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The Dallas STEM Gateways Collaborative: Initial analysis of course grade data vs. external test scores

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Abstract

The University of Texas at Dallas, Collin College, and Richland College of the Dallas County Community College District have established a joint effort, the NSF-sponsored Dallas STEM Gateways Collaborative, to significantly increase the number of undergraduate students completing degrees in Science, Technology, Engineering, and Mathematics (STEM) in the North Texas region. Building upon previous cooperation among these three institutions and the remarkable concentration of high-tech businesses in the Dallas-Fort Worth Metroplex, the Collaborative has implemented best-practice methods to bring about a cultural change that will lead to a sustained increase in the production of STEM-trained graduates. In this paper we will examine some of the initial data collected for the project. Specifically, these data were studied to determine weaknesses in student preparation and subsequently, develop appropriate targeted interventions. Currently the data set consists of grade and test score data from approximately 13,000 individual students at UT Dallas. Grade data is from 19 courses covering Math, Physics, Chemistry and Engineering, from fall 2008 onward. Those courses were chosen as perceived 'gateway' courses into STEM disciplines. An initial analysis of the data is underway. As expected, there is an observed correlation between 'math' test score data and most of the Math, Physics, Chemistry and Engineering courses monitored. Surprisingly, we have also found a correlation between some 'English/writing' test score data and many of the Math, Physics, Chemistry and Engineering courses monitored. We will present a small subset of the data with the intent of developing causal relationships between the tests and the related course grades.

Introduction

There is now ample documentation that the United States is facing an economic crisis unless it increases its production of talented science, technology, engineering and mathematics (STEM) graduates.[1,2] As described in *Rising Above the Gathering Storm*,[1] the global demand for skilled STEM workers is increasing and the number of American students pursuing STEM careers is likely to continue to decline unless the Nation intervenes. In areas like the Dallas-Fort Worth metroplex, with its concentration of high tech businesses and industry and rapidly growing population, the need is made even more apparent.

The state of Texas, recognizing the need for a scientifically and mathematically literate citizenry recently introduced a new high school graduation requirement: each student must successfully complete four years of science and four years of mathematics to earn a high school diploma. Even with this additional high school preparation, many students who have an interest in

STEM careers will find the traditional undergraduate courses in STEM fields intimidating. Furthermore, many who start their undergraduate careers in community colleges find barriers to transferring to four-year colleges and universities to finish their baccalaureate degrees.

In spite of the alarming national trends, many colleges and universities have recognized that by creating programs that excite and stimulate students early in their STEM careers, many more students will successfully earn their undergraduate STEM degrees.[3,4] For example, due to wide-spread efforts in the physics community, the number of undergraduates earning degrees in physics in the U.S. increased by more than 35% from 1999-2007 with almost all of these being domestic students. Detailed data are available from the Statistical Research Division of the American Institute of Physics. The lesson here is that focused efforts that address the entire student program, not just the curriculum, can lead to significant increases in the number of STEM majors.

To address the STEM workforce problem and to increase significantly the number of students earning undergraduate STEM degrees, the University of Texas at Dallas (UTD), Collin County Community College, and Richland College of the Dallas County Community College District have formed the Dallas STEM Gateways Collaborative (referred to as the "Collaborative" in this document), a cooperative project providing a comprehensive and coordinated set of activities focusing on the gateway experiences during the first two years of the students' undergraduate experience. The activities include recruitment and retention efforts aimed at STEM students combined with a series of curricular and faculty development activities that are designed to produce significant cultural changes in the institutions' focus on undergraduate STEM education. The activities build on and significantly extend existing collaborative activities and are in alignment with and enhanced by other recent initiatives at the three institutions. We report here on progress associated with establishing a pipeline of STEM students that begins in the high schools, proceeds through the two-year institutions and finishes with graduation at the four-year institution in STEM disciplines.

