Integrative Approach For A Transformative Freshman-Level STEM Curriculum

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ABSTRACT

In 2014 Wesley College adopted a unified undergraduate program of evidence-based high-impact teaching practices. Through foundation and federal and state grant support, the college completely revised its academic core curriculum and strengthened its academic support structures by including a comprehensive early alert system for at-risk students. In this core, science, technology, engineering, and mathematics (STEM) faculty developed fresh manifestations of integrated concept-based introductory courses and revised upper-division STEM courses around student-centered learning. STEM majors can participate in specifically designed paid undergraduate research experiences in directed research elective courses. Such a college-wide multi-tiered approach results in institutional cultural change.

Keywords: Wesley College; STEM; NSF S-STEM; Cannon Scholar Program; Student Retention; Student Success; NSF EPSCoR; DE-EPSCoR; NIH NIGMS (IDeA) INBRE; DE-INBRE

INTRODUCTION

A Georgetown University study (Carnevale, Cheah, & Hanson, 2015) analyzed the U.S. wages for 137 college majors and showed significantly greater demand for careers in science, technology, engineering, and mathematics (STEM) that commanded higher wages. For decades, the United States considered STEM disciplines to be principal drivers of long-term economic growth (Noble, 1979). Today, technology, globalization, and information are transforming knowledge practices, making integrative abilities even more necessary and valuable (Fink, 2013). Thus the boundaries of academic and scientific disciplines are blurring and falling away, and new disciplines are emerging at the borders of the old ones (Kalantzis & Cope, 2012).

The goal of liberal education is to empower students with an experience that enhances their capacity to comprehend problems and find solutions using fundamental ethical judgments (Bentley, 2012; Huber & Hutchings, 2004; Kolb, 2014). Integrative learning is central to successful scholarship at all levels, as it enhances discovery and creativity and makes it possible to apply knowledge to real-world problems (Savery, 2015). Not only will building students' integrative thinking skills help students succeed, but a more integrative approach to learning has the potential to improve retention in STEM majors as well (Fink, 2013). Research suggests that for many students, low retention in STEM has little to do with student performance or attitude; rather, it is more closely linked to a loss of interest in science, perceptions of poor teaching, insufficient information about how courses and requirements connect to careers, and perceptions that STEM disciplines are unpleasantly competitive (Drew, 2015). Revising courses, curricula, and support services to foster integrative learning gives students both the enthusiasm and the cognitive tools to persist and succeed in challenging STEM majors (Brewer & Smith, 2011; Brophy, 2013; D'Souza, Kroen, Stephens, & Kashmar, 2015; Gale, 2013).

Activities such as first- and second-year seminars, common intellectual experiences, learning communities, undergraduate research, early alert systems, and peer and faculty mentoring have significant impacts on student success, particularly for those from underrepresented groups (Burkum, Habley, McClanahan, & Valigga, 2010; Chang, Sharkness, Hurtado, & Newman, 2014; D'Souza, 2012; D'Souza, Barile, & Givens, 2015; D'Souza, Curran, Olsen, Nwogbaga, & Stotts, 2015; D'Souza, Curran, & Stotts, 2014; D'Souza, Dwyer, Allison, Miller, & Drohan, 2011; D'Souza, Kashmar, et al., 2015; D'Souza, Kroen, Stephens, & Kashmar, 2015; D'Souza, Walls, Rojas, Everett, & Wentzien, 2015; D'Souza & Wang, 2012; Edwards, 2015; Gale, 2013; Habley & McClanahan, 2010; Kuh, 2008; Nerd Scholar, 2013). Also, coordinated, comprehensive intervention programs have been found to be very effective (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013; Nerd Scholar, 2013; Tinto, 2012).

WESLEY COLLEGE

Wesley College (Wesley) is a residential, minority-serving, baccalaureate, liberal arts institution in Dover, Delaware. It serves a significant number of students from populations that traditionally have had limited access to higher education. The fall 2014 undergraduate head count was 1,528 students. Females comprised 54.1% of the total population, and 39.9% were Caucasian.

THE OLD COLLEGE CORE CURRICULUM

Formulated in the early 1990s, the college's core curriculum had requirements (45-48 credit hours) developed under five core threads and included a menu of classes from mathematics, humanities, laboratory and social sciences, religion, and physical education:

- Communicating in the World →12 credit hours
  - to include College Writing and Literature for Composition
- Analysis → 6–8 credit hours
  - to include one mathematics course and one applied analysis course (could be in mathematics, music, philosophy, or psychology)
- Scientific Literacy → 7–8 credit hours
  - to include at least one physical or natural laboratory science course
- The Human Experience → 11 credit hours
  - to include one religion course
  - to include one literature course at the 200 level or higher
  - to include two credit hours of physical education
  - to include one elective in art appreciation, music appreciation, literature, media aesthetics, psychology, philosophy, or religion
- Global Society and Its Culture → 9 credit hours
  - to include three electives in economics, sociology, history, or political science

In this "old" core, non-STEM majors needed a minimum of 7 credit hours in science and at least 3 credit hours in mathematics. A 4-credit-hour lab-science component involved the content-heavy introductory courses in biology, chemistry, physics, and basic anatomy and physiology. The scientific process was addressed in the lab component of an introductory science. A second 3-credit-hour "contextual science course" delved into science topics more intensively.

For non-STEM majors, the mathematics competency core course was Math Concepts and Operations II (MA108). It included the fact-based teaching format and covered a review of basic mathematical operations and topics in algebra, consumer mathematics, measurement and coordinate geometry, probability, and statistics. Typically, non-STEM and non-business students opted for a listed music, philosophy, or psychology course to fulfill their applied analysis requirement.

All of these "standard" science and mathematics courses used a prescribed textbook and the classes often included both STEM and non-STEM majors. The instructional styles were lecture based, theoretical, and terminology heavy. As a result, the courses were challenging.

Wesley is a small college with only 15 full-time STEM faculty who teach all of the biology, chemistry, environmental science, physics. and mathematics courses, including all associated labs. Hence the effective class size and the number of STEM class offerings are limited. Prior to 2014, it was common for some nonmajors to put off their core STEM requirements until their junior or senior year. This generated logistical problems. Upperclassmen had limited course options and were forced to register for uninspiring and uninteresting standard STEM courses. Dropping or failing a STEM class resulted in the postponement of graduation. Hence, delaying the fulfillment of STEM core requirements not only resulted in poor grades and low morale, but also cut off any opportunity for recruiting new majors or minors into the STEM fields. The faculty realized that this old core was an ineffective way of meeting STEM global leadership goals. To address such problems, the college faculty devised a new core that required students to meet their STEM requirements early in their academic career.

