Gateways-ND: Advancing Learner-Focused Instruction to Catalyze STEM Student Success

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Paul Kelter's 38-year career has focused on the integration and transfer of knowledge among students and teachers at all educational levels. He was the inaugural director of the Science Outreach Office at the University of Wisconsin – Oshkosh in the late 1980's through early 1990's. Many of the programs he instituted via external funding are still part of that office. He was the co-PI on the successful, long-term Operation Chemistry literacy program for all levels of teachers, and parlayed that national program into grant-funded summer and year-round workshops in Wisconsin, Nebraska, and North Carolina over a 15-year period. During his 7-year tenure at Northern Illinois University (NIU), Kelter worked extensively with middle school teachers in high-Latino population communities in the service of science education. He has been at the forefront of science literacy for postsecondary students via three major chemistry textbooks, aimed at the first-year chemistry audience, as well as a book on the international impact of chemistry and learning. Kelter has won two dozen campus, state, and national awards in education, including career-long designations at distinguished teacher at the Universities of Wisconsin-Oshkosh, Nebraska, and Illinois. He was Board of Trustees professor at Northern Illinois University, the highest professorship available at that university. He began present position as the inaugural director of the Office of Teaching and Learning at North Dakota State University in June 2014. His current interest is advocating for literacy in sustainable development among students and teachers.

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Gateways-ND is a five-year (2015-2020) National Science Foundation (NSF)-funded instructional faculty and instructional staff development program that is designed to offer relevant, collaborative, and sustained support to science, technology, engineering, and math (STEM) educators at North Dakota State University (NDSU). Gateways-ND has changed, and is changing, the culture of STEM education at NDSU, which is influencing STEM educational training programs throughout the institution and the state. When the program started in 2015, the university was at a critical juncture in its approach to STEM education, and this program has accelerated the pace of positive educational change at NDSU and beyond. Our institutional premise for this vital change in culture is best stated by Project Kaleidoscope, the authors of which wrote, "We now have indisputable evidence (emphasis added) that active and collaborative strategies that engage students in their own learning, and in relevant ways, are highly successful across all disciplines (not just STEM) …" [1], [2]. Our ultimate goals are to maximize instructional effectiveness and, therefore, student success in, and engagement with, STEM. By "success," we are referring to a range of variables, including improved completion and pass rates, grade improvement, improved attitudes toward STEM, and improved study and engagement habits.

Need for the Project.

Institutional data at NDSU uniformly indicates the need for increased resources aimed at bolstering the adoption of innovative learner-focused teaching practices in STEM - especially in gateway courses. The John N. Gardner Institute for Excellence in Undergraduate Education lists three attributes for "gateway" courses: 1. They are foundational, that is, they are developmental or lower-division courses; 2. They have a high proportion of students with D, F, W or incomplete grades, and; 3. They have high-enrollments [3]. Overall student retention and graduation rates at NDSU persistently lag behind those of peer institutions. Students who do not pass are more likely to have left NDSU without having completed a degree. Faculty, students and alumni are dissatisfied with the level of support for instruction and overall instructional quality for gateway courses at NDSU, and students have consistently reported lower levels of engagement in behaviors associated with positive academic outcomes [4].

Lagging Outcomes. An average of 53% of NDSU's first-time, full-time students graduated from the campus within six years for cohort years 2002-2007 versus 63% of first-time, full-time students at Integrated Postsecondary Education Data System (IPEDS) peer institutions. These graduation rates compare even less favorably for four-year graduations (25.4% at NDSU versus 46.7% at peer institutions). Departments within the NDSU College of Science and Mathematics mirror our institutional graduation rates. Average six-year graduation rates for cohort years 2005, 2006, and 2007 for first-time, full-time students choosing to major in the College of Science and Mathematics by the end of first semester sophomore year were 51.4% for Biological Sciences, 50.0% for Chemistry and Biochemistry, 48.0% for Computer Science, and 43.7% for Psychology. This suggests students declaring a STEM major early on, and therefore enrolling in entry-level gateway STEM courses early in their academic careers, do not graduate from NDSU within six years as often as is desirable. A 4% improvement in the six-year graduation rate of first-time, full-time students would raise NDSU to the average of our peer institutions with similar admissions selectivity (e.g., ACT and high school GPA). There are many variables that

contribute to an institution's overall graduation rate, and an important one is student success in gateway courses [5]. Overtime, we expect the graduation rate to rise as a result of Gateways-ND.

