There Is Another World Out There: Students of Color and Undergraduate STEM Research

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Abstract: The article focuses on one set of findings from a two year phenomenological study examining effective student/faculty STEM (Science, Technology, Engineering, Mathematics) Undergraduate Research (UR) mentoring relationships and their impact on the goal of retaining students of color in the sciences. The research site was a large urban East Coast public college where three fourths of all incoming freshmen receive need based aid and an estimated ninety percent are students of color. Four student/faculty paired mentoring relationships were followed for two years; all four student participants of color are at the time of this writing continuing to pursue degrees in the STEM disciplines. This article looks at the success of these relationships for students in terms of providing: hands on science, career direction, affective support and identity development. In addition, the findings presented suggest that for students of color in the STEM disciplines, UR is a particularly beneficial pedagogical tool for retaining these students in STEM.

Keywords: Undergraduate Research, Students of Color, STEM, College Retention

“I want the students to see is that there is another world out there… inner city kids seeing that they could be an Einstein, mentoring, and exposing them to the possibility of that world.”

UR Faculty Mentor

Introduction

When first interviewed two years ago at the inception of the study, Justin was a teenager, new to college, and participating in his first UR experience. He is now a junior enrolled in a research college completing summer UR at John Hopkins University. His faculty mentor, Professor R, states that Justin is well on his way to becoming a MD and Ph.D. Professor R. paved the way by making the right phone calls to the right people.

Tosin is a gregarious, talkative young Black female of African descent who had participated in UR for two years at the time of data collection. Professor P was her favorite mentor, the one she says called her “his adoptive daughter” with whom she felt a close relationship – a father-daughter relationship. Tosin is now at a research university completing her bachelors and preparing for graduate school.

Matthew speaks about his relationship with Professor C and the affective and cognitive learning and nature of the relationship, and speaks of it in the present tense.
I can go to him for personal advice. I feel that way. He is a sort of big brother to me for personal issues as well as science. I learned the steps in scientific research, the systemic nature of research, the procedures—literature review, data collection, data analysis, mixed methods.

Anthony, a young man of color from Ghana, who supports a family while going to school and working, described what could be labeled as a flow experience (Csikszentmihalyi, 1991) while doing undergraduate research. He described his UR experience as almost being “lost” in the research. He compares the classroom instruction to UR.

The classroom learning is totally different than the research learning. Organic chemistry in the classes is more memorized. The research experiments are hands on, totally different. With the research there is a chance to think, rethink, rich experience.... Sometimes Professor A does not even ask me to come, and there is such high interest, I want to come and initiate with the professor even on Saturdays.

Justin, Tosin, Matthew and Anthony are well on their way to becoming scientists, doctors and STEM teachers. They attribute their success thus far, in part, to their participation in undergraduate research relationships with caring professionals who provided highly beneficial UR experiences.

**Literature Review**

According to the Institute for Higher Education Policy, the numbers of young men of color completing high school and college and majoring in STEM are far from encouraging (Espinosa, 2010). “National Science Foundation (NSF) data from 2006, reported that Black, Hispanic, and Native Americans made up just 5, 6, and less than 1 percent of STEM bachelor’s degrees granted to men, respectively” (Espinosa, 2010, p. 1).

We now also know that once enrolled in college men and women of color face serious obstacles and challenges to staying enrolled and are thus more likely to leave STEM majors, and perhaps college all together. In Espinosa’s words, “it is no longer enough to simply enroll first-year STEM aspirants. We must identify, pursue and support educational policies and pedagogical strategies that retain underrepresented students in the STEM disciplines” (2010, p. 1).