FEDERAL AND STATE ROLE IN HIGH-IMPACT MENTORING PROGRAMS

In states with historically low cumulative success rates for National Science Foundation (NSF) and National Institutes of Health (NIH) grant funding, NSF and NIH created large peer-reviewed consortia programs to establish, stimulate, and strengthen the STEM higher education and research infrastructure. The NSF Experimental Program to Stimulate Competitive Research (EPSCoR) and the NIH Institutional Development Awards (IDeA) are two such federal programs. At the NIH, the IDeA research capacity–building program is administered through the National Institute of General Medical Sciences (NIGMS). The NIH-NIGMS IDeA Networks of Biomedical Research (INBRE) program and the NSF-EPSCoR program are specifically designed to advance a state's competitive research capacity. To enhance the country's STEM talent pipeline, both programs necessitate that the consortia engage all statewide primarily undergraduate institutions (PUIs).

In these historically noncompetitive states, the PUIs typically serve a greater than typical proportion of students from disadvantaged communities. One goal of the EPSCoR and INBRE programs is to improve the trajectory of success for the participating PUI students by developing proficiencies in STEM skills and experience, so that they can envision and thrive in the research enterprise in industry and in postgraduate pathways.

The NSF Scholarships in STEM (S-STEM) programs are designed to "positively affect the retention, success, and graduation of academically talented students with demonstrated financial need" (National Science Foundation, 2015). Many universities and colleges have benefited from such federally established policies (Kuenzi, 2008) and have significantly improved access to STEM education for economically disadvantaged students through such S-STEM programs.

In Delaware (DE), the University of Delaware (UD) serves as the lead institution on the NSF-EPSCoR (DE-EPSCoR) and the NIH-NIGMS INBRE (DE-INBRE) programs. Wesley College is one of four higher education partners in these programs. Furthermore, the Delaware Economic Development Office (DEDO) incentivizes the DE-EPSCoR and DE-INBRE programs by providing a programmatic state match.

At Wesley College, the federal (DE-EPSCoR, DE-INBRE, and S-STEM) and state programs are collaborative efforts between STEM faculty and administrators. These programs are designed around the best practice of multi-tiered mentoring and are committed to evidence-based approaches that support and retain students. Wesley's DE-EPSCoR and DE-INBRE programs play an important role in addressing gaps in the regional and national approach to strengthening the STEM workforce pipeline by providing undergraduates with increased opportunities to delve into practical interdisciplinary research projects in a nationally recognized directed research program, in Scholars Day projects, and during senior capstone research projects (D'Souza, 2012; D'Souza, Barile, & Givens, 2015; D'Souza, Curran, Olsen, Nwogbaga, & Stotts, 2015; D'Souza, Curran, & Stotts, 2014; D'Souza, Dwyer, Allison, Miller, & Drohan, 2011; D'Souza, Kashmar, et al., 2015; D'Souza, Kroen, Stephens, & Kashmar, 2015; D'Souza, Walls, Rojas, Everett, & Wentzien, 2015; D'Souza & Wang, 2012; Edwards, 2015; Nerd Scholar, 2013). Wesley undergraduate research projects have also raised a number of key issues of concern that affect public health and economic development within Delaware (D'Souza, Barile, & Givens, 2015; D'Souza, Kashmar, et al., 2015; D'Souza, Walls, Rojas, Everett, & Wentzien, 2015).

The Cannon Scholar program (NSF S-STEM) is a renewable scholarship program that is designed to recruit and retain academically astute, diverse, and financially challenged students who thrive in robust Wesley STEM programs (D'Souza, Curran, Olsen, Nwogbaga, & Stotts, 2015; Edwards, 2015). This dynamic program offers a comprehensive package of student outreach and support consisting of an active living-learning community (LLC), academic mentoring, and career advancement and job placement counseling. Each scholarship cohort is made up of both freshmen and returning students. We further support these scholars by helping them move into paying positions on campus and encouraging their participation in our mature undergraduate research programs. This project helps to ensure that the scholars will graduate with B.S. degrees and then either continue on to graduate school or enter the science or technical workforce.

CULTIVATING AN INTEGRATIVE COLLEGE CORE CURRICULM

In AY 2011, the Jessie Ball DuPont Foundation funded an extensive independent external evaluation of the college's goals, aspirations, and strengths (D'Souza, Kroen, Stephens, & Kashmar, 2015). This self-study included more than 150 interviews, analyses of institutional data, surveys of current and former students, and an assessment of student services. The assessment classified low financial stability as a key destabilizing factor for the majority of undergraduates. The study also highlighted an urgent need to reevaluate and revamp the inventory of academic and nonacademic functions to serve the college's educational mission.

For AY 2014 undergraduates, the median family adjusted gross income (AGI) was $32,680. The AY 2013 freshman-to-sophomore retention rate was 52%, and for the 2004–2008 freshman cohorts, the 6-year graduation rate was 28%.

Among entering freshmen, approximately 20% of Wesley students enter undeclared, nearly twice as many as those who choose STEM majors. On average, the Jessie Ball DuPont study found that more than 80% of freshmen who enter undeclared did not return for the sophomore year. For the AY 2011 study, there was no significant difference in the average reported high school grade point averages (GPAs) and SAT scores as compared to overall average entering freshmen (2.8 and 1240 for the undeclared students as compared to 2.7 and 1265 for freshmen as a whole). Therefore, on these bases, the undeclared students were equally qualified.

The combined average SAT score of all incoming AY 2014 freshmen was 1294 out of a possible 2400. The College Board uses a benchmark combined score of 1550 or higher to gauge preparedness in college-level reading, writing, and math (Mulhere, 2015).

The SAT scores of the AY 2014 entering class are in alignment with the 2011–2012 Jessie Ball DuPont study, (D'Souza, Kroen, Stephens, & Kashmar, 2015) which identified the top three reasons for which students did not return as:

1. lack of finances (40%),
2. lack of academic ability (20%), and
3. lack of academic preparation (16%).

