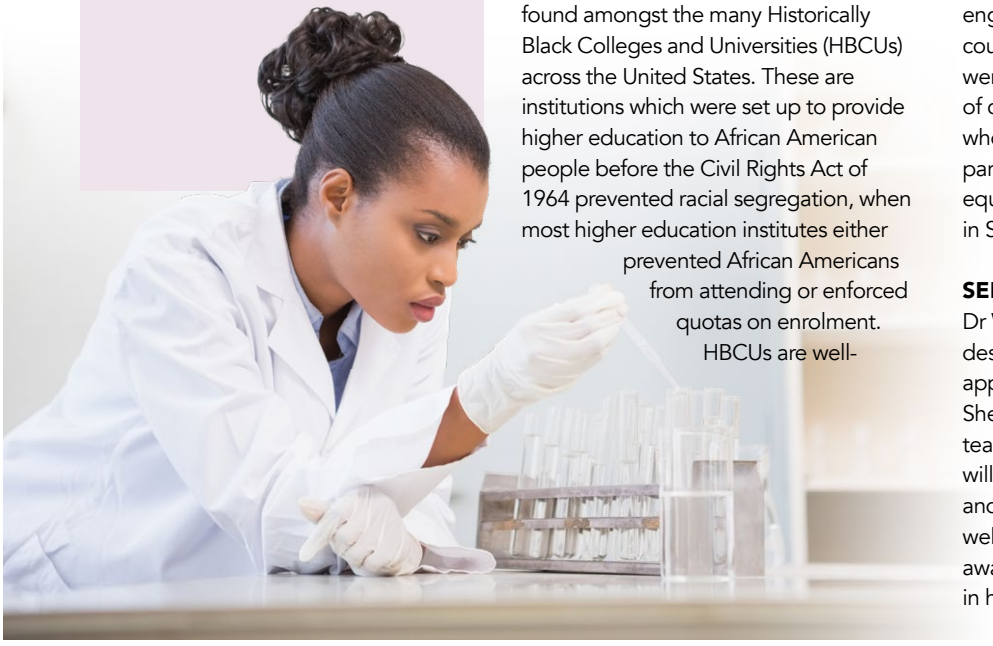
Inquiry learning:

Empowering African American women in STEM

By employing modern theories of learning such as metacognitive skillfulness, agency, and inquiry-based learning, Dr Leyte Winfield, former Chair of the Department of Chemistry & Biochemistry and current Chair of the Division of Natural Sciences and Mathematics at Spelman College in Atlanta, GA, is creating an environment where African American women can gain critical thinking skills to thrive in Science, Technology, Engineering and Mathematics. Students learning chemistry at the college are being educated through authentic, culturally-relevant learning experiences.



African Americans make up almost 15% of the United States' population. Despite this, in 2013, around 5% of PhD recipients in the US were African Americans, and fewer than 1% of PhDs were awarded to African American women. Whilst African American women are well-represented early on in higher education in Science, Technology, Engineering and Mathematics (STEM) subjects, the proportion of this demographic drops at each point along the 'STEM pipeline' – the journey through STEM education into the workforce. The under-representation of black women in academia may not come as a surprise, but these statistics reveal a startling injustice: African American women face significant barriers to progressing in STEM careers.

Research often highlights this issue, but there is little information on successful measures for improving retention of under-represented groups in academia and into the labour force. Measures for broadening participation of African American women in STEM may be found amongst the many Historically Black Colleges and Universities (HBCUs) across the United States. These are institutions which were set up to provide higher education to African American people before the Civil Rights Act of 1964 prevented racial segregation, when most higher education institutes either prevented African Americans from attending or enforced quotas on enrolment. HBCUs are well-versed in providing an education for African Americans and facilitating their progression through academic science.

SPELMAN COLLEGE

One such institution is Spelman College in Atlanta, Georgia. Spelman College has been educating African American (AA) women since 1881, the first institution created for this purpose, and is the top bachelor degree granting institution of origin for AA females who go on to earn STEM PhDs; the second for AA individuals in general. More than half of the faculty members in Spelman's STEM departments are female, 64% of whom are African American. One-third of those entering Spelman's degree courses major in STEM subjects.

