

## **Undergraduate Research, Data-Science Courses, and Volunteer Projects, Inform and Accelerate Wesley College's Retention Among First- and Second- Year Students**

Lily S. Neff  
STEM Undergraduate Research Center for Analytics, Talent, and Success  
Wesley College  
Dover, Delaware 19901 USA

Faculty Advisor: Dr. Malcolm J. D'Souza

### **Abstract**

Wesley College is Delaware's minority-serving, private, undergraduate, liberal-arts institution<sup>1</sup>. The College continually advances innovative programming to boost college readiness and to stem the dropping numbers of its first-time (freshmen) applicants. In order to help unprepared students for the rigors of its programs and to enhance a truly integrated STEM curriculum<sup>2-8</sup>, Wesley strengthened diverse academic equity by implanting data-science as cornerstone undergraduate research projects<sup>9-11</sup>. To further scale-up student-engagement and to nationally disseminate our high-impact STEM-education successes<sup>12,13</sup>, the College developed an Undergraduate Research Center for Analytics, Talent, and Success (UR-CATS)<sup>14</sup>. To streamline procurement documents and hazardous-waste handling workflows, the College implemented the use of an online platform<sup>15</sup> that resulted in major annual savings. To engage middle and high school students, Wesley STEM undergraduates established a Science Club to demonstrate hands-on science lessons, so STEM concepts come to life. To help explain the learning mechanisms by which integrated STEM experiences support outcomes, this paper presents interventions with particular attention to curriculum design for incoming STEM freshmen who place into pre-Calculus or a lower math course. To show that engagement with STEM college students as role models have a positive impact on high-school student interest, we provide examples where Science Club members pose challenges and show different perspectives on everyday items. In summary, Wesley project outcomes have allowed for coordinated interventions<sup>3-9,12-14</sup> in student well-being and student success.

**Keywords:** Wesley College, STEM, undergraduate research, student success, student retention

### **1. Introduction**

Wesley College (Wesley) was founded in 1873 and is affiliated with the United Methodist Church<sup>1</sup>. Wesley is located in downtown Dover, Delaware, and as a minority-serving, private liberal-arts undergraduate institution, it serves<sup>1-16</sup> a major segment of Delaware's historically marginalized population. Wesley offers 29 undergraduate programs and its Fall 2018 undergraduate enrollment<sup>1</sup> was 1228 students. The racial/ethnic enrollment composition was 40.88% African-American, 36.97% Caucasian, 7.41% Hispanic, 5.86% Biracial, 1.3% Asian, 0.24% American Indian, 0.24% Pacific Islanders, 0.41% nonresident aliens, and 6.68% were not identified.

During the past five years, like other (small) regional liberal-arts colleges, Wesley has a falling enrollment due to a dropping high school (HS) senior applicant pool<sup>17</sup>, and this negative college enrollment trend is contributing<sup>17-19</sup> to a variety of financial and structural academic changes. Furthermore, Wesley nurtures an economically and academically challenged population<sup>1-16</sup>, who are less likely to complete college<sup>20</sup> and are especially inclined to forsake STEM degree attainment<sup>20-22</sup>. Therefore, in order to help this undergraduate population to overcome some of the academic stressors that impede concentration, Wesley with the help of external federal and state support, implemented (College-wide) evidenced-based<sup>23-26</sup>, multitiered and comprehensive, interventions<sup>2-16</sup>. To provide guidance and programming that

engages students within a supporting and motivating learning environment, Wesley developed<sup>2-16</sup> both stand-alone approaches and curriculum-based initiatives to ensure strong student performance to close the opportunity gaps with the needs of its Mid-Atlantic regional employers.