Diminished Satisfaction and Engagement. Several sources of survey data inform our understanding of these lagging outcomes. Most telling, NDSU students consistently indicate lower levels of engagement than students at peer institutions and a national sample of higher education institutions over the course of four administrations of the National Survey of Student Engagement from 2007-2013 [4]. In 2013, both first-year and senior-level NDSU students reported less satisfaction than peers with teaching practices across the board (e.g., clearly explained course goals/requirements, course taught in an organized way, provided prompt and detailed feedback, etc.). They also indicated less frequently exhibiting behaviors associated with high quality student-faculty interactions such as talking about career plans with faculty, discussing academic performance with faculty, and discussing course material with faculty outside class. Lower satisfaction with instruction and student-faculty interaction sets the tone for learning; first-year and senior-level students reported lower levels of engagement in tasks associated with higher-order learning, reflective and integrative learning, and quantitative reasoning.

Instructional Strategy.

The instructional material of the program draws on current evidence-based pedagogy and course design to teach faculty and staff how to create and/or reinvent STEM courses to be learner-focused and engaging. The aims are to increase student learning, improve student outcomes in gateway (high-enrollment, first-year, a high rate of D, F, and W grades) STEM courses, and to form mutually supportive groups of faculty interested in teaching and learning. Each fall, 30+ instructional faculty and staff form a cohort that participates in workshops and ongoing faculty learning communities (FLCs) over two years. Each cohort includes 10 full days of workshops spread over 1.5 years, as well as smaller FLCs that meet every three weeks during the academic year.

Research Design.

Behavior Change in STEM Instruction and Learning. Informing our research into the relationships among faculty and student attitudes, pedagogical approach, and pedagogical intervention is the Theory of Planned Behavior (TPB) [6], [7]. TPB posits that behavior is a rational, thoughtful choice that can be predicted by a relatively small number of individual beliefs [8]. For example, TPB can be used to make a prediction about whether an educator will choose to change his or her pedagogy from passive to active learning techniques based on the educator's beliefs about active learning strategies. Gateways-ND applies the TPB to two elements of the education process to change adoption rates of evidence-based, high-impact practices, and thereby, improve student outcomes in the STEM education classroom. The first application of the theory is directed toward changing faculty behavior and the second will be toward changing student behavior inside and outside the classroom environment.

Teaching-Related Data Collection. To evaluate teacher pedagogical change, observers from the FLCs and the grant team use the Classroom Observation Protocol for Undergraduate STEM (COPUS) instrument to note teacher classroom techniques and student classroom activities with

a particular view to active and engaged teaching and learning. Teachers are observed 1-2 times per semester during their two-year professional development period.

Results to Date.

Faculty Participation. Gateways-ND has been successfully running for 2.5 years. To date, 103 faculty have been a part of three cohorts. In total, 56% of the 103 participating faculty are women, and the 83 STEM participants (52% women) come from a wide variety of STEM fields, including the biological, pharmaceutical, geological, plant, animal, and computer sciences; industrial, electrical, civil and environmental, and mechanical engineering; as well as psychology, coatings and materials, physics, and math. The 20 non-STEM participants, which were funded through additional sources within the Office of the Provost, are participating in the program to extend active learning ideologies past STEM disciplines within the institution and to create diversity within the cohorts.

Teaching-Related Data Collection. Teaching-related data has been collected using the COPUS instrument and student attitudinal data from separate surveys. Participant journals show the positive impact of the FLCs and other project collaborations have on active learning-based teaching, including assessment. Workshops examining learner analytics (i.e., using early student course performance to identify and intervene with students) resulted in suggested courses of action including early alert messaging, further integrating existing student support services, and framing interventions to increase student belonging. Classes are also becoming more active for students. Instructors are showing a 20% year-over-year reduction (M = 67.61%, S.D. = 23.8% vs. M = 56.32%, S.D. = 21.6% percent of coding intervals) in lecturing, as captured by the COPUS for the first cohort [$t(27) = -2.30$, $p = .03$] and a three-fold year-over-year increase (M = 5.2%, S.D. = 9.4% vs. M = 16.1%, SD = 21.6% percent of coding intervals) in the amount of time instructors use group work in the classroom [$t(27) = 2.52$, $p = .02$].

Discussion.

Gateways-ND will continue for three more years (until 2020), at which time roughly 163 faculty will have completed the two-year faculty development program at North Dakota State University, which will directly impact the educational experiences of approximately 30,000 students. Research questions posed by Gateways-ND is allowing us to discover how faculty attitudes, norms, and beliefs influence the implementation of active teaching and learning strategies. The same is true about student attitudes, norms, beliefs, and student-faculty interactions. Cultural transformation at the institutional level will ultimately influence NDSU graduates as they tackle economic and social questions that impact us on a daily basis in North Dakota and beyond, including environmental concerns, health care, and agriculture.

References.

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