An important consequence of the comprehensive college evaluation was the complete revision of the college's core curriculum (Gibson, Dwyer, & Barnhardt, 2015), which began in AY 2012. Wesley implemented best practices targeted at increased recruitment of all students, improved retention and graduation of students through curriculum reform, and an intensive focus on academic support (D'Souza, Kroen, Stephens, & Kashmar, 2015).

Through DE-EPSCoR and DE-INBRE support, a faculty core-development team was assembled to participate in the Association of American Colleges and Universities' (AAC&U) Institute for General Education and Assessment (Gibson, Dwyer, & Barnhardt, 2015). The institute focused on building a campus learning culture through an intentional, well-defined, and meaningfully assessed core curriculum. During the institute, the team explored core curriculum models, processes of redesign and implementation, clarification and integration of learning outcomes, and strategies for assessment. The team, serving as facilitators of the campus process, brought back models, themes, and information to help the whole faculty develop a new and enhanced set of Core Curriculum Outcomes. To develop a consensus, the core-development team initiated several lively formal and informal faculty discussions. At a very early stage, all college faculty agreed to incorporate high-impact active-learning instructional strategies and undergraduate research in the revised core.

In AY 2012, the college faculty approved the learning outcomes listed below:

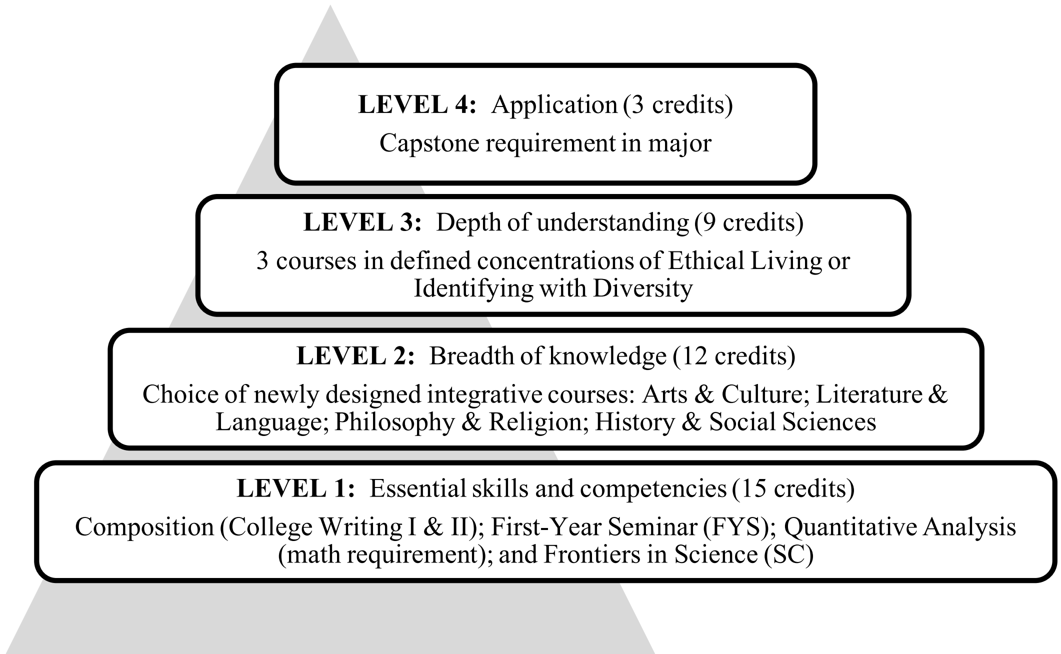
- Communicate
    - Read with understanding
    - Speak with clarity
    - Write with insight
    - Listen thoughtfully
- Investigate, inquire, and evaluate
- Practice professionalism and ethical behavior
- Integrate the liberating arts
    - Understand discipline-specific content and aesthetics
    - Explain intersections among disciplines
    - Integrate knowledge and apply to current trends
- Understand multiple perspectives
- Value ongoing intellectual curiosity
- Balance personal goals with community needs

Retention strategies include the adoption of an enhanced academic early-warning system (D'Souza, Kroen, Stephens, & Kashmar, 2015), reform of the college's core curriculum organized around integrative learning (Gibson, Dwyer, & Barnhardt, 2015), college-wide adoption of pedagogical best practices, including learning communities, problem-based learning, peer-led team learning, and inverted (flipped) classes (D'Souza, Curran, Olsen, Nwogbaga, & Stotts, 2015).

The faculty revised the core (see Figure 1) to meet the learning outcomes. In collaboration with the Department of Student Success and Retention, the faculty implemented three major initiatives:

1. Increase academic support for freshmen by implementing a comprehensive first-year program.
    a. Freshman living-learning communities (LLCs), including a Cannon Scholar (NSF S-STEM) program for STEM majors
    b. Interdisciplinary First-Year Seminar (FY100)—a topical 3-credit integrative and inquiry-based learning class that includes an introduction to undergraduate research
    c. A required quantitative reasoning math course (MA180). This project-based course includes problem solving, measurement and dimensional analysis, consumer mathematics, probability, and statistics.
    d. A Frontiers of Science project-based course (SC100). This course introduces all non-STEM majors to the intricate uses of empirical and logical reasoning in the systematic investigations in science.
    e. Seminars for Academic Success
    f. A study strategies course for students taking developmental classes
2. Strengthen academic programs to improve student outcomes
    a. Revise core curriculum courses to foster integrative learning
    b. Revise gatekeeper and upper-division STEM classes to implement student-centered learning
    c. Encourage student participation in a research-based enrichment program, beginning in the freshman year and culminating in a poster presentation
    d. Develop assessment rubrics for each learning outcome
    e. Institute learning communities linking STEM and non-STEM classes
3. Strengthen support structures for at-risk students
    a. Implement an early alert system to identify at-risk students and coordinate support services, as supported by Pharos software (Pharos Resources, 2015). Cannon Scholars are required to meet a minimum tutoring requirement of 5 hours/week.
    b. Create an executive director of Student Success & Retention position.

Figure 1. Progressive AY 2014 Wesley College core curriculum.



Through DE-EPSCoR and DE-INBRE support, the college held 3-day faculty workshops (i.e., Faculty Institutes) to help its STEM and other faculty revise their courses around the concept of student-centered teaching—learning methods to shift the focus of activity from the teacher to the students. These methods include active learning, in which students solve problems, discuss, explain, debate, or brainstorm during class; cooperative learning in which students work in teams on problems and projects; and inductive methods such as inquiry-based learning, case-based learning, problem-based learning, project-based learning, discovery learning, and just-in-time teaching. The Faculty Institutes helped all faculty explore different models of student-centered teaching.

