: 2012 Report Card on How Arizona's Technology Sector is Performing and the Contributions of Science Foundation Arizona," available online at www.sfaz.org, SFAz (2012).
4. **Marra, R. M., Tsai, C.-L., Bogue, B., & Pytel, J. L.**, "Alternative pathways to engineering success - using academic and social integration to understand two-year engineering student success," *American Journal of Engineering Education, 6*(2), pp. 69-83 (2015).
5. **Tsapogas, J.,** "The role of community colleges in the education of recent science and engineering graduates," NSF 04-315, NSF (2004). http://www.nsf.gov/statistics/infbrief/nsf04315/ (accessed 02.05.16)
6. **Community College Research Center**, "What We Know About Transfer," Research Overview, Columbia University, pp. 1-8 (2015).
7. **Starobin, S. S. & Laanan, F. S.**, "Broadening female participation in science, technology, engineering, and mathematics: Experiences at community colleges," *New Directions for Community Colleges*, **142**, pp. 37-46 (2008).
8. **Laanan, F.S.,** "Transfer Students: Trends and Issues," Jossey-Bass, San Francisco, CA (2001).
9. **Townsend, B. K. & Wilson, K.**,""A Hand Hold for A Little Bit": Factors Facilitating the Success Community College Transfer Students to a Large Research University," *Journal of College Student Development,* **47** (4), pp. 439-456 (2006).
10. **Monaghan, D. B. & Attewell, P.,** "The Community College Route to the Bachelor's Degree," *Educational Evaluation and Policy Analysis,* **37** (1), pp. 70-91 (2015).
11. **Carlan, P. E., & Byxbe, F. R.,** Community colleges under the microscope: An analysis of performance predictors for native and transfer students. *Community College Review*, *28*(2), 27–42 (2000).
12. **Tinto, V.**, "Dropout from Higher Education: A Theoretical Synthesis of Recent Research," *Review of Educational Research*, *45*(1), pp. 89–125 (1975).
13. **Rendón, L., and Jalomo, R. and A. Nora.,** Theoretical considerations in the study of minority student retention in higher education. In R*eworking the student departure puzzle* ed. J. M. Braxton. Nashville, TN: Vanderbilt University Press, (2004).
14. **MacGregor, K.**, (September 26), Social capital and 'grit' help poor students to succeed, *University World News*, (2015). http://www.universityworldnews.com/article.php?story=20150925161144888 (accessed 02.05.16)

15. **Packard, B. W-L., Gagnon, J. L., LaBelle, O., Jeffers, K., Lynn, E.,** "Women's Experiences in the STEM Community College Transfer Pathway," *Journal of Women and Minorities in Science and Engineering,* **17** (2), pp. 129-147 (2011).
16. **Pike, G. R.**, "Learning about learning communities: Consider the variables," *About Campus, November-December*, pp. 30-32 (2008).
17. **Northern Arizona University, Housing and Residence Life**, Residential Learning Communities home page. https://nau.edu/residence-life/housing-options/residential-learning-communities/ (accessed 02.05.16).
18. **Shapiro, N. S., & Levine, J. H.**, *Creating Learning Communities: A practical guide to winning support, organizing for change, and implementing programs*. Jossey-Bass, San Francisco (1999).
19. **Astin, A. W.**, Achieving Educational Excellence. Jossey-Bass, San Francisco (1985).
20. **Tinto, V. & Goodsell**, A., "A Longitudinal study of freshman interest groups at the university of Washington," National Center for Postsecondary Teaching, Learning and Assessment, University Park, PA (1993).
21. **Borden, V & Rooney, P. M.**, "Evaluating and Assessing Learning Communities." *Metropolitan Universities*, 9(1), 73-88 (1998).
22. **Scholnick, E. K.**, "A two-year longitudinal study of science and math students in the college Park Scholars Program." Unpublished report, University of Maryland, College Park, PA (1996).
23. **Tinto, V, Goodsell Love, A. G., Russo, P.**, "Building learning communities for new college students: a summary of research findings of the Collaborative Learning Project," National Center of Postsecondary Teaching, Learning and Assessment, Syracuse University, University Park, PA (1993). http://evergreen.edu/washingtoncenter/docs/buildinglcsfornew.pdf (accessed 02.05.16)
24. **Campbell, T. A., Campbell, D. E.**, "Faculty/Student Mentoring program: Effects on Academic Performance and Retention," *Research in Higher Education*, **38** (6), pp. 727-742 (1997).
25. **U.S. News & World Report**, Best Colleges 2013, McGrath, A. (Ed.) http://colleges.usnews.rankingsandreviews.com/best-colleges/northern-arizona-university-105330/overall-rankings (accessed 02.05.16)
26. **Anonymous**, "The top producers of Native American graduates," *Diverse Issues in Higher Education, 32*(21), pp. 20-23 (2015).
27. Top 100 Minority Degree Producers 2015, http://diverseeducation.com/top100/BachelorsDegreeProducers2015.php (accessed 02.05.2016).
28. **Borden, V. M. H.**, "The top 100: bachelor's/master's/professional doctoral degrees conferred," *Diverse Issues in Higher Education, 31*(18), pp. 20-48 (2014).
29. **Bourdieu, P.**, "The forms of capital (1986)," Chapter 8 in I. Szeman & T. Kaposy, eds., "Cultural theory: An anthology," Wiley-Blackwell, Chichester, West Sussex, UK, pp. 81-93 (2011).
30. **Packard, B. W-L., Gagnon, J. L., LaBelle, O., Jeffers, K., & Lynn, E.**, "Women's experiences in the STEM community college transfer pathway," *Journal of Women and Minorities in Science and Engineering, 17*(2), pp. 129-147 (2011).
31. **Leptien, J. R.**, "Aligning needs, expectations, and learning outcomes to sustain self-efficacy through transfer learning community programs," *New Directions for Student Services,* 149, pp. 41-54 (2015).
32. **Creswell, J. W.**, "Research design: Qualitative, quantitative, and mixed method approaches" (3rd ed.), Sage Publications, Thousand Oaks, California (2009).
33. **Strauss, A. L., Corbin, J. M.,** *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*, Sage Publications, London (1990).
34. **Mertler, C.A.**, "Introduction to Educational Research," Sage Publications, Inc., Thousand Oaks, CA (2016).