Results and Discussion

The Collaborative is a partnership between three institutions (UT Dallas, Collin College and Richland College) to facilitate the recruitment and success of STEM students. Specific programs include the following with selected activities highlighted in subsequent sections. The successful 2+2 articulation program in engineering (including important curricular alignment agreements) between Collin College, Richland College and UT Dallas was expanded to all STEM disciplines at both Collin College and Richland College. Enhanced Advising has played a key role in this effort at the community college level. Direct presentations to students, parents, and counselors coupled with the offering of Technical Dual Credit coursework at local high schools has produced a collaborative recruitment effort aimed at making the 2+2 programs known to high school juniors and seniors in the diverse Dallas-Fort Worth Metroplex. Expansion of the award winning Peer-Led Team Learning (PLTL)[5-9] program in gateway STEM classes at UT Dallas has occurred and is in the process of being leveraged to Richland College and Collin College. There have been many collaborative activities among the three institutions to build a STEM student learning community. These activities have included opportunities for: undergraduate research and internships, joint student organization activities, an undergraduate research fair and STEM mentoring career workshops. A Faculty Innovation Grant Award program was created to facilitate research and education innovations across all three institutions. There has been an expanded effort at Richland College to address the Math and Science Tutoring needs of STEM students in specific higher level Math, Physics and Chemistry

courses. An outreach effort at Collin College to build a pipeline of STEM students targeted to attend UT Dallas through Robotics Camps and College Robotics Competitions is bearing success. Finally, and of particular significance, a robust method for the tracking of Collin and Richland transfer students within classes and degree programs at the University of Texas at Dallas has been developed to aid the Collaborative in channeling resources to appropriately lower transfer barriers for students.

Specific program elements include:

1. The successful 2+2 articulation program in engineering (including important curricular alignment agreements) between Collin College, Richland College and UT Dallas was expanded to all STEM disciplines at both Collin College and Richland College. Enhanced Advising has played a key role in this effort at the community college level.
2. Direct presentations to students, parents, and counselors coupled with the offering of Technical Dual Credit coursework at local high schools has produced a collaborative recruitment effort aimed at making the 2+2 programs known to high school juniors and seniors in the diverse Dallas-Fort Worth Metroplex.
3. Expansion of the Peer-Led Team Learning (PLTL) program in gateway STEM classes at UT Dallas has occurred and is in the process of being leveraged to Richland College and Collin College.[5-10]
4. There have been many collaborative activities among the three institutions to build a STEM student learning community. These activities have included opportunities for: undergraduate research and internships, joint student organization activities, an undergraduate research fair, STEM mentoring career workshops.
5. A Faculty Innovation Grant Award program was created to facilitate research and education innovations across all three institutions.
6. There has been an expanded effort at Richland College to address the Math and Science Tutoring needs of STEM students in specific higher level Math, Physics and Chemistry courses.
7. An outreach effort at Collin College to build a pipeline of STEM students targeted to attend UT Dallas through Robotics Camps and College Robotics Competitions is bearing success.

In this publication we will focus on the development of student tracking data. This is necessary to understand the needs of the students at all three schools. Specifically, these data were studied to determine weaknesses in student preparation and subsequently, develop appropriate targeted interventions. Currently the data set consists of grade and test score data from approximately 13,000 individual students at UT Dallas. Grade data is from 19 courses covering Math, Physics, Chemistry and Engineering, from fall 2008 onward. Those courses were chosen as perceived ‘gateway’ courses into STEM disciplines. An initial analysis of the data is underway.

Transfer Student Data Tracking

In order to benchmark and track the Collin College and Richland College transfer student population at UT Dallas, a robust, secure method is needed for accessing student data that addresses the appropriate questions relating to absolute numbers of STEM transfer students, identification of transfer student gateway courses, performance in classes and time to graduation in STEM fields. In addition, the impact of specific programs, including the summer research experience and PLTL for example, on transfer student numbers and performance hinges on such a method. One of the most

significant achievements of the Collaborative has been the development of a method to track transfer students at UT Dallas. These data are providing rich information to not only assess progress, but to target interventions that will allow for greater transfer student success. Selected data are shown in Figures 1 and 2. The Collaborative objective of filling the pipeline with STEM students is shown to be working well as represented by the enrollment data in chemistry (Figure 1) over a five-year period. There is a dramatic increase in transfer students from Collin College and Richland College (as monitored by enrollment from the Dallas County Community College District, of which Richland College is a member) in the gateway chemistry courses at UT Dallas, but not in transfer students from other institutions. However, as shown in Figure 2, representative data from the same gateway chemistry courses clearly show that transfer students need intervention to be more successful as transfer student performance lags significantly behind that of native UT Dallas students. The data in both Figures 1 and 2 are consistent with data for gateway mathematics and physics courses. As we implement Collaborative interventions, the success, persistence and retention of transfer students will be tracked by our innovative data collection methodology. Conversely, specific *data driven* interventions at the three institutions can now be targeted to aid transfer students in final STEM baccalaureate success.