All of the new core courses are designed to provide students with the basic skills needed for progression through successive, more complex topics, culminating in a senior capstone project. Foundation-level freshman math and science courses are now specifically designed for student success. As a result, the college altered the student apprehension about STEM courses for nonmajors, which are now focused on integrative exercises that develop qualitative and quantitative reasoning skills, rather than solely on content. Furthermore, all students are required to develop research projects and assess peer-reviewed literature. Core-course material and experimental item expenses for all STEM-related courses are sponsored through the DE-EPSCoR and DE-INBRE programs. Pertinent costs associated with the core liberal arts courses are supported through the academic component of the college's facilities and administrative return. A trial of the Wesley College progressive core model (Figure 1) began in AY 2013, and in AY 2014 this core was fully implemented. Details of the core courses are available in the college catalog.

Freshman Learning Communities: To increase academic support and engagement for freshmen, we used a learning community approach based on the "Confluence Model" developed at the College of San Mateo (Gale, 2013). A confluence is a place where two streams or rivers come together and combine. In a confluence learning community model, two separate courses are periodically brought together to explore a common theme. The courses are in different disciplines and enroll different groups of students who meet periodically to share perspectives and work on a common assignment. The advantage of this approach is that it fosters integrative learning by helping students see the connections between disciplines. With the confluence model, most freshmen will not even know that they are in a learning community until they start attending classes. A good example is one that links freshman composition and freshman math.

Each pair of classes is a learning community and is organized around a common theme. In the mathematics classes, students solve problems and analyze data related to the theme; students in the English classes read and write essays related to the theme. Periodically the two classes meet jointly for a forum. At the forum, the students hear instructors for both classes and/or guest speakers give 10–15 minute "TED" talks related to the theme. The students in both classes prepare for each forum by reading a common text. After each forum, the students write an essay answering 3–4 questions, including a mathematics problem. As a capstone for the class, students complete an assignment that integrates the material and discussion from the forums. For each assignment, links are often provided to Khan Academy (khanacademy.org) videos that teach the relevant math to students who are not in the math class or need to brush up their skills in order to solve the problem.

The benefit of this approach for the students is that it increases their engagement with the math and composition required courses, which students typically see as barriers to the courses that will prepare them for their careers. Ideally, the learning community gives them a greater appreciation for how math, reading, and writing are all important for solving real-world problems and communicating those solutions. It also benefits the students as faculty teaching two of the crucial freshman classes are working together to support student learning, and it fosters the concept that disparate disciplines are related and can be integrated. A major benefit for the STEM faculty is a closer relationship formed with other faculty across the college.

Cannon Scholar Program: In AY 2014 the STEM faculty developed this NSF S-STEM supported program. To receive an annual renewable scholarship, the scholars must be U.S. citizens or permanent residents, demonstrate financial need, maintain an annual cumulative GPA of 2.7, and remain a STEM major. The rationale for the Cannon Scholar program design is that underrepresented STEM students are more likely to be retained in their majors if they are supported financially, reducing their need to work more than 20 hours per week, and supported academically within an LLC with mentoring by faculty advisors and peer mentors (Chang, Sharkness, Hurtado, & Newman, 2014; Drew, 2015; Kuh, 2008; Perez, Cromley, & Kaplan, 2014; Tinto, 2012).

The Cannon Scholar program intertwines academics, residential life, and student services. This community is supervised by the S-STEM principal investigator (PI), STEM faculty advisors, the executive director of student success and retention, the director of the honors program, and the director of residence life. The directors and STEM faculty advisors ensure that the Cannon Scholars attend class, participate in study groups, take advantage of existing in-residence tutoring opportunities, and visit faculty during office hours. The STEM faculty members also work with the Offices of Academic Support, Residence Life, and Career Services to sponsor periodic guest lectures and special events designed to enhance the Cannon Scholar program experience.

To ensure the program's effectiveness, satisfaction surveys are administered at several points during the program. The results of these surveys are presented to the advisory committee (directors and STEM faculty advisors) for discussion and inform them of needed improvements to program features that are ineffective or counterproductive to helping students succeed.

Mentoring Groups: As freshmen, Cannon Scholars enroll in a weekly 1-hour seminar, Scientific Process. The Scientific Process class includes sessions on time management, financial planning, and an introduction to research opportunities on campus. In the second half of the course scholars design and conduct their first experiment under the guidance of their instructor. The scholars take several common core curriculum humanities classes (see Figure 1) together where the skills of inquiry and communication are emphasized. A number of these courses are writing-intensive and create opportunities where students can work in collaborative groups. In addition to involvement in their LLC, the Cannon Scholars meet regularly with their STEM advisors, who chart the various successes and concerns of the scholars.

Social Events: STEM faculty advisors support student clubs and national honor societies. They invite scholars to social events and regularly scheduled activities to help them feel connected with the community of scholars. Research on college student retention has shown that increased social identification on campus increases student retention (Kuh, 2008; Tinto, 2012). Scholars, mentors, and other project staff also meet at the end of each semester to celebrate the accomplishments of the scholars and debrief the semester. A Facebook page for the Cannon Scholars program is set up with scholars, mentors, and other project personnel as "friends."

Workshops and Seminars: In partnership with the DE-EPSCoR and DE-INBRE programs, the Cannon Scholar program hosts both internal and external experts to conduct science seminars and workshops on academic and career success, GRE preparation, and opportunities at national labs, as well as financial planning, résumé writing, and other life success topics. Scholars who participate in research are required to attend an annual day-long Research Ethics Workshop to receive training in the ethical and responsible ways to conduct research. The S-STEM team draws on our higher education partner contacts to find exciting scientists and mathematicians, as well as good speakers and role models, to lead the seminars and workshops.

Academic Leadership Training: In the second semester of the program, Cannon Scholars are given opportunities to participate in our sponsored mentored directed research program, participate in summer internship and cooperative work experience opportunities, travel to research conferences, and visit national labs and regional scientific institutions and industries. They are also encouraged to give back by serving as peer mentors for incoming freshmen, and as peer tutors or study-group leaders in mathematics and science courses. This experience provides them additional financial support while allowing them to act as academic leaders on campus and give back to younger peers (Kuh, 2008; Tinto, 2012).

