Tomorrow's researchers

Drs Malcolm J D'Souza, **Kathleen Curran** and **Stephanie Stotts** discuss their new initiative integrating project-based STEM learning into a vibrant liberal arts curriculum

What sets Wesley College apart from other teaching establishments in the region?

MD: Small class sizes create an environment that encourages greater interaction between faculty and students – Wesley faculty members are passionate about their subjects and go the extra mile to help students succeed. Often a STEM student advisor will modify the curriculum to match a student's needs: this is possible to accomplish in a small institution like Wesley.

You are engaged in two long-term, collaborative grants: from the Delaware IDeA Networks of Biomedical Research Excellence (INBRE) and the Experimental Program to Stimulate Research (EPSCoR). What legacy do you hope these projects will leave?

MD: Both grants were recently renewed for another five years. Before INBRE, few Wesley STEM students thought about graduate or professional programmes. Now, after an INBRE or EPSCoR undergraduate research experience, over 85 per cent of the STEM participants go on to graduate or professional (typically medical or dental) programmes. A 2011 departmental review indicated that 92 per cent of former STEM graduates are now either working in STEM fields, in graduate school, or are teaching high school STEM courses.

KC: In the science programmes we have required a research project as our capstone for the past 15 years. Additional funds made available by the grants have allowed us to increase the calibre of these projects, and increase faculty involvement in mentoring. This new initiative will allow us to begin integrating research much earlier in our curriculum for all of our students, giving them time to develop and mature their scientific skills.

Do you still in engage in research?

MD: I am very active in basic research in chemical kinetics and structure activity studies in organic chemistry. Students in my group have co-authored peer-reviewed publications (60 undergraduate co-authors on 76 publications) and 59 of these have earned national and regional science awards.

To what extent are students given the opportunity to get out of the classroom and into the field and industry?

KC: I take my non-major general biology students to Bombay Hook National Wildlife Refuge, and my ecology students conduct several projects in the field. Allowing students to collect organisms and make observations outside gives them an appreciation of the challenges encountered when trying to work beyond the laboratory, without the limitations of controlled conditions. Science isn't restricted to the laboratory, so science students shouldn't be either.

SS: When students experience something first-hand, connections are made in their brains that just can't happen in lectures. I have taken my students everywhere: from salt water marshes, freshwater wetlands and rivers to waste and water treatment plants, a free-range chicken farm and local parks.

Why is it important to revise the curriculum on a regular basis?

SS: Student bodies are dynamic and their expectations and needs change with time. To be appealing in the recruiting process and meet these students' needs once they are at Wesley, we have to revise our curriculum regularly.

MD: This semester I am teaching Biochemistry. I decided to use online texts, articles and pertinent YouTube animations to supplement my teaching. The class seems to love the format and there is significantly increased interest in this difficult subject. Teaching this way requires diligence but the eventual reward is immense: the current average class grade is a B.

How does the first-year research component of your undergraduate courses enrich the lives of the student body? Have you documented the success of this initiative post-Wesley?

MD: Several years ago, first on INBRE and then on EPSCoR, we began including freshmen in undergraduate research in a mentored directed research programme. With time,

At the heart of innovation

With undergraduate courses that prompt questioning, investigation and analysis, the innovative curriculum at **Wesley College**, USA, is preparing its STEM students to be the researchers and educators of tomorrow

a majority of the participants significantly matured in their analytical ability and laboratory skills and then went on to graduate programmes. Some are now PhDs and MDs, and a number were of minority status or first-generation students. To see them succeed has been a tremendous achievement.

Wesley provides students with grounding in statistical analysis and the scientific method. How does this help them to succeed?

MD: It provides them with a conceptual framework to reflect and revisit important ideas that often result in unique and critical contributions to research.

A number of former participants who are currently in graduate programmes note that their hands-on INBRE/EPSCoR Consortium research was essentially the hallmark initiative that helped them gain independence in their thought processes.

Dr Stephanie Stotts' field class.