## 2. Collaborative Continuum Of Academic And Social Interventions

Using the Fall 2014 to Fall 2018 semester census snapshot<sup>1</sup>, Figure 1 clearly shows a 19.6% decline in the undergraduate headcount, that is in line with the enrollment trends in similar degree-granting post-secondary institutions<sup>17-19</sup>. Most Wesley College undergraduates are from historically marginalized communities (Figure 2) and in Fall 2018, 55% of the undergraduate population were individuals who self-classified as a minority (Figure 2). The majority minority population is African American, and the Fall 2014 to Fall 2018 enrollment of female students is consistently higher than the enrollment of male students at Wesley (Figure 3).

In academic years (AYs) 2010-2014, the college-wide, first time-full-time (FTFT), first-to-second year retention rate<sup>6,7,12</sup> was 46% and the associated STEM program retention rate was 44%. More recent internal AYs 2014-2018 needs analyses show that 95% of undergraduates receive financial aid and 59% receive federal Pell-grant support. Additionally, 57% of the incoming Wesley College freshmen class place into developmental courses which reveals a glaring gap in the nation’s historically underserved HS education system<sup>17,20,22,25,26</sup>.

The average first-to-second year, FTFT cohort retention rates in AYs 2014-2018, was 53.6%<sup>1</sup>. This is eight percentage points lower than the corresponding 2018 national average (61.5%) for four-year private institutions with open admission selectivity (similar to Wesley College)<sup>27</sup>. The Wesley student to faculty ratio of 15:1 provided the impetus to develop interventions (described in detail below) for a nurturing environment<sup>2-16</sup> that gave students access to one-on-one help from professors and College staff.

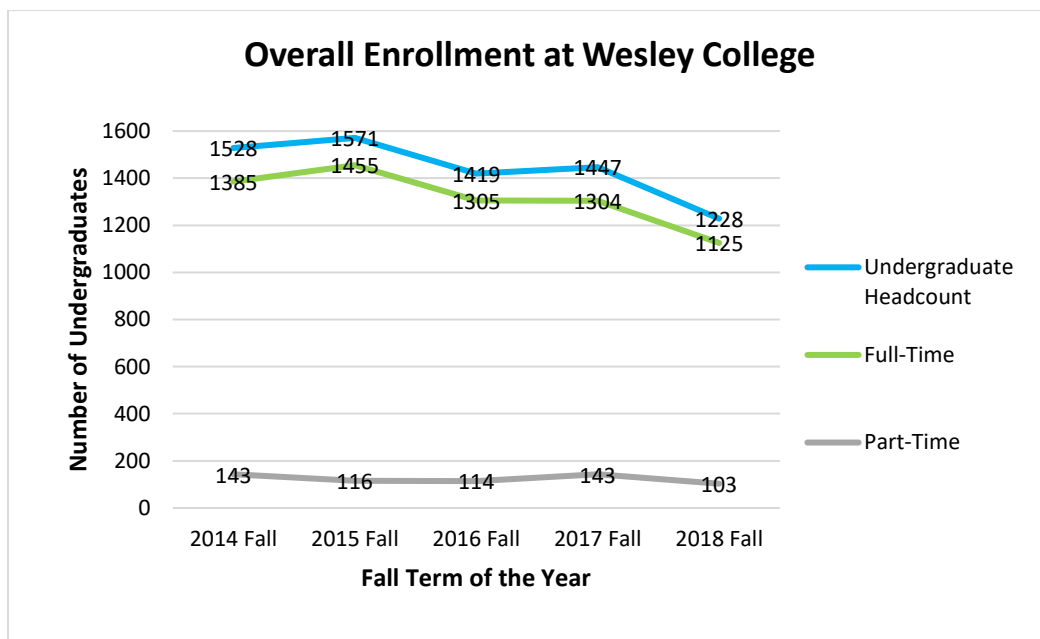


Figure 1. 2014 Fall – 2018 Fall full-time, part-time, and overall undergraduate enrollment at Wesley College.

