2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time

Paper ID #34291

DuSTEM: A Comprehensive Approach to Student Success

Dr. Kristen Ann Thompson, Loras College

Dr. Kristen Thompson is currently an Associate Professor of Engineering at Loras College. She teaches Thermodynamics, Fluid Mechanics, Dynamics Systems, and Introductory Physics courses. She earned her Ph.D. from the University of Wisconsin - Madison and her B.S. from Michigan Technological University both in Chemical Engineering.

Dr. Danial J. Neebel PE, Loras College

Dr. Danial Neebel, PE is a Professor of engineering and computer science at Loras College. He is currently the program chair for the engineering program and takes part in recruiting students to the College. He also teaches courses and helps with curriculum development in computer science. His research interests include digital system design and testing, computer architecture, and computer science and engineering education.

Dr. Robert S. Keller, Loras College

Robert Keller is a Professor of Mathematics and Chair of the Division of Mathematics, Engineering, and Computer Science at Loras College. Dr. Keller has taught at Loras since earning his Ph.D. in Mathematics in 1999 from the University of North Carolina, Chapel Hill. Since that time, Dr. Keller's primary focus has been mathematics education, working with both preservice and practicing teachers. In addition to his role at Loras College, since 2017 he has held the position of Interim Director for the Jacobson Institute for Innovation in Education at Grand View University in Des Moines, IA. In recent years, Dr. Keller has become interested in data science and the use of analytic techniques for gaining insights and improving strategic decision-making. He completed his M.B.A. with an emphasis in Business Analytics in 2018.

DuSTEM: A Comprehensive Approach to Student Success

Introduction

The DuSTEM program at Loras College has the main goal of increasing enrollment and retention in STEM programs with a focus on the majors of Chemistry, Computer Science, Engineering, and Mathematics. This program was launched in the fall of 2018 thanks to NSF S-STEM grant #1742158. The first applicants were recruited to begin in the fall of 2019. Participating students are selected based on need and aptitude. All participants are required to participate in a one credit seminar course each semester. These courses are designed to assist in retention by facilitating developing participants identity as a scientist as well as provide transition and career support.

To date, 36 students have been awarded scholarships. At this point there are 17 students in their second year and 14 students in their first year. Each year students are able to renew their scholarships for a maximum of 8 semesters.

Program Highlights

The DuSTEM program is designed to improved retention of students in STEM. Support is broken into three areas: financial, academic, and community [1]. These ideas are predicated on the nine key principles advanced by the non-profit "Building Engineering and Science Talent" which identifies nine qualities of programs that are successful in nurturing well-qualified STEM graduates [2]. These principles are

- Institutional leadership
- Targeted recruitment
- Engaged faculty
- Personal attention
- Peer support
- Enriched research opportunities
- Bridging to the next level
- Financial assistance
- Continuous evaluation

The DuSTEM program is designed support each of these three areas utilizing the nine principles. Financial support is provided in the form of scholarships. The programming then supports students both academically and develops community through two main components, a first-year seminar and seminar grouping subsequent years together. The first-year seminar focuses on key skills related to the transition to college. In subsequent years, the program shifts its focus to applications, incorporating a community-based learning project and developing skills to find internships and research opportunities. We initially tried an approach of using as many of these research-backed best practices as possible. This beginning tactic has helped us identify the components that make the largest impact on students to streamline the program. The DuSTEM faculty team then decided on the practices to keep and focus on those with the largest impact.

First-students take part in a seminar that includes basic academic skills, how to find a variety of resources at the college, and skills for personal wellbeing. During the year, students work through a *The Grit Guide for Teens* [3], based on Dr. Angela Duckworth's work on Grit [4]. From student comments by far the largest impact on their success were the topics focused on wellbeing, where we brought the school psychologist in the counseling office into class as well as watched TED talks on grit [5], motivation [6], and emotional intelligence [7]. Additionally, the seminar often gives students the opportunity to be mentored by an instructor in STEM that is not the instructor for one of their content-based classes in their chosen major. This gives the students in the program one more resource in navigating the world of STEM academics as well as an engaged faculty member to provide personal attention to this group of students. Third, because the ultimate goal is for these students to join the STEM workforce either in industry or

the academy, students are mentored on building bridges to their future careers including how to find and apply for internships, co-ops, and undergraduate research opportunities.

The focus on these strategies, in particular a focus on wellness, has helped students weather the challenges of the COVID-19 shutdown in the spring of 2020. After the transition online, class time moved primarily to networking among the students (peer support) as well as personal check-ins from the instructor.

Strategies that were tried and not continued in the first-year seminar for the second cohort were the use of general tutors and living-community arrangements. Students did not utilize the general tutors in the first-semester likely because most of the first-year STEM courses already have peersupport in the form of Supplementary Instruction (SI) where an upper-level undergraduate student provided support specifically for these classes [8]. Instead, an SI support was added to Engineering Statics, one of the few challenging first-year STEM courses that did not have an SI.