Dr Leyte Winfield is the current Chair for the Division of Natural Science and Mathematics at Spelman College. In her previous position as Chair of the Department of Chemistry & Biochemistry, she was able to redesign the organic chemistry curriculum in order to better engage the female students in her courses. More specifically, the measures were designed to increase the number of chemistry and biochemistry majors who persist in this course of study, as part of a broader goal of creating better equity for African American women in STEM higher education.

SELF-GUIDED LEARNING

Dr Winfield's approach to curriculum design runs counter to the 'chalk and talk' approach common in university settings. She uses interactive engagement teaching strategies, which she hopes will benefit institutions with culturally and ethnically diverse populations, as well as contributing to the general trend away from lecture-based content delivery in higher education.

COMMUNITY OF INQUIRY

The type of self-regulated learning Dr Winfield is employing in the department is based on a framework for learning called Community of Inquiry (CoI). The CoI framework identifies that social, cognitive and teaching factors are all important in shaping how people learn. Combining these factors creates an environment where learning can occur through group work on problem-solving, with an emphasis on questioning and critical thinking. Dr Winfield's research explores what happens when the CoI framework is used with students who have been taught theories of metacognition and agency.

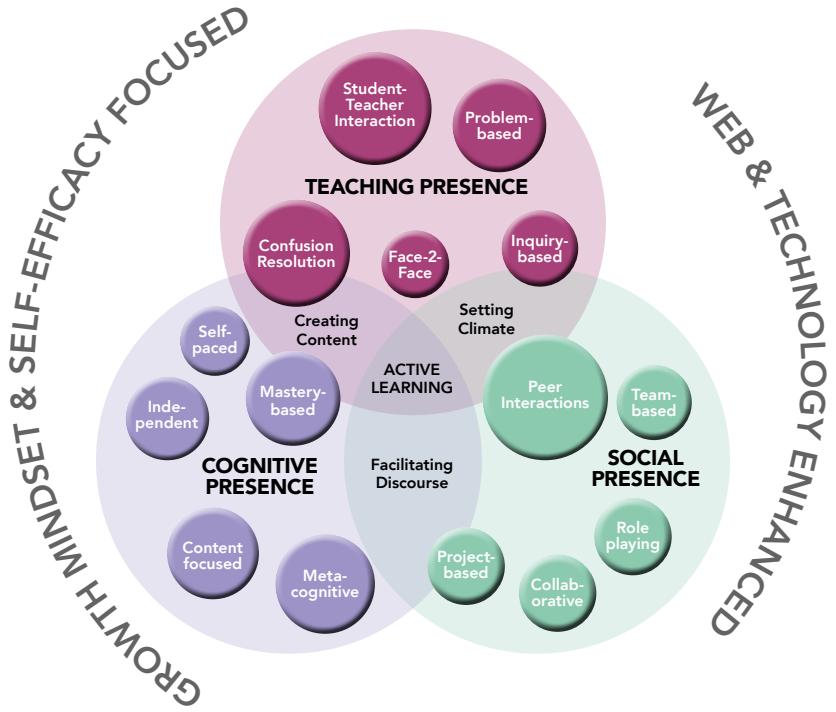
METACOGNITION AND AGENCY

Metacognition, or more specifically metacognitive skillfulness, is an awareness of how learning occurs – or more simply, 'thinking about thinking'. It can be used to self-evaluate and influence learning. Agency is a description of someone's ability to control their own actions. Learners with a sense of agency are more able to engage with and invest in learning. In combination, metacognitive skillfulness and agency allow learners to self-regulate by setting goals, employing effective learning techniques, and examining the results of their efforts.

IMPLEMENTING THE FRAMEWORK

Dr Winfield began to implement the CoI framework to find out if this learning environment would improve students' ability to learn and utilise key ideas in organic chemistry. Could a Community of Inquiry framework encourage students to engage actively with their own learning? Could self-regulated learning still ensure that students were able to learn the content? Organic chemistry is essential for advancement into many biological and health-related careers. It is a popular course at Spelman College, despite its difficulty. As a result, a high number of students struggle with the academic rigor. For Dr Winfield, this makes chemistry an excellent focal point for innovative teaching methods that could improve diversity across STEM subjects at higher levels.