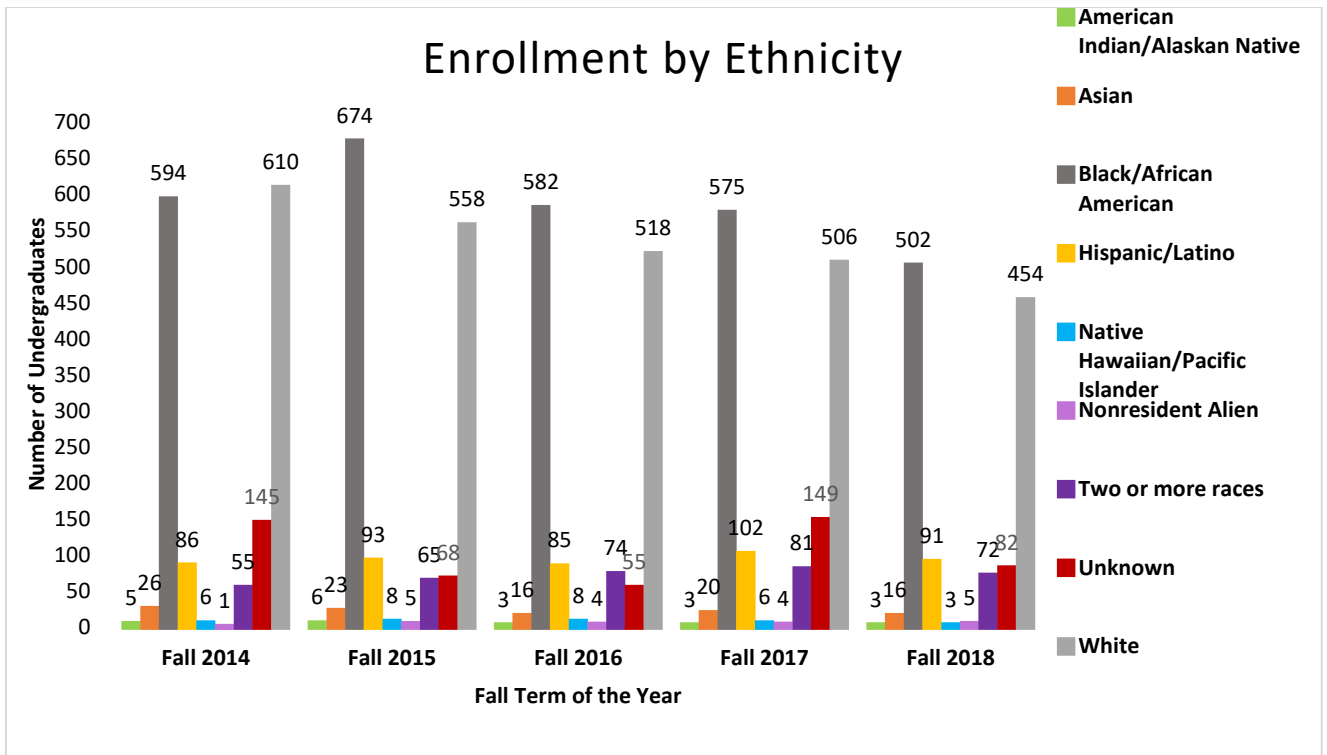


Figure 2. The Fall 2014 – Fall 2018 enrollment of undergraduates at Wesley College by ethnicity.