In Year 1, 27 STEM majors participated in the Cannon Scholar program. The scholars get to know each other at the start of the academic year and are from the varying STEM levels, so collaborations increase exponentially and students from the upper levels are able to peer-tutor those in the lower levels. The first-to-second-year Cannon Scholar retention rate was 96%, and even though participation in undergraduate research is not a requirement, all scholars participated in our mentored research programs.

Interdisciplinary Freshman Seminars (FY100): This 3-credit interdisciplinary seminar is required for all incoming freshmen. The classes of 15–20 students focus on learning outcomes related to communication and inquiry. All faculty, including STEM faculty, teach FY100 courses. Courses are designed around a topic of the faculty member's choice and passion, and include an introduction to research and inquiry exercise in the form of team-based projects. Students are encouraged to be active learners, asking questions and then looking for the answers.

The Office of Academic Advising initially groups freshmen into the courses roughly by major, so, for example, STEM majors will be in the same FY100 sections, and undeclared students will be in the same sections. However, any undergraduate also has a choice of picking an FY100 theme that piques their interest. The hope is that when the students are deliberately choosing their topic—as opposed to merely fulfilling a requirement—they will be more engaged.

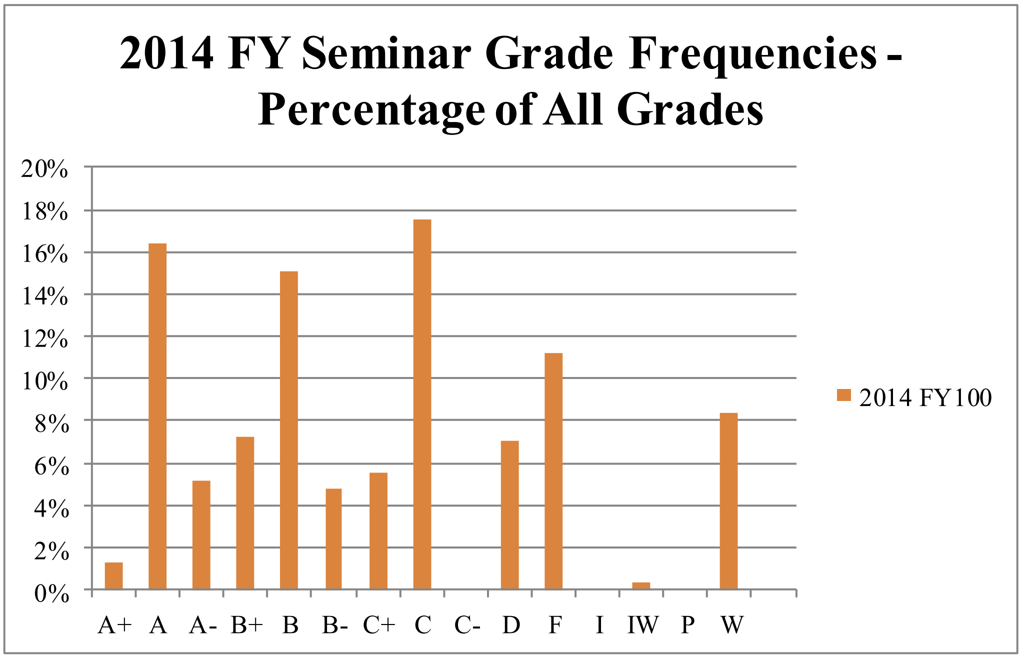
The lack of a home in a department means that undeclared students have less contact with faculty and advanced peers who can act as mentors, resulting in reduced engagement with the college. Providing a proactive nudge toward STEM majors through better understanding of STEM curricula and career opportunities may get such students to move into STEM majors, which will help retain them at the college. In addition, the FY100 program encourages intellectual identification with the college by involving students in integrative and inquiry-based learning. The FY100 program involves all freshmen. However, we expect the science-based themes of the major FY100 elements to pull more students into STEM majors while resonating strongly with students who are already STEM majors. Memorable course titles, such as Sacred Geometry: Math/Meta Journey; Is the World Flat?; Mysteries of Culture; Water Systems of the Coastal Plain; Sacred Stories: Myth & Scripture; Honey of a Hobby; and Mathematics of Gambling, were assigned to pique student interest.

Assignments include presentations, debates, and critiquing classmates' term paper assignments. Additionally, all courses include an inquiry and analysis component. For example, students enrolled in "Water Systems of the Coastal Plain" investigated the water of Silver Lake, DE. "Honey" students used randomized surveys to test faculty versus student preferences regarding the characteristics of honey and how they were marketed. Although all STEM seminars have a science-related theme, faculty design freshman seminars according to their own disciplinary interests and allow students to connect their major with the principles and practice of science.

The FY100 courses allow for opportunities where students can maximize their education experiences. The courses are designed specifically to introduce students to general research and inquiry practices.

Figure 2 shows student outcomes in all sections of FY100 for AY2014. Potential reasons for the observed 11% failure or 8% withdrawal rate in AY 2014 (see Figure 2) could be the mandatory participation in extracurricular course-related or in-class activities, failing to comprehend the class-attendance policies, and/or the reading comprehension and writing skills requirements. Additionally, students registering late have fewer or no options, and may be enrolled in a course about a topic that fails to capture their imagination.

Figure 2. Percentage (as a total of all grades) grade comparison for the AY 2014 FY100 core courses. Grades: I = Incomplete; IW = Involuntary Withdrawal; P = Passing; W = Withdrawal.



Quantitative Reasoning Math Core Course (MA180): As a department, the six full-time mathematics faculty initially preferred a two-course core sequence, with one foundational course serving as a prerequisite for the main core course. The college faculty as a whole insisted on a single math course requirement for all majors that would better serve the student community.

To honor this request, over a period of 18 months the Department of Mathematics developed MA180 with goals and outcomes that satisfied all of the project-based experiential learning threads within the redesigned college core. However, through majority faculty vote, no prerequisites (except for a minimum requirement of a score ≥450 on the math SAT) were assigned, even though a large proportion of entering Wesley freshmen have challenging mathematics backgrounds. For curriculum design the mathematics department reached out to various related partner disciplines (i.e., science, nursing, business, and education) to determine specific quantitative and analytical skill set expectations that were deemed essential for students to succeed. A prior Wesley study (D'Souza, Kroen, Stephens, & Kashmar, 2015) demonstrated that comprehension of statistical and mathematical concepts was an important predictor of student success in the introductory physical and natural science courses.