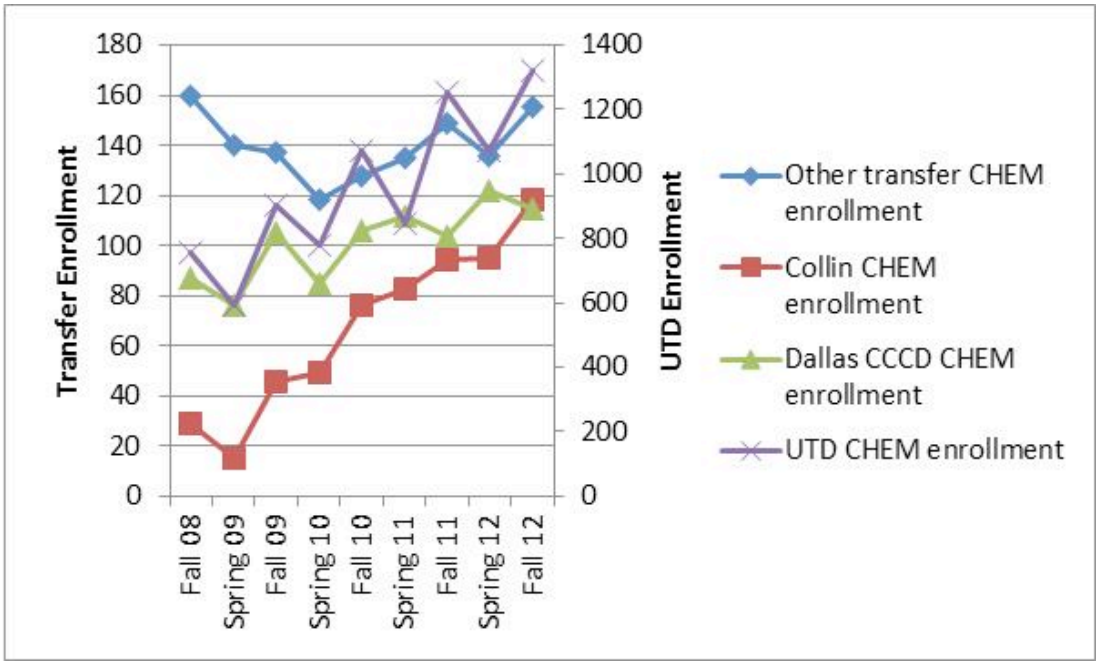

Figure 1. Enrollment data for transfer and native students in chemistry courses at UT Dallas.

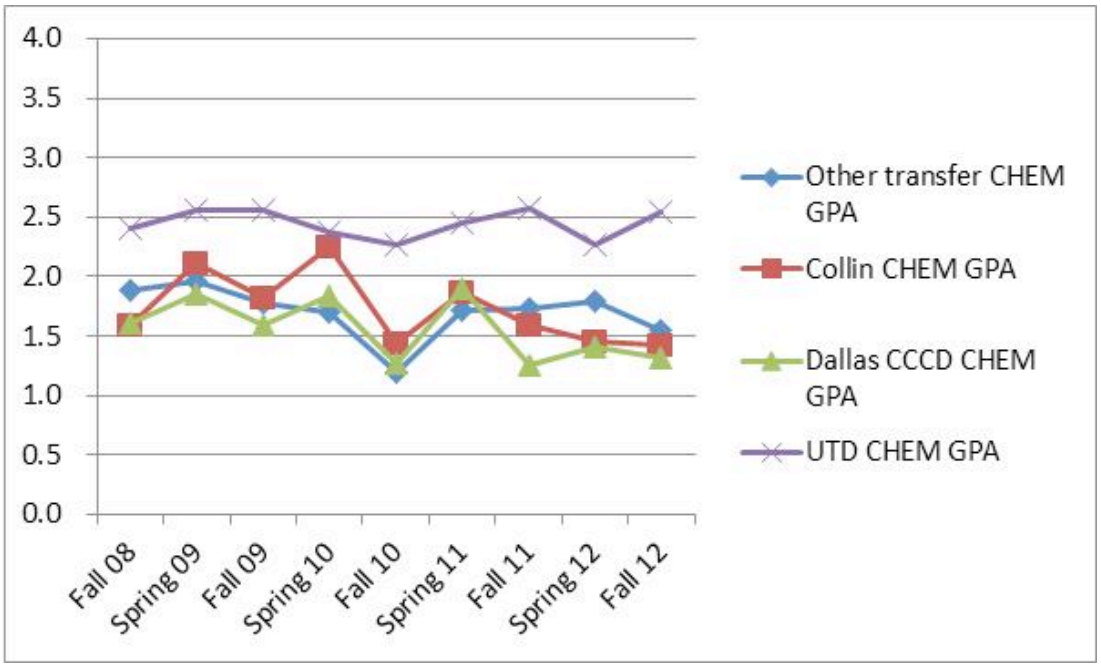

Figure 2. Average GPA of transfer and native students in chemistry courses at UT Dallas.