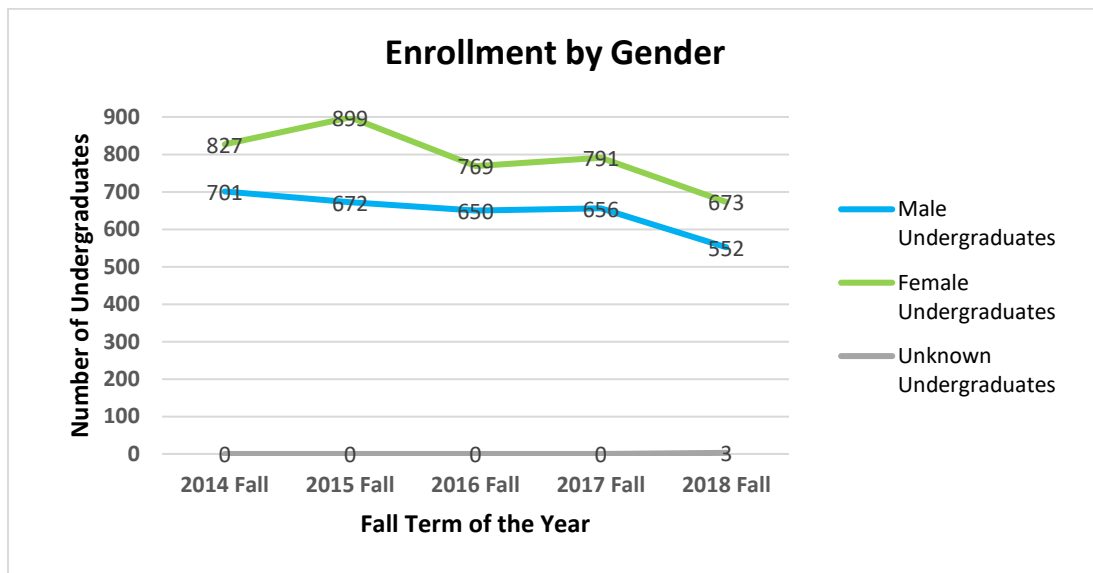


Figure 3. The Fall 2014 to Fall 2018 enrollment of undergraduates at Wesley College by gender.

## 2.1 Mentored Independent, And Course-Embedded Research Programs

In the Wesley College STEM areas, undergraduates can major in biology, biological chemistry, environmental science, environmental policy, medical technology, and mathematics. The AYs 2014-2018 average year-to-year retention rate for STEM majors was 66.8% and the analogous non-STEM major rate was a tad higher at, 69.6%<sup>1,12</sup>. The Wesley STEM undergraduates not only delve into subject area content but their major core-requirements are very

(STEM) cross-disciplinary. Additionally, through federal and state support, students are afforded paid opportunities to participate in vibrant collaborative research projects with a STEM faculty member<sup>2-4,9-12,15,28-48</sup>. The STEM faculty also redesigned their introductory STEM courses and transformed the upper-division laboratory experiences to make experiential learning coupled with written reflections to be integral components<sup>4-7,9-11</sup>.

Besides their required STEM core-courses, STEM-students work with their STEM advisors to enroll in Wesley's progressive liberal-arts core-curriculum<sup>5-8</sup> where in year one, students are introduced to intellectual examinations, analytical inquiry, and quantitative reasoning<sup>5,7,8,10</sup>. In the second year<sup>8,10,11</sup>, they are shown the connections, communications, and qualities associated with the liberal arts, and in year three<sup>8-11</sup>, undergraduates effectively learn to use their cause-and-effect problem-solving skill sets within a common defined theme. Finally, as a summative expression, all Wesley seniors complete a capstone thesis project<sup>8,28-42</sup>. Mentored involvement<sup>2,4,5,7,23,24,49</sup> is shown to contribute to a supportive learning environment where student engagement, motivation, and retention are essential to the health of the STEM programs.

## 2.2 Data-Science In The STEM Fields And Within The College Core-Curriculum

In Wesley's integrated STEM curriculum, data-science is a key feature in the upper-division undergraduate laboratory, and in mentored chemometrics, cheminformatics, ecology, microbiology, epidemiology, geospatial analysis (GIS), and SAS-programming research projects<sup>9-11,28-42</sup>. STEM majors also have access<sup>9-11</sup> to Informatics Certificate and Minor programs. Both provide expertise in compiling and analyzing very large data sets. In addition, the GIS and SAS-programming courses (required for Informatics Certification) are encapsulated in the College's liberal-arts core<sup>10,11,49</sup> as the data skill sets<sup>9-11,34,36,44-47</sup> of information management, data mining, data processing, and data visualization, power and add value to modern businesses.

