Increasing personalisation in scientific college courses

In the U.S., women and minorities are severely underrepresented in the science, technology, engineering, and maths (STEM) workforce. Nationwide, and only 40% of students who enrol in a STEM course complete their training. Dr Aditi Pai is exploring the challenge of making undergraduate biology more engaging with the aim of increasing student success. Instead of the traditional approach which uses textbook examples of evolution, natural selection, migration, and genetics, Dr Pai's classes focus on personalisation and the real-life histories of her students at Spelman College.

In the U.S., building a diverse science workforce is a national priority. It has been suggested that one million qualified workers are urgently required in the fields of science, technology, engineering, and maths (STEM). But there is a persistent problem with retaining students in these disciplines, and data suggests that only 40% of students who enrol in a STEM course complete their training.

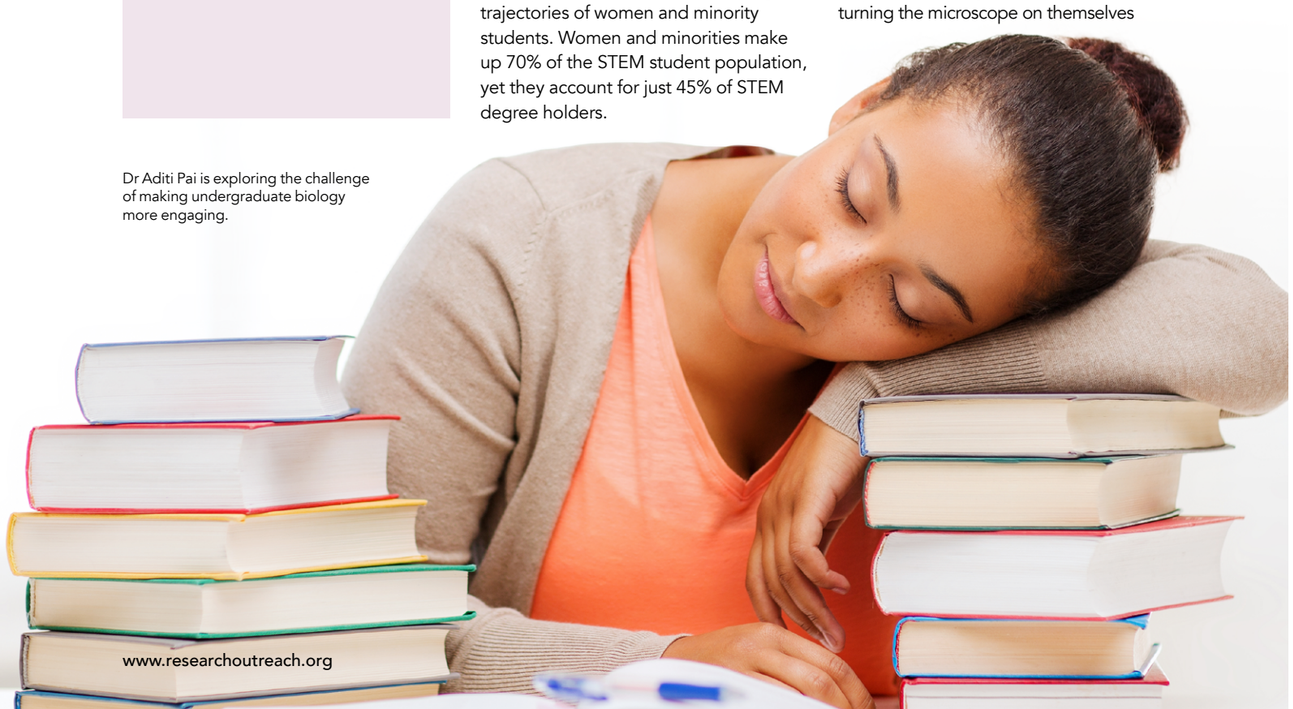
Introductory science courses are one of the biggest points of loss, partly because they are often designed as gatekeeper courses where failure is expected from a large percentage of students. Studies show that many students leave STEM courses because they feel alienated and disenfranchised by the fact-orientated culture of sciences. Students often report feeling isolated by large-enrolment classes and the abstract nature of course material which seems devoid of relevance in the context of their future lives.

These negative influences have a disproportionate effect on the college trajectories of women and minority students. Women and minorities make up 70% of the STEM student population, yet they account for just 45% of STEM degree holders.

This lower graduation rate is resulting in a significant underrepresentation of women and minorities in the STEM workforce. For example, in the workforce itself, African Americans comprise 13% of the total U.S. workforce, but only 3% of the technical or STEM workforce. For all these reasons, educators in STEM faculties must focus on decreasing student attrition by eliminating the factors which lead students to quit their courses.