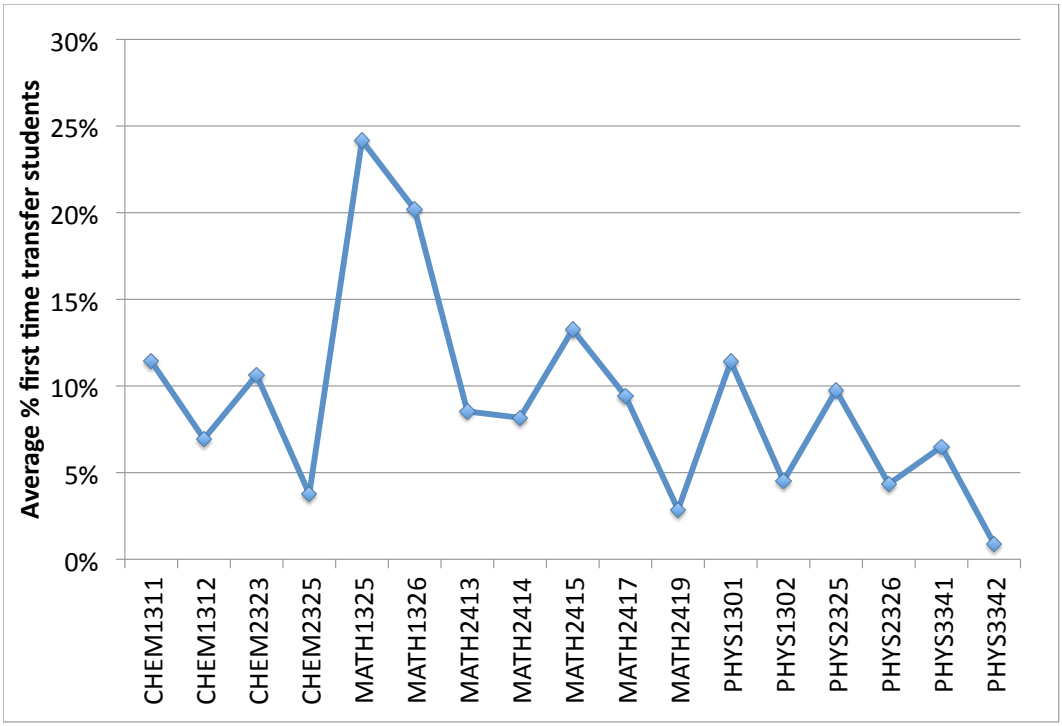

Figure 3. Average % of first time transfer students in various gateway courses at UT Dallas. The higher two, MATH 1325, 1326 are Applied Calculus I and II.

To ascertain the success of the transfer students, in comparison to traditional students, a set of 'core' courses are being monitored. Those courses are:

- CHEM1311 General Chemistry I

- CHEM1312 General Chemistry II
- CHEM2323 Introductory Organic Chemistry I
- CHEM2325 Introductory Organic Chemistry II
- MATH1325 Applied Calculus I
- MATH1326 Applied Calculus II
- MATH2413 Differential Calculus
- MATH2414 Integral Calculus
- MATH2415 Calculus of Several Variables
- MATH2417 Calculus I (Accelerated calculus)
- MATH2419 Calculus II (Accelerated calculus)
- PHYS1301 College Physics I
- PHYS1302 College Physics II
- PHYS2325 Mechanics (Physics I for STEM majors)
- PHYS2326 Electromagnetism and Waves (Physics II for STEM majors)
- PHYS3341 Physics for Bio Science I
- PHYS3342 Physics for Bio Science II
- ENGR2300 Linear Algebra for Engineers
- ENGR3300 Advanced Engineering Mathematics

Further, we have divided the student population into groups:

- FTIC First time in college – first semester
- FTIC-CONT First time in college – subsequent semesters
- TRSF Transfer students – first semester at UT Dallas
- TRSF-CONT Transfer students – subsequent semesters
- And a few minor categories

We find that both semesters of applied calculus have the largest average percentage of first time transfer students, see Figure 3. However many of the courses also have semesters with high enrollment rates for first time transfer students, see Figure 4. This suggests that we will need to develop a semester-by-semester targeted intervention system, placing resources where they are needed each semester.