WITHIN MANY HIGHER education institutions, research is commonly the domain of postgraduates and academics; undergraduate courses tend to follow a more prescriptive format. At Wesley College in Dover, Delaware, however, under the direction of Dr Malcolm J D'Souza, Professor of Chemistry, STEM undergraduates are supported through sponsored research projects, which have now become an integral part of the curriculum.

This federal-funded initiative has been a unique facet of a Wesley College education for 15 years, and has revolutionised graduate prospects. Founded in 1873, Wesley is a College in the Liberal Arts tradition with an undergraduate population of 1,476 students. The College is officially classed as a minority-serving institution, with students from ethnic minority backgrounds comprising more than half of the College's enrolment. Moreover, over 40 per cent of the student body are the first in their family to embark on a College education. This is a position with which D'Souza, who grew up in India and whose parents did not attend College, can empathise. Being able to inspire these students through offering a vibrant, research-driven, student-centred and, above all, supportive curriculum, is therefore hugely important on a personal level.

AN UNWAVERING SUPPORT NETWORK

STEM is traditionally perceived to be male-dominated and D'Souza and his colleagues, Drs Kathleen Curran, Lynn Everett and Stephanie Stotts, are aware of the need to place emphasis on encouraging female students in these subjects. Although D'Souza maintains that women are no longer considered a minority in biology and chemistry, he concedes that they remain underrepresented in physics and mathematics. Similarly, although Everett and Stotts have received great support in their scientific careers, they recognise the importance of scholarships and other grants which encourage and aid women in the pursuit of scientific careers. "At Wesley, 37 per cent of the full-time science faculty are women," remarks Everett. "In collaborative efforts with Delaware State University, our students have a chance to work with female full-time researchers." The opportunity for students to work with female researchers is also important to Curran, who ensures that she educates her students on the changing role of women in science, as well as in society as a whole.

The support network Wesley offers its undergraduates in order to ensure that they get the most out of their courses and research projects is extensive. It includes, but is not limited to: the PULSE Mentoring Program, which aims to increase the retention rate of minorities through peer-role models, community involvement and education, whilst encouraging personal growth; a work study programme (for minorities and undergraduates from low-income families); and leadership development programmes. There are also honours and study abroad programmes, as well as the chance to attend regional and national conferences. Students are strongly encouraged to view their studies as a period of great opportunity to acquire new skills and sample novel experiences.

AN INNOVATIVE OUTLOOK

It was from this school of thought that the research component of undergraduate STEM studies at Wesley was born, and this thirst for innovation and improvement drives the faculty to regularly revise its curriculum. It is a policy that has had a great deal of success over the past 15 years. D'Souza reports that prior to 2002, only one Wesley graduate had gone on to complete studies at medical school. Now, the majority of Wesley STEM graduates (upwards of 90 per cent) continue to work in STEM fields, either through postgraduate study, research careers or in teaching. With the new core curriculum, developed with, and funded by, the National Science Foundation (NSF) Delaware Experimental Program to Stimulate Competitive Research (EPSCoR) and the National Institutes of Health (NIH) National Institute of General Medical Sciences IDeA Network of Biomedical Research Excellence (INBRE) grants, they will continue to build on this achievement.

Dr Malcolm D'Souza with Students at the ACS New Orleans event.


Barbados class photo at Cherry Tree Hill with Dr William Kroen and Professor Paul Olsen.

STEM faculty and staff are passionate about these changes to the curriculum, relishing the opportunity to guide their students towards a more self-directed mode of study

Dr William Kroen, Professor of Biology, is responsible for the science curriculum at Wesley. As is typical within the liberal arts tradition, there is a focus on interdisciplinary studies, prompting students to see the 'bigger picture' by learning to synthesise information across courses. "By the end of the second year, our students have completed general chemistry, organic chemistry, general biology and microbiology," Kroen explains. "As the college implements a new general education curriculum that emphasises writing and interdisciplinary understanding of the humanities, we hope that our science majors will increase their ability to synthesise content and form more 'real world' connections."