## 2.3 Student Support Structures Are Designed For Student Success

The acknowledged federal and state grants allowed for the implementation of strategic, proactive and personalized, student support structures<sup>3,6,8-14</sup> that maximize student potential. The Wesley College Academic Success Center's case management systems<sup>6,8</sup> allow for timely and broad, student-centered, advisory, social, emotional and career support programs. In addition, students have access to free subject-area peer-tutoring<sup>6,7</sup>.

## 2.4 Support Systems Through Connected Learning Communities

In the STEM-areas, the Cannon Scholar program was developed through the Track-1 National Science Foundation's Scholarships in STEM (S-STEM) program<sup>12,13</sup>. To participate, students must be a full-time STEM major, a U.S. citizen or permanent-resident, have a GPA  $\geq 2.7$ , and demonstrate financial need. Due to the commonality in coursework, Cannon Scholars (S-STEM students) interact with each other as a cohort and stay connected. In addition, they share the S-STEM learning space that was created in the basement of a College dorm and Cannon Scholar programming offers workshops, seminars, mentoring groups, peer-tutoring, co-curricular activities and opportunities to participate in research with support for travel to conferences<sup>12,13</sup>. Furthermore, Cannon Scholars have monthly meetings with the Assistant Director of STEM Initiatives to review and ensure academic success and career progress towards their chosen STEM field<sup>12</sup>.

STEM majors who are not Cannon Scholars and other non-STEM majors can participate in other high-quality learning communities that offer a similar academic and social experience<sup>5-8</sup>. As freshmen, the first-year seminar courses are linked to 1 or 2 other courses that focus on the first steps to information literacy, collaboration, and written and oral communication links, on the pathway to successful college-transition. High achieving freshmen can also participate in the educationally motivated Honors learning community<sup>6,12</sup>.

## 2.5 Success In STEM (SIS) Program – Summer Bridge Program

A considerable number of Wesley College STEM freshmen begin with deficiencies in mathematics skills and hence, are placed into a pre-Calculus or a lower mathematics course<sup>6</sup>. As a result, these students cannot begin in freshmen chemistry the foundation to all of the molecular sciences, and they fall a year behind. To intervene and address this issue, the 3-week Success in STEM (SIS) program was launched to give incoming freshmen (and other interested local high-school seniors) the opportunity to prepare for the rigors of college-level STEM coursework<sup>16</sup>. This free,

on-campus, summer bridge program introduces formative experiences and targets student's knowledge with intensive faculty engagement in accelerated (non-credit) classes in mathematics, chemistry, scientific writing, and time management. While enrolled in SIS, participants are made aware of learning styles and strategies, and the additional benefits of being associated with the Wesley STEM program; including Directed Research and Lab Assistant positions, STEM scholarship opportunities, and a paid summer internship program<sup>2-12</sup>. Additionally, each semester, 50-75 SIS students and STEM majors participate in recreational weekend activities including out-of-State trips, campus events, and industry visits that allow for student bonding<sup>16</sup>.

## 2.6 STEM-Program Outreach And Volunteer Opportunities

Wesley College is a longstanding landmark in Dover, and so it is very important for STEM majors to get involved with the local community<sup>5,13,43</sup>. To engage K-8 students, STEM majors, in AY 2018, established the Wesley College Science Club. The Science Club partners with community centers and the K-8 school-system to organize safe science outreach activities using demonstrable hands-on science experiments. The Club's multifaceted goal revolves around getting younger participants interested in science, by providing family experiences from the visually stimulating experiments, and by creating an educational platform for parents to learn about science vocabulary and its pattern of thinking. During organized events, science club members pose scientific questions to the audience and they demonstrate answers by using different perspectives on everyday items.