Starting in the second year, the focus of the seminar shifts to focus on building bridges by learning to apply their coursework to their future career. The main focus of the seminar is to work on a community-based learning group project as well as continue to work on skills related to finding summer positions. Students practice job search skills by writing resumes and participating in practice interviews.

Participation in community-based projects has been shown to increase retention of engineering majors [9] [10] [11]. The goal of the project is to facilitate "enriched research opportunities" as well as "additional bridges to the next level" by connecting what they are learning in class to real world problems. Additionally, these experiences help students be able to articulate their growth in STEM when they apply to either graduate school or apply for an industrial position. These articulation skills are practiced in class in the form of personal reflections. The four requirements of the project are that the scholars work in a group, they use their new and growing STEM skillset, the project must benefit the community, and it must be sustainable. In this case sustainable means that the project itself can continue for multiple years, with new students possibly taking over. The projects that are currently under way include STEM education programming, Mental Health Information, Expanding Local Food Options, and Assessing College Energy Usage.

Program Goals

The program, as funded by the NSF S-STEM grant, has four goals set forth in the original project proposal. Three are centered on increasing enrollment and retention while the fourth seeks to find what best supports student success. The four goals are listed in Table 1. While originally specifically targeting four majors, we have sought to expand the number of disciplines to which Goals 1 through 3 apply, expecting similar affects across all STEM fields Additional STEM disciplines targeted at the author's institution: Biology, Biochemistry, Neuroscience and Data Science in addition to the target disciplines.

Table 1: The Four DuSTEM Goals

Goal 1:	Increase Enrollment in targeted programs.	*Increase enrollment in Computer Science, Chemistry, Engineering, and Mathematics, by an average of 28% annually. This 28% represents all of the 18 new DuSTEM scholars entering a DUSTEM target major.*

Goal 2:	Increase Retention in targeted programs.	*Increase retention in Computer Science, Chemistry, Engineering, and Mathematics by an average rate of 43 percentage points (from 38% to 81%, the college average) based on intended major on their application. The current retention rate is depressed because of the number of those who are undecided or do not indicate a major on their application.*
Goal 3:	Increase Number of Graduates in targeted programs.	*Increase the number of graduates from Computer Science, Chemistry, Engineering, and Mathematics by 28%, and assist them in successfully obtaining employment or entry into graduate school. This 28% represents all of the DuSTEM scholars graduating a major.*
Goal 4:	Assess effects of community-based learning and cohort support mechanisms	*Determine if the combination of community-based learning projects and cohort support mechanisms will impact student success in meeting these goals. The DuSTEM leadership team postulates that implementing academic support and communitybased learning projects will be synergistic to helping students not only gain the skills they need to succeed, but also able to provide students with meaningful reasons for pursuing STEM careers, including the potential positive impact they can make.*

Early results

Early data indicates that the DuSTEM program has positively impacted enrollment and retention for the targeted programs as well as other STEM programs at the institution.

Goal #1: Increase Enrollment

Enrollment in specific majors is indicated by a declaration, which is generally completed by students by the latter part of the sophomore year and officially recognized by the institution. As of February 3, 2021, of the 22 DuSTEM scholars who were originally recruited as first-year students in the Fall of 2019, 19 of 22 were retained at the college and 18 of these 19 had declared at least one major.

Considering these 18 students who had declared at least one STEM major as of February 2021, 9 were majoring in Computer Science, Chemistry, Engineering, or Mathematics – those majors targeted by the DuSTEM program. This equates to a (weighted) average increase in enrollment of 11.1% in the targeted programs. Additionally, since the program is open to more than just the targeted majors, this resulted in a (weighted) average increase of 11.1% in these other sciences collectively.

Goal #2: Retention

This preliminary analysis reveals a (weighted) average retention of 66.7% within the four programs targeted by the DuSTEM program. To accomplish this analysis, a matched control group was created. The control group was formed to closely reflect the DuSTEM group on five variables: student class (year), intended major, composite ACT score, high school GPA, and sex. As such members of the control group were selected from first-year students who matriculated to

Loras College in Fall 2019 and who intend to major in a STEM discipline. Regarding the latter, students who were enrolled in at least three STEM courses during the 2019-20 academic year were considered for potential inclusion. The original DuSTEM group consists of 22 students, while the matched control group was formed with 30 students.

The control group is statistically indistinguishable from the DuSTEM group considering high school GPA and ACT composite score or equivalent (difference of means 0.07; $t = 0.75$, P = .46 and difference of means 1.66; $t = 1.63$, P = .11 respectively). Due to population size restrictions, the control group does not accurately match on sex, with 14 who identify as female and 8 as male in the DuSTEM group and 14 who identify as female and 16 as male in the control group.