Kroen also offers selected lucky students the chance to participate in a travel course in Barbados. Before their trip, students research the natural history, human development and culture of the island. Once there, they visit important geographic sites, taking part in activities such as snorkelling on the reefs and trekking through the tropical forest. They also learn more about the island's manufacturing and economy by visiting a sugar mill and the Mount Gay rum distillery. Findings from the different research projects that participating students undertake are presented to fellow students upon their return. Kroen views this travel course as an ideal way to combine skills and knowledge from a number of different disciplines, and hopes that in the future, more Wesley students will be able to benefit from similar experiences.

A WEALTH OF RESEARCH OPPORTUNITIES

One of the most notable innovations of the curriculum, which was first prompted by Wesley's Provost, Dr Patricia M Dwyer, is that the research component of undergraduate STEM courses will commence from the first semester of year one. To facilitate the rolling out of this initiative, four workshops were held with a view to training STEM faculty and staff to involve their first-year students in research from the outset. In order to get undergraduates up to speed, various introductory courses are run: a first-year research experience course, a Frontiers in Science course and a mathematics course with a vital statistical component. Course convenor Dr Derald Wentzien, Professor of Mathematics, highlights the far-reaching benefits of completing such a course: "It is not only necessary training for undergraduate and postgraduate research, but mastering problem solving, probability and statistics is a wise move for anyone hoping to pursue careers in educational or analytical fields".

STEM faculty and staff are passionate about these changes to the curriculum, relishing the opportunity to guide their students towards a more self-directed mode of study. They have proposed a wide range of interdisciplinary projects that students can sign up for. In the autumn semester of 2013, Curran directed a course entitled 'Honey of a Hobby', in which students learned about the ecological importance of the honeybee. The assignments were very much hands-on – typical of the Wesley teaching and learning model – and included market surveys and debates, peer presentations and even creating honey mustard blends. This autumn, she proposes something completely different; students will explore emerging infectious diseases in order to gain an understanding of how the scientific method works. Interactive learning and the promotion of understanding through engagement, is close to Curran's heart: "If we involve students in a process that we ourselves are passionate about, science will become something they value instead of a box they need to check off on their list of core requirements," she enthuses.

Stotts, Assistant Professor of Environmental Studies, also offers a project that is closely relevant to her personal research interests. Field work will form a major part of her students' project on waterways and sea levels. Furthermore, Everett, Professor of Biology, wants her students to develop their enquiring faculties. Her project, 'When Sugar Isn't Sweet' will see students investigating Type 2 diabetes, comparing articles on the subject in peer-reviewed journals and the popular press. "Our goal is to prepare all of our graduates to be well-informed, effective citizens who are able to make reasoned judgments about the validity of scientific claims," she explains.


Professor Agashi Nwogbaga with students at a regional EPADeL Mathematics conference.

Success stories

Professors Paul Olsen and Derald Wentzien, Chair and Professor of Mathematics respectively, recall some of their most outstanding mathematics undergraduates

PO: By offering undergraduate research early on, students interact with upperclassmen and gain a glimpse of what can be achieved through hard work. The motivation drives them to succeed. I tutored Kasey Thompson in mathematics three years ago. She was exposed to classical applications of calculus in the classroom and then took this to bigger and better heights by combining calculus and statistics with Dr Wentzien and using it to estimate the mass of asteroids from photographs of the asteroid.

DW: Melissa Earley interned with Dr Cathy Wu one summer. Melissa is now working as a programmer for HighMark. I believe that the internship helped her to get the job and provided her with experience that she needed. Similarly, Benjamin Barile created a smartphone fertiliser app, and received an offer for an internship with the National Security Agency shortly after. I am confident the skills he gained helped him to secure the placement.

(From left to right) Top row: Professor Paul Olsen, Drs Kathleen Curran, Lynn Everett, Stephanie Stotts, Patricia Dwyer and Frank Fiedler. Bottom row: Drs Malcolm D'Souza, Kent Hurst, Richard Kashmar, William Kroen, Derald Wentzien and Professor Jonathan Kidd.