Recent research indicates that students of color or underrepresented racial minorities (URM) are now entering the STEM disciplines as college freshmen in the same proportional interest (as compared to interest in the liberal arts) as their White and Asian American classmates. However, these students of color continue to graduate with degrees in STEM at a considerably lower proportional rate than their White counterparts. (HERI, 2010). The Higher Education Research Institute’s study “Degrees of Success” states that for URM’s who started as freshmen in 2004 and desired to major in a STEM discipline, they graduated with a STEM degree at completion rates of on average 14% lower than their White and Asian American classmates with the same aspirations. Data indicates STEM degree completion rates across all Racial Groups are low, but with a particular low rate for students of color as compared to Whites and Asians (HERI, 2010).

The literature suggests that undergraduate research is a promising pedagogical strategy for retaining students in STEM. Seymour’s (2004) study concludes that student responses
to their undergraduate research experiences are “overwhelmingly positive” with few negative, ambivalent, or qualified assessments” given. She cites 54 examples of literature on the subject of the benefit of undergraduate research including: research and evaluative studies, descriptive accounts, promotional and discussion articles, histories and reviews (2004). Although the bulk of this work heralds the benefits to students of UR, Seymour’s analysis of this literature has one qualifier, the selections do not most often specifically look at students of color.

In spite of this qualifier, the body of evidence to date supports the goals of the 2002 Boyer Commission Report that promote the UR model for science. Hunter, Laursen, and Seymour’s longitudinal and comparative qualitative study of 367 student and faculty participants in a liberal arts college with a strong UR history, *Becoming a Scientist: The Role of Undergraduate Research in Students’ Cognitive, Personal, and Professional Development*, concludes that well over 90% of both students and faculty believed UR to be beneficial particularly in the categories of “thinking like a scientist”, “becoming a scientist”, and “personal-professional gains” (2006). These categories encompassed as well the development of self-confidence, clarification and confirmation of career paths, graduate school preparation, communication skills acquisition, and ability to work independently (2006).

According to Guterman, “the belief that undergraduate research attracts students to careers in science – and makes them better candidates for such work – has gained almost universal acceptance in academe” (2007). Guterman goes on to cite three studies on the benefits of undergraduate research by Lopatto (2005), Russell (2007), and Seymour (2004) that substantiate this belief.

Additional literature relevant to this study, address issues around doing research with and about people of color or marginalized populations, research that is culturally sensitive and not coming from a deficit perspective. Tillman’s (2002) writing makes the case for research that is culturally sensitive in approach and contextualized in terms of cultural experience and history. Tuck’s (2009) article also seems pertinent in approaching research with people of color from a “desire-based” as contrasted to a “damage-based” framework.

Parsons (2008) asserts that science education research must “consider the positionality of people of color, specifically African Americans in the United States” (p. 1127) and consider that there are costs to individuals and communities when we fail to consider research that is not culturally sensitive taking account of “history, traditions, beliefs, values, and social organization patterns that substantiate and proclaim the worth of their existence” (Parsons, p. 1138). Few studies during the course of this review were found to meet these criteria and few seemed to examine UR through the contextualized and culturally sensitive lens of culture and race.

Pertinent to this discussion, is Johnson’s (2007) view that science education settings and relationships attempt to be “neutral to race, ethnicity, and gender” when in fact this very attempt is not possible and “is not actually working either to diminish the racist beliefs of particular science students or to make science a more comfortable place for students of color” (Johnson p. 816).

In light of this literature review, another study focusing on the UR relationship, especially a small study of this type seems suspect. Yet the author maintains that this study fills a gap in this body of research providing an in depth look at four student/faculty undergraduate research relationships in an urban college with a majority student population of color. Most undergraduate research studies, when they do focus on students of color, look at them within White universities and often with great breadth but not the depth of this qualitative
work. By design, it takes into account the positionality of people of color, and the non-neutrality in terms of race, gender and ethnicity of science education. The approach is an attempt to be both culturally sensitive and not damage based (Tillman 2002, Tuck 2009).