An analysis of these data reveal that students in the DuSTEM program were nearly four times more likely to be retained from Fall 2019 to Spring 2020 than students who were in the matched control group (OR = 3.95 using Haldane-Anscombe correction). Considering retention from Fall 2019 to Fall 2020, students in DuSTEM were 1.27 times more likely to be retained than those in the control group (OR = 1.266). And lastly, when considering retention from Fall 2019 to Spring 2021, students in DuSTEM were 1.58 times more likely to persist than those in the control group (OR = 1.583).

Some students have changed their major after enrolling in the DuSTEM program. At this point, five of the first cohort students switched to another major within STEM while two students have chosen to leave the program by choosing a major outside of STEM.

Performance relative Goal #3, increased number of graduates, cannot be assessed until students are eligible for graduation.

Goal #4: Assess effects of community-based learning and cohort support mechanisms

A primary measure of student success is semester GPA. Data available at this stage includes student GPA for the Fall 2019, Spring 2020, and Fall 2020 semesters. The table below shows the GPAs by term for each group. In each term, the mean GPA for students in the DuSTEM group was higher than that for those in the matched control group.

Table 2: GPAs for DUSTEM vs Matched Control Group

	Mean GPA by Term		
	Fall 2019	Spring 2020	Fall 2020
DUSTEM Cohort	3.29	3.10	3.32
Matched Control Group	2.95	2.93	2.86
Difference of means, t, P	0.35, t = 1.36, P = 0.09	0.17, t = 0.44, P = 0.33	0.47, t = 1.72, P = 0.047

As may be seen, the most significant differences appear in Fall 2019 and Fall 2020.

For the Spring 2020 semester, while DuSTEM scholars still outperformed their counterparts in the matched control group, any GPA advantage held by DuSTEM students had diminished. Due to the sudden and highly disruptive impacts of the COVID-19 pandemic, many features of the DuSTEM project were paused or modified in Spring 2020 to meet the demands of the time.

Conclusion

In summary, the DuSTEM program appears to be successful in increasing enrollment and retention in STEM, both in the targeted and non-targeted STEM fields. Participants in this project receive not only a financial scholarship but development of skills useful both inside the classroom and in their professional careers. This program puts their education in the context of both a learning community as well as impact to the broader community.

References

[1] P. Gándara and J. Maxwell-Jolly, "Priming the Pump: Strategies for Increasing the Achievement of Underrepresented Minority Undergraduates," 1999. [Online]. Available: http://research.collegeboard.org/sites/default/files/publications/2012/7/misc1999-1increasing-achievement-minorities.pdf.

[2] BEST, (Building Engineering & Science Talent);, "A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics," BEST, San Marcos, CA, 2004. http://www.bestworkforce.org/sites/default/files/research/downloads/Bridge for All Higher Ed report.pdf

[3] C. Baruch-Feldman, The Grit Guide for Teens: A Workbook to Help You Build Perseverance, Self-Control, and a Growth Mindset, New Harbinger Publications, 2017.

[4] A. Duckworth, Grit: The Power of Passion and Perseverance, New York, NY: Scribner, 2016.

[5] A. Duckworth, *Grit: The power of passion and perseverance {Video],* TED Conferences, 2013. https://www.ted.com/talks/angela_lee_duckworth_grit_the_power_of_passion_and_perseverance

[6] D. Pink, *Drive: The surprising truth about what motivates us [Video],* RSA ANIMATE, 2010. https://www.thersa.org/comment/2010/04/rsa-animate---drive

[7] R. Hacker, *Six steps to improve your emotional intelligence [Video],* TED Conferences, 2017. https://www.ted.com/talks/ramona_hacker_6_steps_to_improve_your_emotional_intelligence

[8] E. Alpaya, P. S. Cutler, S. Eisenbach and A. J. Field, "Changing the marks-based culture of learning through peer-assisted tutorials," *European Journal of Engineering Education,* vol. 35, no. 1, pp. 17 - 32, 2010.

[9] E. J. Coyle, L. H. Jamieson and W. C. Oakes, "EPICS: Engineering Projects in Community Service," *Int. J. Engng Ed.,* vol. 21, no. 1, pp. 139 - 150, 2005.

[10] D. M. Hall, A. J. Curtin-Soydan and J. H. Blackshear, "Creating a Layered Assessment Model to Engage and Retain Diverse Learners in Gateway STEM Courses," in *Transforming STEM Higher Education presented by the Association of American Colleges and Universities*, Atlanta, GA, 2014.

[11] B. Toven-Lindsey and M. Lewis-Fitzgerald, "Assessing and Improving Persistence of Underrepresented Minorities in Science," in *Transforming STEM Higher Education presented by the Association of American Colleges and Universities*, 2014.