A Summer Opportunity Programme for Aspiring Scientists – with a Digital Twist

Emmanuel Vazquez-Rivera, Kristen CM Malecki, Mark D. Marohl, Laszlo Pazmany, Catherine Deeprose, Christopher A. Bradfield

Scientia

A SUMMER OPPORTUNITY PROGRAMME FOR ASPIRING SCIENTISTS – WITH A DIGITAL TWIST

The development of a talent pool in Science Technology Education and Medicine that is as diverse as our population, has been a difficult goal for decades. Increasing the diversity of scientists from underrepresented communities can drive both innovation and creativity within the sciences. The Molecular & Environmental Toxicology Centre at the University of Wisconsin-Madison, USA, has run a summer research opportunity programme since 2011, providing scientific experiences and promoting scientific careers in the environmental health sciences for aspiring young people from backgrounds historically underrepresented in this field.

Developing a Diverse Scientific Workforce

The USA is home to some of the most prestigious and well-funded universities and research institutes in the world. As such, there is strong competition for scientific positions at these institutions. While many scientific opportunities exist, they may not be equally as accessible to all.

Many factors can contribute to a recent undergraduate not being fully prepared/competitive for graduate studies or other scientific positions. Students may not be aware of or have opportunities to access cutting edge research laboratories or they may attend colleges with fewer resources for hands on laboratory experiences. Further, students may not always know that research is something they want to do in the future. This is particularly true for first generation students who are not as familiar, and don't have the support of family members or mentors who know the process of applying for graduate school and what might look good in a graduate research application.

This contributes to a lack of diversity within graduate training programmes in Science Technology Education and Medicine (STEM) careers. In turn, the lack of diversity in training programmes can lead to many underserved populations not seeing these professions as available or welcoming to them; they may see the scientific field as a 'gated community' that only allows certain people into its ranks. In addition, a lack of scientific training opportunities for our entire population leads to fewer scientists overall and unfilled professional positions. These consequences are not unique to the USA; a quick look at the official website for UK Immigration Services shows that professionals with biochemistry and biological science backgrounds rank high on its 'Shortage Occupation' list.

What is the problem here? Why is it that countries, home to some of the oldest and most prestigious universities in the world, fail to generate talent or junior scientist pools that are reflective of the diverse populations they serve? Moreover, have these same countries recognised that the most pressing environmental issues facing our world, including plastic pollution, climate change, and the potential emergence of new infectious diseases, are likely to require creative solutions generated by the previously untapped potential of individuals who may not currently see a path to enter the scientific workforce?

This need for a generation of scientists from varied backgrounds and representing a diversity of thought is likely to exist worldwide. To answer the scientific challenges of tomorrow, there needs to be a greater and more diverse pool of young scientists from which to produce our future scientific leaders.

The answer to this problem may be complex but one initial step appears to lie in the increased access to early-career scientific opportunities for students from underrepresented communities. A specific example includes an increase in experiential programs at major research institutions to both draw new populations into scientific research and provide essential early exposure to science and state-of-the-art technology. Importantly,

such an effort can be part of a more holistic approach, as over the long-term, its success can reduce the stereotypical images of unfamiliar scientists superimposed over unfamiliar instrumentation or data forms. Unsurprisingly, such stereotypes may not 'sell' scientific career paths to all ambitious university graduates, and especially not to those from underrepresented backgrounds.

A Touch of History

In efforts to increase diversity within STEM, universities are developing outreach activities to entice all talented young people into careers they may not have previously considered. The University of Wisconsin-Madison's Molecular & Environmental Toxicology Centre (METC) is an early adopter of this strategy. Every summer, they host a small group of aspiring young people from all over the USA and Puerto Rico so they can get a taste of life in a scientific career and explore whether this is a viable future for them.

This programme, the METC-summer research opportunity programme (METC-SROP), ran for the first time during the summer of 2011 after gaining external funding from the National Institute of Environmental Health Sciences. Since its inception, MET-SROP has recruited students from underrepresented communities, including those who identify as Black, African American, Hispanic, Latino, Native American, Alaska Natives, Native Hawaiians, and Pacific Islanders. As the National Institutes for Health evolved their definition of 'underrepresented', the programme also encouraged those from a disadvantaged socioeconomic status, those with a documented disability, and those who are the first in their families to attend a university. While the programme focused on students currently in college or university, the selected participants were often chosen because they may not have access to a research experience at their institutions of study or their institution might not have a focus on environmental health science.