This framework for teaching manifests itself very clearly at Spelman College. For a start, the classrooms in the Albro-Falconer-Manley Science Center, where chemistry and biochemistry courses are taught, have been remodelled to facilitate



The structure of the chemistry course at Spelman College is loosely based on the Community of Inquiry (CoI) framework which connects elements of social presence, cognitive presence, and teaching presence.

active learning: they contain modular workstations for group work, holding data projectors and computers. Now more than half of the STEM faculty use digital teaching methods which facilitate active learning. Instead of using classroom time for organic chemistry lectures, students now watch narrated presentations on a digital platform, followed by an online quiz, utilising a technique known as 'flipped learning' – so-called because the impetus to learn is 'flipped' onto the student. The benefit? More classroom time is now free for face-to-face skills development, guided by worksheets.

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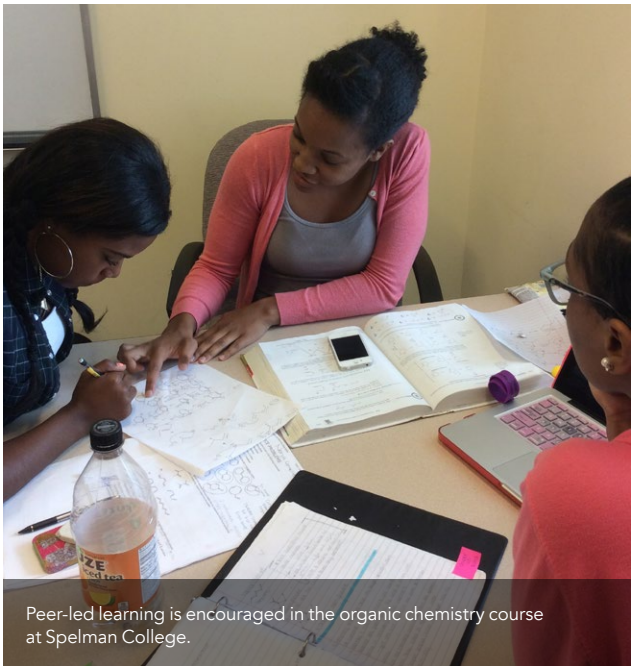
Dr Winfield hoped that this combination of flipped learning with classroom-based inquiry and digital learning would have a positive impact on her students.

The Community of Inquiry framework applied at Spelman College improves students' ability to learn.

Organic chemistry lab courses at Spelman College place emphasis on inquiry and discovery.


Peer-led learning is encouraged in the organic chemistry course at Spelman College.

After measuring performance over two consecutive year-groups, Dr Winfield had an answer: not only was the academic performance of the students comparable to those taught using traditional methods, but pre- and post-testing of students also showed that students remained motivated throughout the course, and demonstrated more responsibility for their own learning. What's more, students interacted more with their peers – a skill that Dr Winfield thinks is an important one for student self-belief.

IN THE CLASSROOM

One challenging aspect of the chemistry curriculum is organic chemistry, which deals with large, complex molecules. In organic chemistry, high-level concepts are made even more difficult by the need to visualise chemical structures in three dimensions. Traditional pen-and-paper representations limited to two dimensions mean that many students struggle to make links between representations of molecules and the three-dimensional molecular world.

Dr Winfield's approach here is to turn to digital tools for inquiry-based and peer-led learning. In one organic chemistry course, students are given instruction on how to use the digital tools, and by visualising chemical structures on iPads and physical models, students work individually through a problem sheet. This inquiry-based approach is followed by small-group discussions where peer-led learning can occur, and an instructor is available to answer questions and confirm answers. Across the four years this method has been used and evaluated, 71% of students felt that using technology was valuable or extremely valuable, and 79% thought that the iPad app should be used in future teaching courses for the same material. Inquiry plays an important role in laboratory work too. Lab courses are being moulded into experiences which place an emphasis on inquiry and discovery. Prescriptive instructions are removed, and experimental outcomes are left to the students to discover. By closely mimicking research procedures, students learn problem-solving skills important for STEM careers.