The quantitative reasoning core course emphasizes problem solving, consumer mathematics (e.g., percent, applied percent, interest), metric system and dimensional analysis, probability, and applied statistics (i.e., descriptive and inferential statistics covering topics such as regression and correlation analysis).

For successful completion of the course, the Department of Mathematics developed the following set of expectations:

- Problem-Solving Techniques
  Apply the following problem-solving techniques:
  - Restate the problem in one's own words
  - Choose a strategy to solve the problem
  - Execute the strategy
  - Check the solution
  - Translate findings in the context of the problem and into a format appropriate for the intended audience
- The Metric System and Dimensional Analysis
  - Identify and convert units of measurement within the metric system
  - Convert English units of measurement (non-metric) to and from metric units
  - Engage in real-life applications (such as velocity and dosage computations)
- Consumer Mathematics
  - Compute amortized loan payments, and simple and compound interest costs
  - Make informed consumer decisions associated with car loans, mortgages, student loans, and credit card loans
- Descriptive and Inferential Statistics
  - Organize and describe data in various statistical formats, including frequency distributions, histograms, and other statistical graphs
  - Compute and compare various measures of central tendency and measures of dispersion, as well as measures of position such as percentiles
  - Solve general applied problems involving interpretation and analysis of statistical data and communicate or present the findings in a format appropriate for the intended audience
  - Use correlation and regression to investigate and interpret the relationship between two quantities
- Probability
  - Determine and interpret probabilities that involve fundamental counting principles
  - Determine and interpret probabilities that involve permutations and combinations
  - Determine and interpret probabilities that involve probability rules of addition, multiplication, complement, conditional probability, and mathematical expectation

The college faculty agreed that a substitution procedure is appropriate for departments that require advanced levels of mathematics within their programs. For example, the Department of Accounting requires both Statistics and Calculus I, so these majors are allowed to use these two courses in place of the core mathematics course. Similar substitutions are approved for STEM and business majors.

A project-based research component is a course requirement in MA180. The projects are designed to encourage students to collaborate and complete research projects outside class. Mathematics faculty developed appropriate project topics that are tied to the MA180 course content. For example, one project dealt with the mathematical analysis of nutrition labels for the sugar content in breakfast cereals. This project served as a follow-up study to a prior Wesley body mass index (BMI) article (D'Souza, Walls, Rojas, Everett, & Wentzien, 2015). Other class projects have analyzed consumer loan qualification factors based on payment schedules for student loans and mortgages.

Group-designed, project-based research experiences in mathematics inspire student-learning, encourage self-affirmation, and deemphasize any cultural and gender stereotype threat (Bentley, 2012; Brophy, 2013). Such projects, in tandem with case studies in the MA180 course design, result in serious engagement with the subject matter and make students learn to appreciate the relevance of the seemingly abstract core concepts in mathematics to their individual non-STEM major fields.

Due to the special nature of the course, the choice of a suitable textbook was a major hurdle. Initially, the department attempted to write the text. One summer, three math faculty members met weekly to work on the book.

At the end of the summer, much progress was made, but it became clear that this attempt, due to lack of time, was not in the department's best interest. Consequently, the department adopted a Pearson text, Blitzer's *Thinking Mathematically* (2015), which is supplemented as needed with instructor resources.

All of the mathematics faculty teaching MA180 collectively design and administer the exact same tests and the same end-of-semester final exam. The overall grade is computed as follows:

- Homework/quizzes = 10%
- Projects (undergraduate research) = 10%
- Tests (4 tests at 15% each) = 60%
- Final exam = 20%

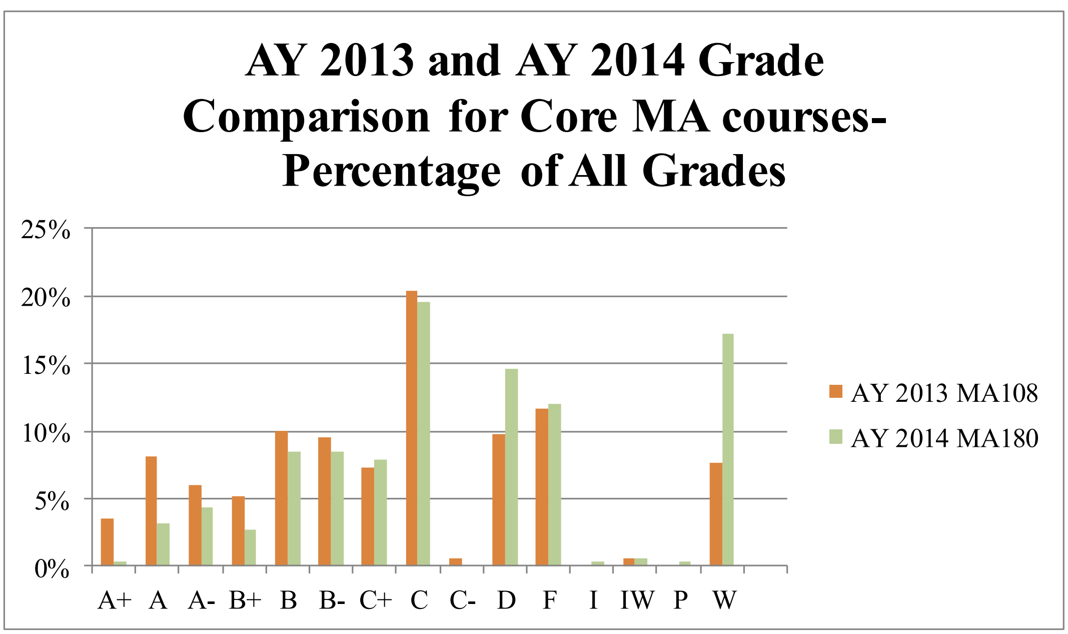
TOTAL = 100%

In all MA180 sections, course expectations are clearly articulated on the course syllabi, and every problem on a test and on the final exam has a 4-point value. This helps with course uniformity and assessment.