Furthermore, to create public awareness of the successes in the Wesley STEM programs and to encourage high school seniors to apply, substantial effort was placed to forge new relationships between the STEM department and the local HS guidance counselors and the HS STEM teachers. These relationships provide a solid foundation to recruit potential STEM undergraduates. At recruitment events, Wesley STEM majors speak on personal (college-related) testimonials and experiences. To further motivate HS students, the Wesley students emphasize their undergraduate research experiences and post-graduation plans. We have found that such open forums allow HS students to feel comfortable about listening to Wesley student testimonials and asking pertinent questions on college-readiness and research opportunities.

## 2.7 STEM Undergraduate Research Center for Analytics, Talent and Success (UR-CATS)

To build a successful STEM capable workforce that emphasizes increased participation from historically marginalized populations, Wesley launched<sup>14</sup> the STEM Undergraduate Research Center for Analytics, Talent and Success (UR-CATS). Through external support, UR-CATS allocates resources for engaging academic interventions, leadership, and service programs (2.1-2.6). UR-CATS advances strategic and well-implemented assessment processes for independent mentored projects, course-embedded projects, informatics analysis (including formal statistical analysis, SAS programming for the management of large data sets, and GIS – geographic information systems), faculty training workshops, STEM student success and support initiatives, entrepreneurship engagement, Honors activities, field work, innovation programs for high-school seniors, career training, and cohort-building STEM outreach/volunteer opportunities.

## 3. Wesley College STEM-Program Outcomes And Impacts

The many academic and social community-building interventions described above, leveled the field for students to develop academic cognition, social and emotional growth. This provided a true sense of belonging on the students' pathway to educational success. The STEM UR-CATS serves as an entrepreneurial arm to effectively engage<sup>2-16,28-47</sup> federal and state stakeholders. It aligns resources for faculty and staff who employ a variety of instructional, assessment and blended support structures, that monitor student performance in pursuit of the maximum intervention benefits. Additionally, the STEM UR-CATS tracks the 3.1-3.3 outcomes and impacts (listed below) using broad-based institutional research and data.

### 3.1 Economic Outcomes And Impacts

The strategic 2.1-2.7 institutional actions progressively aligned the STEM content knowledge with the desired STEM career skills and completely lifted the students' sense of belonging and self-efficacy. Since the 2014 implementation of the S-STEM Cannon Scholar program<sup>12,13</sup>, more of our students are participating in volunteer work and undergraduate research. As a result, retention rates in the S-STEM (Cannon Scholar) learning community<sup>12</sup> are in the mid-90% range and despite the decrease in enrollment rate observed since 2015 (Figure 1), students who participate in the STEM UR-CATS sponsored programs have the tools to persevere and graduate. Furthermore, 100% of STEM graduates<sup>12</sup> place into STEM fields and the well-structured UR-CATS programs truly help the academically and financially disadvantaged students develop their talents to the fullest<sup>3,4,6,9,12</sup>, with several gaining co-authorship on peer-reviewed scientific publications and a large number earn poster presentation awards from the Council of Undergraduate Research, the American Chemical Society, and the NASA Space Grant programs.

In the summer of 2018, Wesley piloted a SIS (Success in STEM) cohort of seven students from diverse academic backgrounds. Six students advanced in their math placements and three placed into Calculus I<sup>16</sup>. In August 2019, the College will host 30 SIS participants and by helping to inspire its historically marginalized students, Wesley received further federal and state grants to boost the STEM UR-CATS' commitment to its students and faculty.

### 3.2 Commercial Outcomes And Impacts Of Course Embedded And Independent Student Projects

Implementation of the informatics research led to crossover projects in chemistry, biology, environmental science, mathematics, and public health. Four major applications have been developed: an ADME/Tox database<sup>44-46</sup>, Cancer and Consumer Drug portals<sup>34,36,47</sup>, a Smart-Phone Fertilizer App<sup>38</sup>, and the implementation of an online procurement and hazardous-waste handling platform (*Quartz*) at Wesley<sup>15</sup>. Moreover, creative data-science projects have provided evidence<sup>9,11,40-43</sup> on public health challenges facing the State of Delaware and the US population.