Under usual circumstances, the MET-SROP selects between 6 and 10 students each year. These participants move to the University of Wisconsin Campus for the summer, where they are housed in a dormitory setting adjacent to campus. Here, the participants build a community of fellow scientists and spend 10 weeks in a research laboratory, conducting their own research with extensive support from dedicated faculty members. In addition, each trainee is assigned a close mentor, who is typically a graduate student in the Molecular & Environmental Toxicology Graduate Program or a field related to each student's interest.

Their projects are designed with two main goals: to gain scientific competency with hands-on tasks and to provide participants with their own, real-world research data set. The latter aspect is often the most impactful, as it allows students to gain insight into data structure, analysis tasks and interpretation. The projects are widely varied and attempts are made to match students' interests. These include but are not limited to topics in biochemistry, molecular biology, and environmental sciences. The multitude of available projects allowed students to choose a topic they personally find interesting, providing further motivation to succeed.

Working in research laboratories can be difficult, even at the best of times. Experiments have a tendency to go wrong or bring unexpected results. Guiding a group of fledging scientists, some of whom are entering a laboratory environment for the first time, to successfully complete ambitious objectives, takes a remarkable amount of forward planning, patience and dedication. Yet, past success is an indication that the necessary planning and training is sufficient to support success. Since the beginning of this effort, 124 students have benefited from a summer experience at the METC-SROP. Of those that have come through the programme, more than half are now either studying in university graduate programmes or now have an advanced degree in science, medicine, or other related professions. This is a considerable marker of success, especially

considering how students from underrepresented communities are currently not well represented in the biological sciences.

Back to the Drawing Board

Then, early in 2020, COVID-19 struck. Because of the many unknowns related to the disease, normal working conditions ceased and all travelling was put on hold. One of the effects that this had was the day-to-day operations at universities. Classes were moved into an online (virtual) format and in-person operations were suspended, including those for important programmes. The university's closure of face-to-face instruction left the future of the METC-SROP programme hanging in the balance. The programme needed to develop an alternative approach that could be delivered in this rapidly emerging new age of online lectures and Zoom calls. To provide this SROP in uncertain times, the planned programme was retooled around five criteria:

1. Replicate the sense of a scientific experience at a major research university
2. Provide a challenging research project
3. Promote an understanding of how the environment affects human health, especially for underrepresented communities
4. Facilitate the development of skills that students could utilise in a future scientific career
5. Promote the University of Wisconsin-Madison as a desirable choice for further research training

The Shape of Things to Come

The team discussed potential innovative strategies and evaluated which elements of the programme could be made available online, together with additional, complementary features. Following two months of intense planning, the team agreed to run the programme virtually.

One of the most crucial elements would be whether or not the participants had reliable access to participate in a summer virtual experience from various locations across the continent. Through follow-up calls, methods were developed to ensure that bandwidth was available for students from a variety of geographical locations. This included connections through their internet service provider or their cellular services. The programme was prepared to provide laptops but that was not needed, as the participants had become prepared through the prior months of adjustment to a virtual classroom at their undergraduate institutions. In fact, they were excited and ready to continue in this virtual world for their research experience.

With evidence that all members of the programme – leadership, participants, and instructors – could be successful in this virtual environment, the appropriate platform was identified. By hiring all participants as remote University of Wisconsin-Madison employees, each trainee was provided access to a variety of communication options, with which the university

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held contracts. The three most prominent platforms used at the time were WebEx, Zoom, and Microsoft Teams.

Following discussions and trial runs, the Teams platform was chosen as a primary venue because of its adaptability for a more 'classroom' feel. To enhance continuity, a channel was created and all members of leadership, instruction, and the participants were invited to join. This software allowed easy saving of files, a more intuitive platform for all-day events, individual break-out rooms for participants and advisors, and the availability to save conversation/discussions.

The first module of the redesigned course – Learning the Basics – was a series of formal daily lectures covering how toxicants enter the body, how they act, and how they are eliminated. This also included problem sets to help participants actively learn the concepts. The second module – Skills for Research Success – introduced students to information searches in the scientific literature, concepts of data analysis, and scientific communication. This included practice in the writing of research papers, the development of poster presentations, and the crafting of scientific talks. Since the module also included a presentation task, participants received training in presentation skills. Each student selected a particular chemical, researched the literature on its toxicity and presented their findings to the student cohort.