PERSONALISATION IN GENETICS AND GENEALOGY

In response to these statistics, Aditi Pai, Ph.D., is working to increase student interest in genetics and evolution. Dr Pai's revolutionary teaching method, which was inspired by a TV show, "Finding your roots," focuses on personalisation and gives students the opportunity to learn the fundamentals of biology by exploring their own DNA. Through the genetics and genealogy project at Spelman College, students are learning about themselves while they learn science. As part of the program, students are turning the microscope on themselves by looking at their own ancestry and skin pigmentation genes.



Dr Aditi Pai is exploring the challenge of making undergraduate biology more engaging.

Dr Pai is working to increase student interest in genetics and evolution by focusing on personalisation; giving students the opportunity to learn by exploring their own DNA.

Personalisation isn't a new concept, and educators have, for a long time, been aware that it is a successful technique for ensuring ideal learning outcomes. There are various ways of delivering a personalised curriculum. These include *individualisation*, which is the adjustment of the pace of instruction for students, *differentiation*, which is the adjustment of the instruction to students' learning preferences, and personalisation, which is the consideration of the relevance and interest to students.

Previously, within the boundaries of traditional curricula, it has been difficult to execute this student-centred learning method. However, advancements in educational technology now facilitate the delivery of content according to students' preferences. Despite this, personalised learning is still a relatively uncommon approach to rectifying the issue of a lack of student engagement in STEM subjects.

A UNIQUE APPROACH TO STEM CURRICULA

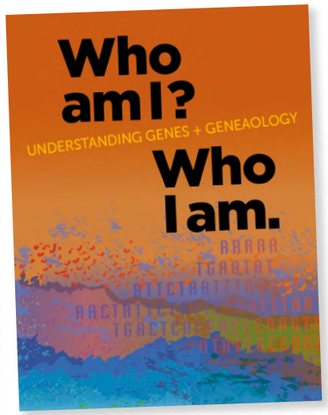
Dr Pai, an evolutionary biologist and faculty member of Spelman College's biology department, is exploring the challenge of making undergraduate biology more engaging for students. She is doing this by personalising the learning experience for every student, with the aim of improving student success and increasing the motivation to undertake a science major. The program introduces students to central biological concepts while looking at human variation and health. Instead of the traditional approach which uses textbook examples of evolution, natural selection, migration, and genetics, Dr Pai's classes focus on the real-life histories of her students.

This unique undergraduate biology program is being conducted at Spelman College, and more recently at two other historically black colleges (Morehouse College and North Carolina A&T), in association with Joe Graves, Kelsie Bernot, Wallace Sharif, Anna Powolny, and Gene McGinnis. A similar program for middle school students is run by Nina Jablonski (Penn State) and her team in summer camps. Spelman College is a small, selective, historically black college for women in Atlanta, Georgia. Spelman has had a positive impact on increasing representations of African Americans in the STEM workforce. The college places a strong focus on interdisciplinary learning, which makes it the ideal institution for Dr Pai's program to take place. Biology is one of the largest majors at Spelman, with approximately 110 of the 500 incoming freshmen enroling in first-year biology each year. Yet, of the 110 students who enrol in the freshman biology class, only 65 graduate as biology majors and almost 25-35% of students leave by the end of their introductory core sequence.

African Americans comprise 13% of the total US workforce but only 3% of the technical or STEM workforce.

MODERN GENETICS AND EVOLUTION

Dr Pai and colleagues piloted an introductory biology class where the course focused on the personalisation of materials to each individual student. The program, which was funded by a National Science Foundation grant, aims to promote science education through an interdisciplinary approach. Its objective is to facilitate the engagement of disadvantaged and minority students in science. By using students' personal DNA, the team is working to increase effort and excitement with the ultimate goal of seeing better representation in the STEM workforce.



Spelman College students conduct a 'Study of me' where they learn the principles of inheritance, modern genetics and evolution.

This approach focuses on genetics and genealogy in an effort to increase engagement while providing students with a strong knowledge foundation on which they can build their future STEM education. In the class, students learn the basics of genetics and evolution by using genetic testing kits to explore their own DNA, or with a DNA sequence of an online avatar. This exercise was designed to encourage students to investigate their own personal narrative using biological and historical tools. Genetics, DNA, personal genealogy and family history combine to answer the question, "Who am I?" Students in Dr Pai's class conduct a *'Study of Me,'* where they learn the principles of inheritance, modern genetics, and evolution. Other unique features of Dr Pai's curriculum include its interdisciplinary approach - using history and sociology to give biological data context. The program is also novel in its use of visualisation tools for understanding genetic data.