**Theoretical Frameworks**

The study on which this article is based was grounded in two major theoretical frameworks: Critical Race Theory (CRT) and Cultural Historical Activity Theory (CHAT). The theoretical framework of Critical Race Theory (CRT) states that race is prevalent in any discussion of education, cannot be separated from a larger social context, is full of contradiction and complexity particularly as it is institutionalized, and that the disparity in educational opportunity is an issue of civil rights and social justice (Heaney, 2000). In addition, CRT emphasizes the importance of the voices of people of color (Delgado and Stephanic, 2001) and the centrality of experiential knowledge through counter-storying (Solorzano, 1998).

In relation to adult education and higher education, critical race theorists see themselves involved in transformation of the current inequitable educational system to one that contributes to the success of all people of color (Ladson-Billings, 2005). In that regard, CRT has both relevancy and usefulness for STEM as issues of inequality of representation and participation of students and faculty in STEM disciplines is clear.

Developed originally from the work of Russian cognitive psychologist, Lev Vygotsky (1978), CHAT, a constructivist approach, has both psychological and socio-cultural underpinnings and can be used to examine complex activity systems. In simple terms, CHAT’s unit of analysis is an activity, and that activity is the engagement of a human subject toward the achievement of a goal or objective. In this case, the activity is the undergraduate research mentoring relationship.

CHAT conceptualizes undergraduate research relationships within systems. CHAT then takes a broad view of learning systems looking at all the component parts: instruments, activities, people, environments, rules, community, needs and outcomes and how they operate together, or in contradiction, within the system and without the system to produce learning (Solorzano Engestrom, 1999b). CHAT provides a lens to comprehensively view student/faculty research relationships and its many faceted component parts and their interactions.
For purposes of this study, using the CHAT framework the component parts of the the UR relationships (or activity systems) are as follows:

1. **Subject**: students and faculty, paired relationships and collective relationships
2. **Object**: the research question; goals of completion for UR project;
3. **Rules**: UR guidelines for participation, laboratory rules, research protocol and procedures, financial incentives for faculty, rules of tenure and promotion, family and cultural mores; spoken and unspoken power structures
4. **Community**: culture of the school, and academic department; culture of academia in the sciences; students’ cultures; faculty’s culture
5. **Division of Labor**: role of faculty; role of student researcher; role of administrators; management styles
6. **Instruments**: lab space, tools of the laboratory, manuals, lab materials, laboratory attire
7. **Outcomes**: benefits/costs to students and faculty; student identity development, career direction, enculturation into academia and research culture; benefits/costs to the college and to students’ and faculty’s families and communities; student retention in STEM disciplines

CHAT seems particularly suited for this study because the activity system, undergraduate research relationships, is a complicated unit of analysis encompassing a variety of components contributing to engagement (objective) of the subjects.

CHAT contrasts with other theoretical approaches that attribute engagement to the individual learner, the teacher’s approach or curriculum design, it rather examines the activity system holistically (Roth and Lee, 2007). CHAT allows the research a wide lens both culturally and historical leading to the possibility of an integrative and unified research approach.

“This [CHAT] avenue therefore promises to lead to an integration of research that heretofore has often been kept separate, such as the sociological and psychological prerequisites of educational achievement. A researcher using CHAT therefore does not separate the poverty or culture of urban students’ home lives from conditions of school-
ing, consideration of curriculum, problems of learning, or learning to teach under difficult settings. The research approach is integrative, broad and subject to contradiction.”

(Roth and Lee, p. 226)

Methodology

Data Sources

The study site was a large East Coast urban public college where half of the student population report being born outside the US, and two thirds are first generation college students. In addition, approximately three fourths of all incoming freshmen receive need based aid and an estimated ninety per cent are students of color. Four student/faculty paired undergraduate research relationships were the focus of the study over a two year span. Students and faculty were all involved in either physics or chemistry research on site in both summer and year-long projects.

By research design, seven of the eight participants were faculty and students of color selected because they were part of a special college initiative to enroll and retain students of color in STEM and suggested by administrators of the initiative as having successful mentoring relationships. Student researchers were required to retain a minimum of a 3.2 GPA with continued college enrollment in STEM to participate in the two year study.