These tasks not only allowed students to apply learning to practice but also helped them build confidence in presenting data confidently and rigorously. The programme finished with the 'Toxicology Research without the Lab' module. Here the initial focus was on learning the principles of a widely used programming language for statistics and data analysis, R, an invaluable skill in all areas of scientific inquiry.

During the final two weeks, utilising all their recently acquired skills, participants prepared a final presentation. However, this time the stakes were higher: the audience included 40 scientists from around the university, including faculty, postdoctoral trainees, and graduate students, as well as some of the off-

campus instructors that provided training opportunities. While nerve-racking for many, this component was the high point of summer – a very good test of skills and demonstration of achievements and confidence.

Some Losses, but Also Major Gains

During the programme, participants worked virtually alongside scientists and interacted daily with research students already at the university through the Teams platform. While the close relationships with role models were unique because they were created online, numerous efforts were made to create community. The most important step that was taken was that at least one member of the leadership team (but often more) attended all meetings. This demonstrated their commitment, both to the participants and to the programme.

In addition, participants were paired with current students within the graduate programme. This happened midway through the summer as they began to look at topics for their final research presentations. The pairing was based on an array of criteria, including but not limited to, research interests and home state/community. Pairs were given time to interact and only they were provided access to specific breakout rooms to ensure there was no confusion about who was working with whom. The interaction with the graduate students turned out to be highly productive and satisfactory for the participants.

The virtual programme brought considerable benefits during the times of a worldwide pandemic, both for participants and those running the modules. The online programme places more emphasis on gaining familiarity with computational skills necessary to conduct modern research. Participants also engaged in didactic learning in toxicology and professional training for the first time in the history of the programme. The breadth of this training demonstrated to participants the formal university-like lectures and small group teaching sessions of graduate study, features that prepare students well for a future at university.

Another remarkable bonus of the digital format was that some teaching sessions were delivered by world-renowned scientists working at other universities. Before the pandemic, it was unheard of to have a prominent guest speaker deliver a seminar 'remotely'. Commonly, there would be a formal invitation and weeks (if not months) of planning and coordination and all of this occurred at a considerable financial cost.

The utility of virtual platforms, as well as the greater availability of speakers because of a world under lockdown fortunately increased access to inspirational speakers. The reduced logistical burden of online symposia also provided greater opportunities for participants to ask questions of distinguished scientists that would not have been possible during times of less innovation and flexibility (the pre-COVID-19 world). Because of the newly accepted use of virtual meetings

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and lectures, the METC-SROP was able to capitalise on the incorporation of alumni, colleagues, and other experts by sending invitations as little as one week in advance, as these speakers did not have their usual in-person obligations (because of working from home) nor did they require the travelling and logistical requirements that are associated with guest and expert speakers and their travel.

Those delivering the programme also spotted notable benefits. The organisers found that some of the online lectures could be delivered by current university students and alumni from around the world, who also delivered virtual small group training sessions and interacted with the participants of METC-SROP online. These activities had the added benefit of preparing the university's own present and past scholars for a future career in teaching at university level and helped them develop the necessary skills to inspire the next generation of budding scientists.

As a result of the COVID-19 pandemic, the METC-SROP leadership came away with the blueprint for a successful online education programme in the future. Moreover, as a result of this success, online courses will represent a valuable educational tool even after the pandemic subsides. In coming years, the METC-SROP will not only deliver more virtual educational content, but can also use these tools to bring in additional scholars and teachers, encourage interactions, and build greater relationships between participants and those running the course. This puts the University of Wisconsin-METC at the forefront of online education and provides an example that other universities, and other educational institutions, may find of use.

Meet the researcher

Emmanuel Vazquez-Rivera
Postdoctoral Trainee
University of Wisconsin-Madison
Madison, WI
USA

Postdoctoral trainee Emmanuel Vazquez-Rivera received his bachelor's degree from Universidad del Esta (Carolina) in 2010 and his PhD from the University of Wisconsin-Madison in 2019, where he validated the use of yeast as a model organism to study the aryl hydrocarbon receptor. He continued his postdoctoral training, studying mercury methylation utilising metagenomics and transcriptomics. In addition, he has recruited and trained undergraduate and doctoral students, especially those from underrepresented communities. Seeing this as his passion, he hopes to gain a permanent position, utilising skills learned from this and other training opportunities to prepare the next generation of scientists for biomedical breakthroughs.

CONTACT

E: vazquezriver@wisc.edu

FURTHER READING

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