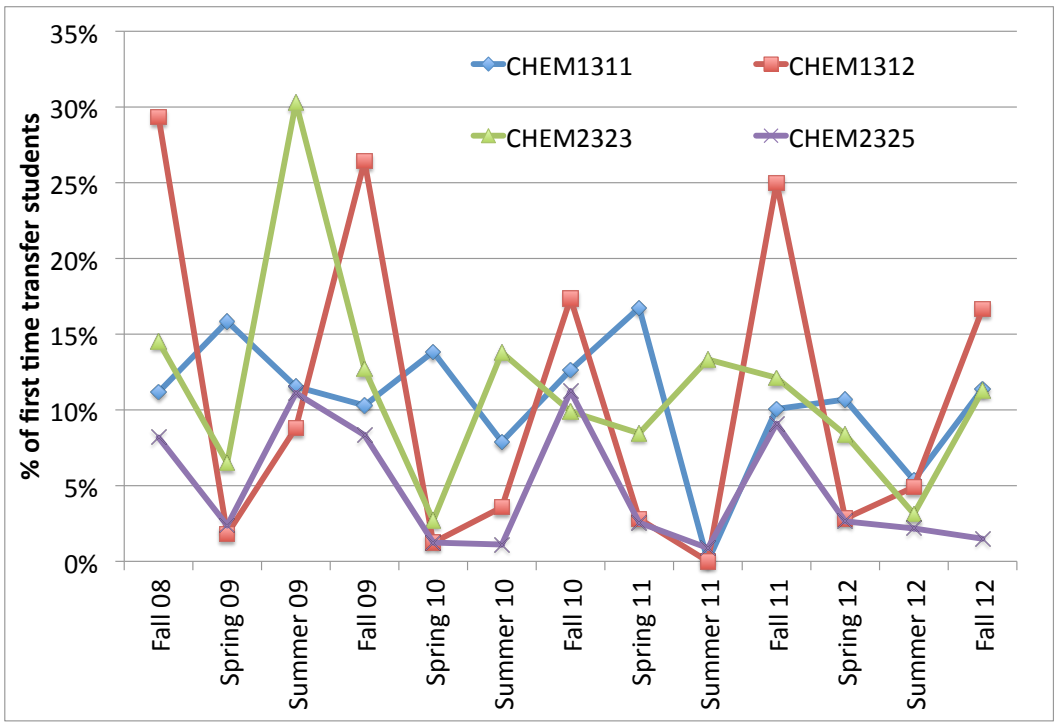

Figure 4. Variation in transfer semester, and initial course at UT Dallas varies significantly. Here, it is observed that each semester General Chemistry I (CHEM 1311) typically has 10-15% first-time transfer students. Meanwhile General Chemistry II (CHEM 1312) varies significantly from ~20% in the fall to less than 5% in the spring semester.

Initial observed correlations

As expected, there is an observed correlation between typical 'math' test score data and most of the Math, Physics, Chemistry and Engineering courses monitored, see Figures 5 for example. Surprisingly, we have also found a correlation between some 'English/writing' test score data and many of the Math, Physics, Chemistry and Engineering courses monitored, see Figure 6 for example. We will present a small subset of the data with the intent of developing causal relationships between the tests and the related course grades.