At the beginning of the research, all participants were either freshmen or sophomores enrolled in a chemistry technology associate degree program or a teacher education program at the research site. By the completion of the study, all four participating students were successful in completing a two year degree and three have transferred to research universities to complete their studies and to go on to graduate school, or in one case pharmacy school. Chart 1:1 outlines some basic demographics of the student participants.
CHART 1: 1 – Student Research Participants

<table>
<thead>
<tr>
<th>Student Researcher</th>
<th>Age</th>
<th>Gender</th>
<th>Race</th>
<th>Country/ Continent of Birth</th>
<th>Previous Schooling</th>
<th>Research Focus</th>
<th>Current Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justin</td>
<td>Under 21</td>
<td>Male</td>
<td>Black</td>
<td>USA</td>
<td>USA public schools</td>
<td>Organic Chemistry</td>
<td>Transfer major research institution</td>
</tr>
<tr>
<td>Tosin</td>
<td>22</td>
<td>Female</td>
<td>Black</td>
<td>Nigeria</td>
<td>Nigeria</td>
<td>Organic Chemistry</td>
<td>Transfer to large research institution</td>
</tr>
<tr>
<td>Anthony</td>
<td>21+</td>
<td>Male</td>
<td>Black</td>
<td>Ghana</td>
<td>Ghana</td>
<td>Chemistry</td>
<td>Transfer to Pharmacy school</td>
</tr>
<tr>
<td>Matthew</td>
<td>21+</td>
<td>Male</td>
<td>Black</td>
<td>Guyana</td>
<td>Guyana</td>
<td>Physics-Climate Change</td>
<td>STEM teacher education program</td>
</tr>
</tbody>
</table>

Data Collection and Analysis

A total of fifteen and a half hours of interviews and focus groups were conducted. Both the interviews and focus groups used a semi-structured questioning format. Written surveys were completed by three of the eight participants as well. Fact sheets from student participants were created from the institution’s academic records for further analysis.

Concentrated analysis began with coding for emerging categories within the transcriptions of interviews, focus groups, and surveys. For further data reduction and visualization of the broad categories, matrix displays were utilized (Miles and Huberman, 1984) using the emergent themes as matrix headers. Cross-case analysis compared responses from students with other students and faculty with faculty, as well as a comparison of student and faculty responses with one another.

A second layer of analysis utilized the CHAT framework and categories. Data was analyzed and coded into one of the seven CHAT categories to examine the complex relationships and in some cases contradictions between certain coded categories.

Validity and Reliability

Two techniques were employed to ensure validity and reliability: data and method triangulation, and member checking (Lincoln & Guba, 1984). Member checking was a particularly effective technique in that the data collection and analysis covered a span of two years during which time participants were engaged in the research, completed their work, and in the case of three of the pairs, moved on to research universities or graduate school. Participants were then able to reflect on the research relationship from a vantage point of time and space.
Limitations

The literature in the field supports the need for an in depth qualitative study examining up close the benefits and costs of UR in social and cultural context with students and faculty who are underrepresented in the research. And at the inception of this study, African Americans males born in the US and having attended US schools were envisioned in the program design. However, the available pool of undergraduate research relationships including this group was limited; therefore, students of color born in other countries but currently American citizens were included. This phenomenon and study limitation raises issues for further investigation.

Study Findings

The findings seem to suggest that if colleges and universities want to retain students of color in the sciences and produce scientists of color, while compensating for the inequalities and inadequate preparation in the sciences of many marginalized populations, undergraduate research relationships are an effective strategy. The data strongly suggests that the benefits of an UR experience to students is impactful in terms of hands on learning, “opening doors to academia”, affective support, and academic identity development. Consistent with previous UR studies, the findings of this study show that UR is highly positive, “life changing” and “transformational.” Findings further suggest that the impact may be greater for students of color than for White students.