Through Dr Pai's personal genomics program, students who once viewed biology as being far removed from their lives have been given the opportunity to see science in a much more personalised way. And, the course has proven itself to be an excellent tool for achieving the goal of inclusive excellence in STEM subjects.

IMPROVED ENGAGEMENT AND OUTCOMES

Data collected at the beginning of this project suggests that students were enthusiastic about a personalised curriculum in biology classes. Eighty-nine percent of students that were asked stated that they would enrol in a genetics class that used their individual genetic data, and 65% of students said that they would be more likely to enrol in a biology course which offered DNA testing than one without this option. Overall, students reported that they were "very excited" about the specific elements that would be incorporated in the personalised genetics and genealogy course.

In addition to students reporting high levels of engagement, Dr Pai and her colleagues also demonstrated improved outcomes for students who studied biology through their own DNA. Results show that there is a significant difference in the success rates of students who participated in the personal genomic analysis and those who did not. In 2017, over 90% of students who participated passed the course, compared to just 50% of those who did not take part. The withdrawal rate was lower in those students who used the personal genomic kits, and growth was also noted in students' engagement in classes using personal genomics. Students' learning gains also increased, and there was a clear improvement in their general knowledge, understanding of skin pigmentation, and of human evolution and speciation. Overall, around a 20% knowledge increase was seen after the genes and genealogy modules had been completed.

Dr Pai's unique approach to Spelman's introductory biology course focuses on genetics and genealogy in an effort to increase engagement.

Approximately 220 underrepresented female students have benefitted from this personalised course during its first three years, and hundreds of other students benefitted from attending talks from experts on 'Race, Genetics, and Genealogy.' Additionally, more than one dozen faculty members at three historically black colleges and universities are receiving training via faculty development workshops. Dr Pai predicts that the biggest impact will likely be from the dissemination of the gene and genealogy modules and supplementary talks, and the DNA Portrait Builder app, which has the potential to be adopted by faculty anywhere.

To find out more about the Genes and Genealogy Project at Spelman College, visit https://www.youtube.com/ch?v=K0wMH69b7EY

Behind the Research

Dr Aditi Pai

E: apai@spelman.edu **T:** +1 404 2705778 **W:** https://www.youtube.com/watch?v=K0wMH69b7EY

Research Objectives

The Genes and Genealogy Project at Spelman College is an innovative research-based program that aims to promote science education through an interdisciplinary approach using genealogy, and for students to engage in biology concepts through exploring their personal DNA.

Detail

Dr Aditi Pai
269 Science Building,
Biology Department,
Spelman College,
350 Spelman Ln,
Atlanta, GA 30314

Spelman College
A Choice to Change the World

Bio

Aditi Pai is an evolutionary biologist and faculty in Biology Department at Spelman College. In 2018, she was selected for the Governor's Teaching Fellowship by the University of Georgia, Athens. Pai has served as Vice Chair of Biology and is currently co-director of Spelman's Teaching Resource and Research Center.

Funding

National Science Foundation

Collaborators

- Nina Jablonski, Penn State
- Joe Graves and Kelsie Bernot, North Carolina A&T
- Wallace Sharif, Morehouse College
- Anna Powolny, Gene McGinnis, Jennifer Kovacs and Yonas Tekle, Spelman College
- Lynn Fellman, Fellman Studio

References

The Genes and Genealogy Project at Spelman College, YouTube video https://www.youtube.com/watch?v=K0wMH69b7EY

Spelman College News, 2015. "Aditi Pai, Ph.D., Leads Pioneering Genetics and Genealogy Program with Students Tracing Ancestry." https://spelman.edu/about-us/news-and-events/our-stories/stories/2015/11/20/aditi-pai-ph.d.-associate-professor-of-biology

Penn State Digital, WPSU. Finding your roots: the seedlings. Dig into ancestry with genetics and genealogy. https://wpsu.psu.edu/digital/finding-your-roots-the-seedlings/

Personal Response

What is a realistic goal for women and minority representation in the STEM workforce in the next ten years?

" From 1990 to date, STEM fields have seen an overall increase in representation of women in the workforce, however representation of women is very specific to the particular STEM field. For example, in the health sciences, women now comprise 74% of the workforce whereas only 14% of Engineering workforce are women (Source: Pew Research Center, 2018). Similarly, Blacks and Hispanics continue to be underrepresented in STEM workforce (Source: Pew Research Center, 2018).

Studies reveal that workers from underrepresented groups state 1) lack of access to education, 2) lack of encouragement, 3) lack of role models and 4) discrimination as some of the major factors that hinder their progress in STEM fields. Therefore, the best way to ensure that the STEM workforce is representative of the nation's population is to focus on eliminating the above sources of bias from workplaces and institutions of higher education. A key component of this would be to make science education more inclusive, for example, through curriculum reform such as personalisation. "