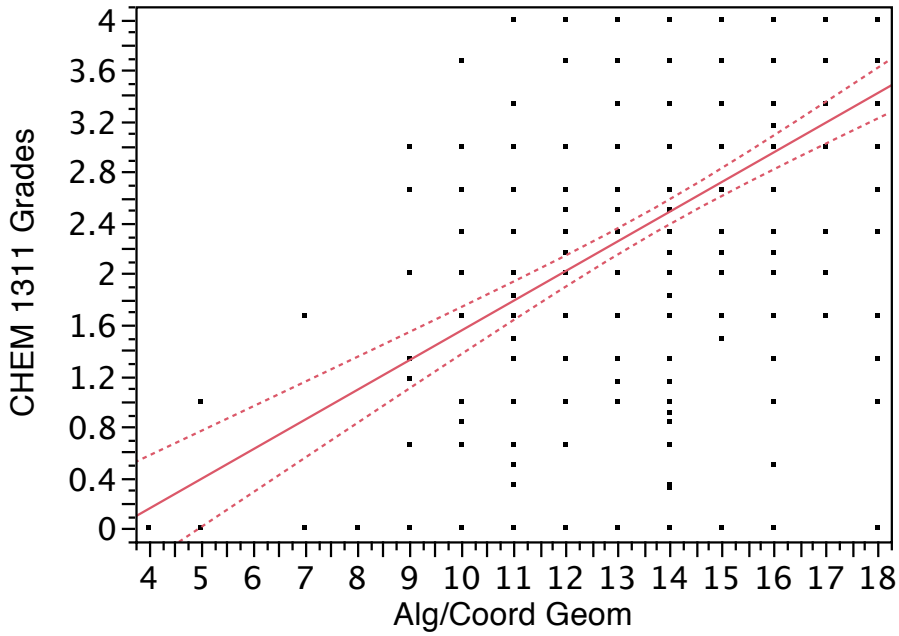

Figure 5. Observed correlation between General Chemistry 1 (CHEM 1311) and a standardized algebra / geometry test.

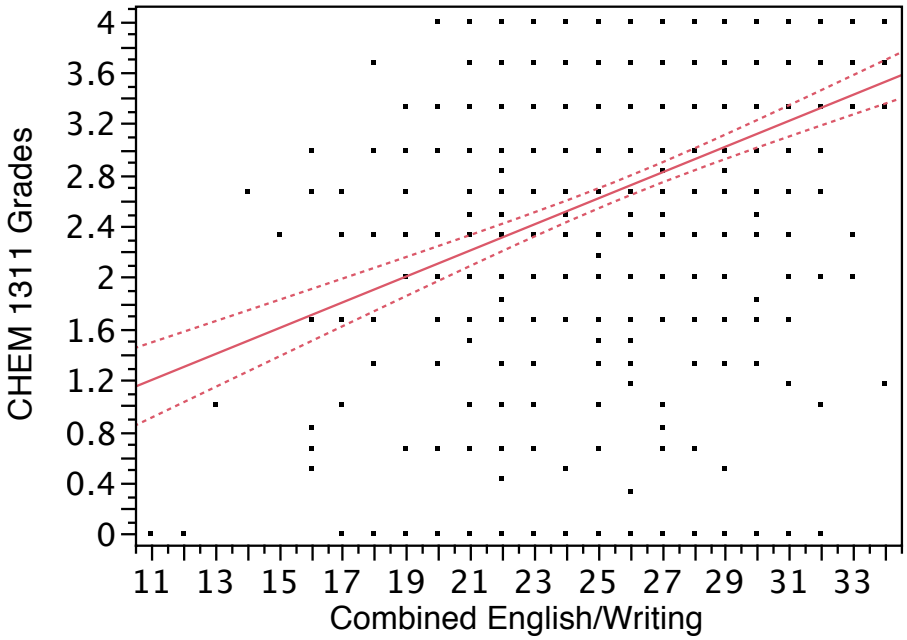

Figure 6. Observed correlation between General Chemistry 1 (CHEM 1311) and a standardized English / writing test

Summary and Conclusions

The Dallas STEM Gateways Collaborative has been established to provide a comprehensive and coordinated set of activities across three campuses (UT Dallas, Collin and Richland Colleges), focusing on the gateway experiences during the first two years of the students' undergraduate career

with the ultimate goal of establishing and growing a pipeline for STEM majors from the two year institutions, Collin College and Richland College, to UT Dallas that will lead to more STEM majors in an absolute sense and greater opportunities for success and engagement as these students proceed to STEM degrees. The pipeline has been established with focus now being drawn to interventions that will facilitate transfer student success at the four-year institution. This material is based upon work supported by the National Science Foundation under Grant No. DUE 0856549. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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JOHN SIBERT

Dr. Sibert is an associate professor of chemistry at UT Dallas with research interests that lie in the area of molecular architecture, designing and building new molecules for applications that span from medicine to environmental science to advanced new materials. He has an educational emphasis on engaging learners in innovative methods centered on curiosity and discovery.

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Dave Galley serves as the Director of Engineering and is a member of the faculty at Collin College. He has twenty years of industrial experience working as an engineer and in management and executive capacities. His current interests focus on the recruitment and success of STEM students from high school through the university and into the workplace.

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Dr. Goldammer coordinates the Nanotechnology and Semiconductor Manufacturing program while serving on the faculty at Richland College. He has fourteen years of experience working in the semiconductor industry.