Now more than half of the STEM faculty use digital teaching methods which facilitate active learning.

EXPANSION

More recently, Dr Winfield has been able to complete a five-year assessment of the flipped learning format. This evaluation indicates that students perform better under the flipped learning teaching style than students did previously. As a result, Winfield has expanded and honed the format for other organic chemistry courses: the courses are topped and tailed by assessments to check student progress, and include timed elements of individual work, group work and solutions given by the instructor. Evaluations of these workshops once again showed positive outcomes: students valued the workshops, reported higher confidence on completion of the worksheets, and demonstrated learning through the pre- and post-tests.

IMPACT

A major motivating factor in Dr Winfield's curriculum design is the introduction of 'culturally-relevant teaching' – the idea that curricula should be designed with a regard to the culture and language of the students undertaking the course. By utilising discovery learning methods, Dr Winfield has created a curriculum where students encounter rigorous and authentic problem-solving tasks which have culturally-relevant, real-word implications.

Dr Winfield feels that her work is not done yet – she highlights in her research that evaluation of the courses is ongoing. One thing can be said: Winfield's influence is one which, by utilising contemporary teaching approaches, is empowering many African American women with critical thinking skills for careers in science.

Behind the Research

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Research Objectives

Dr Winfield is dedicated to creating culturally responsive initiatives and curricula that result in the productive engagement of minorities and women in various academic settings and in activities that promote gender equity in science careers.

Detail

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Bio

Leyte Winfield is the Division Chair for Natural Sciences and Mathematics at Spelman College. She directed departmental efforts to establish new strategies for structured curricular reform. In doing so, she led the department's efforts to broaden the curriculum to reflect a liberal arts education while simultaneously providing students with resources that promote improved engagement and performance in chemistry and biochemistry courses. She is dedicated to creating culturally responsive initiatives and curricula that result in the productive engagement of minorities and women in various academic settings and in activities that promote gender equity in science careers. Her work currently focuses on characterising agency in interactive and peer learning spaces.

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Collaborators

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References

Winfield, L.; Hibbard, L.; Jackson, K.; Johnson S.S. (2019) Cultivating Agency through the Chemistry and Biochemistry Curriculum at Spelman College. Broadening Participation in STEM, 152-181.

Winfield, L.; Jackson, K. (2014) Realigning the Crooked Room: Spelman Claims a Space for African American Women in STEM. Peer Rev. 2014. 16(2), 9–12.

Hibbard, L.; Fullilove, F.; Winfield, L. (2016) Engineering Course Success Through Interactive Engagement. Teaching a New Generation of Students, A National Symposium [online] Available at: https://facultyresourcenetwork.org/publications/teaching-a-new-generation-of-students/felicia-fullilove-lisa-hibbard-leyte-l-winfield-engineering-course-success-through-interactive-engagement/.

Winfield, L.; McCormack, K.; Shaw, T. (2019) Using iSpartan To Support a Student-Centered Activity on Alkane Conformations. Journal of Chemical Education, 96(1), 89-92.

Winfield, L. (2015) Community-based Interactive Engagement in an Organic Chemistry Course. Appears in: Proceedings of the International Conference of Education, Research and Innovation 2015 (IC-ERI2015) Conference, 16th-18th November 2015, Seville, Spain. ISBN: 978-84-608-2657-6.

Personal Response

Benefitting African American women is clearly a driving force in your research into inquiry learning. Why do you think these teaching approaches specifically benefit African American women in STEM over other demographics?

"I don't believe these practices benefit African American women more than other demographics. I do believe that these teaching approaches benefit diverse populations in general as they are flexible. They speak to individuals with different learning styles and they place students at the centre of the learning activities. Active learning strategies inspire science identities by showing students that you have confidence in their ability to learn at a higher level, thinking critically and acting without prompting but with thoughtful facilitation from the instructor."