A graphic analysis of student performances in the MA180 core course as compared to the prior year's old core math (MA108) requirement is shown in Figure 3. In MA180 and MA108, earned student grades followed a similar distribution pattern. The MA180 course is a more intense math core course that includes a written research project and does not have a review of basic algebraic skills. This increased degree of difficulty is reflected in the AY 2014 student grades, with fewer students earning As (7%) and Bs (19%) and a greater percentage withdrawing (17%) or earning Ds (15%) and Fs (12%).

Interestingly, the MA180 withdrawal rate of 17% corresponds to the incoming freshman AY 2014 average SAT score of 1294, which is exactly 17% below the benchmark 1550 average SAT score proposed by the College Board for the determination of student aptitude for college readiness (Mulhere, 2015).

Figure 3. Percentage (as a total of all grades) grade comparison for the MA108 and MA180 courses in the old and new cores, respectively. Grades: I = Incomplete; IW = Involuntary Withdrawal; P = Passing; W = Withdrawal.



Frontiers of Science (SC100): This 3-credit core course is restricted to freshman or sophomore non-STEM majors. A passing grade in MA180 is a course prerequisite. The prerequisite requirement was implemented over the objections of non-STEM faculty because prior research proved that Wesley students who successfully passed college-level math have greater success in introductory biology and chemistry (D'Souza, Kroen, Stephens, & Kashmar, 2015).

The scientific course content in the SC100 course varies with the expertise and interest of the instructor, but includes investigations and experimental design and development. All SC100 courses promote better principles of learning that cultivate a broader set of 21st-century skills and dispositions that are beyond academic core content knowledge and are essential in today's digital world (Drew, 2015). In Year 1, course offerings on the registration schedule have included CSI-Wesley, Emerging Infectious Diseases, Island Biogeography, Diabetes, Rivers Shape Our World, Climate Change, Insects in Your Life, and Cancer: Cells Out of Control.

As the course offerings are so very diverse and are scaled for nonmajor audiences, publisher-based textbooks are unavailable. Student readings include articles from peer-reviewed journals, online texts, case studies, and media-based popular science articles. Individual faculty members determine the assessment of the student performance, including the assignment of course grades.

Faculty have greater flexibility with the instructional approach and include discussions, field trips, and active learning projects. This connects students early in their college career to science topics of interest and changes their perceptions of scientific literacy. It also inspires undeclared students to consider a career in science or encourages nonmajors to declare a science field as a minor (Burkum, Habley, McClanahan, & Valigga, 2010; Chang, Sharkness, Hurtado, & Newman, 2014; Fink, 2013; Gale, 2013).

The science faculty expect four student outcomes for all of the SC100 course offerings:

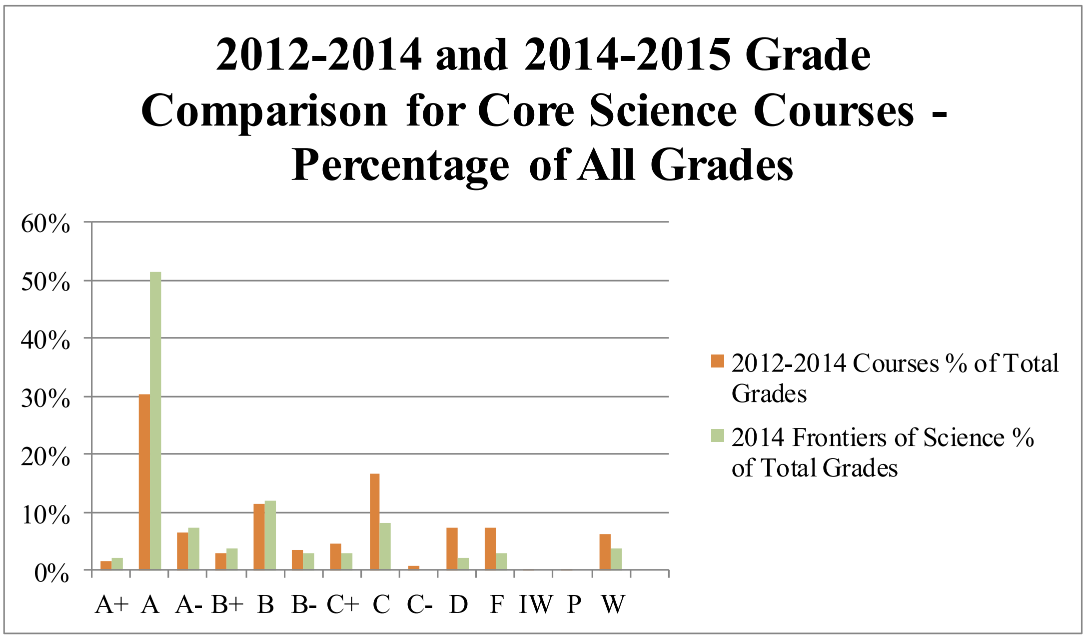
- Use of the scientific method to
  - formulate questions to develop a problem statement
  - state a hypothesis that refers to the problem statement
  - conduct a literature review
  - design an appropriate method to test the hypothesis
  - collect data and analyze it using appropriate statistical methods
  - select an appropriate method of presenting the data
  - draw conclusions based on analysis of the data collected
  - discuss the relevance of the data in light of the hypothesis and the broader issue
- Ability to identify appropriate units of measurement relevant to the context of the course
- Ability to distinguish between evidence-based and non-evidence-based ideas
- Ability to identify appropriate and inappropriate applications of knowledge to current societal issues

Science majors and majors (i.e. nursing, education, and kinesiology) that require multiple content-heavy science courses are exempt from the Frontiers of Science (SC100) requirement. In the other pertinent (100-level) science courses, modifications were made to incorporate the Frontiers of Science learning outcomes. Homework assignments for these substituted courses include writing exercises and critiques of peer-reviewed articles to replace the use of the completion of textbook-homework questions. In addition, laboratory exercises in many of the upper-division (200–400 level) science courses were redesigned to included hypothesis testing and data collection and interpretation (D'Souza, Kashmar, et al., 2015).