### 3.3 Community Outreach Outcomes And Impacts

To promote the value and effectiveness of the Wesley intervention programs, STEM faculty and staff have conducted a series of national conference workshops, and STEM students involved in the Science Club have participated in numerous events that have brought awareness to science and to the STEM programs at the College. Through the Science Club, Wesley College solidified several new connections with the local community. STEM majors use visually stimulating experiments to inspire HS students during *Super Senators Day* at Dover High School. During Dover's *First Friday* events and at the Dover Art League, the Science Club members conduct simple and engaging science demonstrations. The STEM majors also carried out hands-on experiments at *Science Day* at the South Dover Elementary School, the *First State Community Action Agency STEM Fair*, Georgetown, Delaware, and the *Family Science Day* event at the Independence School in Newark, Delaware<sup>2,4,5,12</sup>. Additionally, Environmental science majors and students in Wesley's *Sustainable Living* learning community created a publicly accessible community garden on Wesley's campus<sup>48</sup>.

A July 2019 versus July 2018 STEM program deposit-rate comparison shows significant increases in the recent numbers of committed students. There is a 500% increase in the number of incoming biological chemistry majors, a 300% increase in the number of incoming mathematics majors, a 200% increase in the number of environmental science majors and a 29% increase in the number of incoming biology majors. For medical technology, the numbers are the same in both years. College-wide, there is an 18% decrease in the total freshman enrollment across all 29 majors.

## 4. Summary Of The Innovative STEM Programming Results

The Wesley STEM UR-CATS program sponsors activities that are fundamental to student success and it builds a culture of undergraduate research where all students benefit from hands-on experiential experiences. The SIS summer bridge program and Wesley's leaning communities assist students with college preparedness, and the programs recreational activities allow the cohort to develop friendships and team-bond. The peer-tutoring, group studying, and

the other Academic Success Center's resources and services, lay the foundation for increased accountability on the pathway to academic success. Mentored independent and course-embedded undergraduate research opportunities have allowed participants the chance to present at regional and national conferences. Scientific conference participation has helped develop and enhance the students interpersonal and intrapersonal skillsets; including the resolution of issues with self-confidence, independence, communication, and maturity. The broad skills set from the informatics coursework has opened new avenues in data-driven industries, and the STEM outreach and volunteer work allows for strong resume building qualities, making the Wesley participants to be solid candidates for graduate programs and for STEM job applications.

The online implementation<sup>15</sup> of *Quartz* facilitated stronger STEM faculty and staff teamwork and decreased the amount of time undergraduate laboratory-assistants spend on laboratory preparation procedures. Our environmental footprint has been reduced with an increased efficiency in monitoring chemicals and their associated contaminants. Using *Quartz*'s Effortless Quote System feature, there has been a savings of ~ \$10-12,000 per year and this cycles back into the many STEM UR-CATS initiatives.

Getting our STEM majors actively involved in STEM recruitment strategies, the Wesley programs gained improved exposure in the HS STEM community. HS teachers and counselors have expressed significant enthusiasm and support towards these efforts.

## 5. Acknowledgements

The authors truly appreciate the valuable review comments and express their gratitude to the many efforts of the Wesley College administration, its faculty, and its programming and support staff. Wesley College acknowledges support from an NSF-EPSCoR award (OIA-1757353, Grant No. IIA-1301765), an NSF (DUE) S-STEM grant 1355554 (Wesley College Cannon Scholar program), an IDeA award from NIH-NIGMS (P20GM103446, DE-INBRE program), the NASA Delaware Space Grant Consortium (NNX15AI19H), and the State of Delaware. The opinions and views expressed in this article are those of the authors and do not necessarily reflect the opinions and views of any of the federal and state funding agencies.

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