THE ROAD TO GRADUATION

These first-year projects and STEM courses form the foundation of four years of undergraduate study at Wesley, and are a vital part of every student's education, including those who do not graduate as STEM majors. The analytical, communication and research skills that students gain are invaluable for later years of their degree. In the second year, students focus on liberal arts, and their studies will fall within the remit of subjects such as philosophy, religion, literature and the social sciences. In the third, courses are linked by a common ethical theme as opposed to a subject area; the interdisciplinary training provided by the first year project is a vital aid here.

In their final year at Wesley, students complete courses in their major subject as well as a capstone project, which may take one of several forms: internship, clinical, thesis, portfolio or undergraduate teaching. Once again, being able to think, plan and work independently, as is expected in the first year STEM projects, will be highly advantageous to final year students as they conclude their undergraduate degrees.

BEYOND WESLEY

Undergraduate research at Wesley is not simply a self-contained pursuit. Students who have formerly completed the STEM course have experienced an impressive rate of co-authoring peer-reviewed scientific journal articles. They have also been granted various regional and national awards, including NASA space grants and recognition from the Council of Undergraduate Research. Papers have focused on subjects as diverse as chemical kinetics, small-molecule synthesis and quantitative structure-activity relationship (QSAR) studies of pharmaceuticals, analysis of components in fertilisers, and studies of weight-issues amongst the college student population. These are remarkable successes of which D'Souza is particularly proud. Moreover, D'Souza's role in his students' achievements has earned him recognition from the American Chemical Society. In 2012 he was awarded the E Emmet Reid Award, which rewards outstanding teaching in Chemistry. The figures from D'Souza's classes are impressive: within his list of peer-reviewed articles, 60 undergraduate co-authors feature, and 59 of his students have received national awards. Dwyer credits her colleague for having completely transformed the College with his continuing tireless work both with and on behalf of his undergraduates.

With such a passionate, dedicated faculty, and a proven track record, it seems likely that the newly-revised core curriculum will continue to take Wesley College and its student body from strength to strength.

Dr Lynn Everett's first-year research-experience course, 'All about Dover', at the Delaware Agricultural Museum.

INTELLIGENCE

WESLEY COLLEGE

OBJECTIVES

To liberate and empower students with the knowledge, skills, ethical attitudes and capacity for critical thinking needed to achieve personal and professional goals and contribute to society.

KEY COLLABORATORS

Dr Patricia Dwyer, Vice President for Academic Affairs and Provost • **Emily Wood**, Grants Compliance Coordinator • **Science & Math Faculty** (mentor students in senior-research and Scholar's Day projects) • **Dr Kathleen Curran**, Professor of Biology and Chair of Science • **Dr William Kroen**, Professor of Biology • **Dr Lynn Everett**, Professor of Biology • **Professor Jonathan Kidd**, Professor of Biology • **Dr Richard Kashmar**, Professor of Chemistry and Physics • **Dr Kent Hurst**, Visiting Professor of Environmental Studies • **Dr Stephanie Stotts**, Assistant Professor of Environmental Studies • **Professor Paul Olsen**, Chair of Mathematics • **Dr Derald Wentzien**, Professor of Mathematics • **Dr Agashi Nwogbaga**, Professor of Mathematics • **Dr Frank Fiedler**, Associate Professor of Mathematics

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DR MALCOLM J D'SOUZA is Professor of Chemistry and Director of Sponsored Research at Wesley College, Delaware. He has published 76 peer-reviewed journal articles, has over 300 abstracts in conference proceedings and established a nationally recognised Wesley College Undergraduate Directed Research Program in Chemistry. He has been especially effective at involving undergraduates in his research projects and has mentored over 125 undergraduate students since 1992. In June 2012, D'Souza received the American Chemical Society's (ACS) 2012 E Emmet Reid Award, which recognises high-quality teaching in chemistry at small colleges in the ACS Mid-Atlantic region.

Wesley COLLEGE Great Things Await