In Emerging Infectious Diseases, case studies illustrate the distinction between the scientific method and scientific research. An example is the 1970s emergence of Lyme disease. Students are presented with observations and are encouraged to develop their own hypotheses for the emergence of disease and explanations for geographic variations in disease frequency. As the course progresses, students gain an appreciation of how scientists from many fields contributed to solving the puzzle. Students read peer-reviewed articles, as well as national and international press reports. The importance of citing without paraphrasing is emphasized. Soon differential associations with independent and dependent variables, positive and negative control groups, correlational and experimental studies, theory and hypothesis, and deductive and inductive reasoning are clarified. The concept of consensus is introduced using the "chronic Lyme" controversy. Additional disseminated case studies include West Nile virus, bubonic plague, and Ebola virus. Student assignments require a PowerPoint in-class presentation and, using class information, "designing" a parasitic disease. A research experiment evaluated the efficacy of herbal repellents for ticks and required an experimental research report using the scientific method format.

The AY 2014 SC100 courses have proven to be very popular and 91% earned a C or higher grade (Figure 4). In 2012-2014, those earning a C or higher grade in the old core introductory science courses were 79%. The significant decrease in the AY 2014 attrition for the science core requirement dovetails with the more rigorous mathematical requirements in the quantitative reasoning core math course (MA180). In Figure 4, the greater percentages of As is attributed to the performance of students in the SC100 CSI-Wesley core-course. Current lines of research indicate that freshman are motivated and perform better when they relate to a STEM topic (Burkum, Habley, McClanahan, & Valigga, 2010; Chang, Sharkness, Hurtado, & Newman, 2014; Fink, 2013; Gale, 2013; Kolb, 2014; Savery, 2015).

Figure 4. Percentage (as a total of all grades) grade comparison for the Introductory Science and the SC100 courses in the old and new cores, respectively. Grades: I = Incomplete; IW = Involuntary Withdrawal; P = Passing; W = Withdrawal.



In general, SC100 course evaluations are immensely favorable. Such surveys are particularly good for revealing students' attitudes and opinions. Anonymous course comments included:

> "I was never really interested in science, but this course caught my attention."
> "I learned new things that I didn't see myself learning . . . and I also enjoyed the field trips."
> "I loved this class."
> "a highly recommended course"
> "I had a great time in this course and learned a lot."
> "The professor made understanding the material for the class very easy when science to some like myself is a challenging topic."

IMPEDIMENTS ENCOUNTERED

Implementation of the new core has not been completely smooth. Many of our incoming freshmen do not have sufficient math preparation to take the Quantitative Reasoning Math course (MA180). For these students, the typically second-semester freshman Frontiers of Science (SC100) core course has to be scheduled for the sophomore year. Some non-STEM advisors continue to encourage students to put off their science core requirement until their senior year. To combat this issue, the science departments petitioned the core curriculum committee to restrict enrollment in the third-level core courses until completion of all level one courses. In addition, as we phase out the old core, we encourage the upper-division students to register for the SC100 courses to fulfill their contextual science requirement.

In the new core, all of the FY100, MA180, and SC100 courses require written composition, yet students are enrolled for these courses and College Writing concurrently. A majority of the Wesley freshmen are poorly prepared to write research papers. To overcome this writing deficiency, there is a requirement that first drafts be evaluated by the Writing Center staff.

Initial student reactions to writing assignments in mathematics range from apprehension and bewilderment to utter resistance. Typical comments include:

> "Writing in math too?"
> "Are you kidding?"
> "Term papers in math too?"

The research experience projects consume an inordinate amount of time for both students and faculty. The college-approved writing and speaking rubrics guide students to reliable citation and documentation of sources and help in formulating writing strategies that organize and effectively communicate research results to an audience. With thoroughly planned and relevant research experience projects, students actively collaborate and are actively engaged. However, at times the grading of these projects is disheartening, even though the grading criteria are established by the formative rubrics (Nwogbaga, 2011, 2015).

Designing uniform course exams in MA180 is a major hurdle. Diverse groups of faculty who have their own unique and rich teaching strategies are involved in the teaching of these courses. A large amount of department time is spent on agreeing to fair test questions and to their wording. Furthermore, getting all members of the department to agree to declared in-class policies has proven to be tedious.

For program accreditation and departmental growth, continuous performance assessment of the courses is important, but difficult. A particular challenge is to determine reliable performance measures that reach the level of specificity needed to evaluate the design elements in the research experience projects. In addition, to become familiar with the course requirements, new adjunct instructors have to go through an orientation before teaching the math and science core courses. This results in staffing challenges.

CONCLUSIONS

The combined AY 2014 failure and withdrawal rates for the first-semester FY100 and MA180 core courses were 19% and 29%, respectively. These results were somewhat anticipated, as the earlier AY 2011 Jessie Ball DuPont-funded (D'Souza, Kroen, Stephens, & Kashmar, 2015) college-wide assessment accentuated the underpreparedness of over a third of the non-returning Wesley student population. In addition, the combined average SAT score of all incoming AY 2014 freshmen was 1294.

Notably, the total FY100 and MA180 course failure and withdrawal rate statistics authenticated the effectiveness of these introductory first-semester freshman courses in weeding out weak students who clearly are not fully prepared for the academic challenges of college. Encouragingly, those students who passed these courses and moved into the second-semester freshman Frontiers of Science (SC100) course showed inherent academic strengths and progress, with 91% earning a C or higher grade.

The 2009–2012 Wesley College freshman-to-sophomore retention rates averaged 45%. In AY 2013, during a trial run of the new core (including LLCs) the retention rate increased to 52%. Full implementation of the new core began in AY 2014. The retention rate is now 55%.

The broadest impact of the Cannon Scholar program (with a 96% Year 1 retention rate) is its increased ability to seek out, attract, prepare, and graduate Wesley's financially needy underrepresented minority STEM population.

The Wesley STEM programs have a record (D'Souza, Kroen, Stephens, & Kashmar, 2015) of successfully mentoring underrepresented groups; the Cannon Scholar program will maintain this productive work and continue to shape and benefit students, their careers, and their future impacts on society.

The greatest benefit to the institution is that curriculum reform focusing on STEM courses with student-centered learning has persistent benefits. Faculty who adopted active learning pedagogies into STEM courses not only continue to use them, but also encourage colleagues to adopt the successful approaches. In Year 1 of the newly implemented college core, all STEM faculty now participate in research and/or in the pedagogy of experiential education.

Finally, although there is no formal place in the new core for STEM in the second and third tiers of the core, the humanities courses are expected to be integrated. In both levels STEM has a role. A course in bioethics has been discussed, as well as a collaborative drawing course between the Art Department and Biology that focuses on observations and ecology. A geographic information systems (GIS) integrated course has been accepted for the third level.

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