For purposes of this article only the student participants will be discussed and findings pertinent to the benefits to them. It is important to note that significant findings on the emotional, professional and financial costs to faculty were found but are not within the purview of this article.

“You Think with Your Hands” – Hands on Learning

Data indicates that UR bridges classroom learning with hands-on application that is experiential and yields understanding of the sciences that a classroom experience ordinarily does not. This not to say that traditional classroom instruction is not effective but that in tandem with UR, classroom learning can be actualized. Students learned vocabulary, research methods and techniques, how to do analytic thinking, and how to complete a literature review.

As part of the hands-on, experiential nature of the research mentoring the findings suggest that these relationships are marked by intensity of time and emotional output. The study participants spent between twenty-five to forty hours per week doing research and received no college credit. In addition to time intensity, student participants spoke of the intense transformative nature (Mesirow, 2000) of these relationships for their personal, cultural, social, and academic lives.

During the Justin’s initial summer of UR with Professor R, Justin reported working five days a week involved in creating an organic molecule to mimic photosynthesis, dealing with alternate forms of energy. Justin describes his relationship with Professor R as both personal and professional.

Professor R gives advice, sets up what you should do with the experiment then gives you the freedom to do it. It is very hands on.
He spoke of UR as less pressure overall because there are no grades. He states that the science classroom is more pressure, more penalizing whereas the research is hard work but not pressured. It is an atmosphere where you can make mistakes, learn from your mistakes, and practice what you talked about in the classroom.

Tosin describes her UR experience with Professor P as transformative and “life changing”.

I learned the basics of procedures, inquiry and analysis, to be well-prepared and to question. I have learned to follow the steps, persevere, and the danger of chemicals. I learned how to do a literature review….. Now I own my own laptop, I have had a change in my reading. I use to read romance and fiction. Now I read more research and am better at math.

Tosin went on to describe at length the intensity and her investment in her UR experience.

Most of the time I am engaged, real focus, really engaged. There have been times when I haven’t eaten in two days, forgot myself in the lab even when the school was closing. School closes [in summer] at 5 p.m. I stayed until 7 p.m. with no lunch one time I had more stress. I was crying. I was so engaged, so invested when I almost finished.

Matthew stated that he became a better writer. Matthew would bring the research writing to Professor C his UR mentor, and Professor C would revise and make it more concise. “He would say it in fewer words”. The research writing process was hands on at every stage: drafting, revising, re-drafting, revising further, editing with the end of goal of publication.

Similar to the other three participants, Anthony compared this experience with what he says was available to him in Ghana and sees it this way.

In the beginning [undergraduate research], I was very frustrated and Professor A intervened and showed me alternate ways. It is like an apprenticeship experience….. but in Africa if I would have done this research and become frustrated the research would stop there. There would have been no one to edge you on….. this applies to Black males, Black males give up too easily…. this is why Africa can’t develop.

One of the faculty participants stated that UR is authentic, empowering learning and should be authentic research, as well as a type of on the job training experience.

Research is experiential learning which needs organic chemistry… you think with your hands. More discoveries needed, liberating and empowering. With research, it is OK to be wrong… we are teaching institution. A mentor is like a job. I am the boss.

“Opening Doors to Academia” – Career Guidance

For the four students in this study, their UR experiences were “door opening” opportunities. Faculty served as doorkkeepers, or perhaps more accurately door openers, opening doors to career opportunities, graduate school, publishing, scholarly worlds, scholarships, and the science/academic culture. The faculty role is one of ushering students into and guiding students to navigate a new cultural world of academia with new social capital. This is no small function. Participants felt that they would not survive in academia with its very competitive
edge and set of rules without someone to “open the door” and hold it open until students can do this for themselves. Justin describes this door-opening role this way.

We have conversations on my future goals, the best way. Usually there is a distance between teachers and students, I keep personally keep a distance, with most professors I keep a distance and move on. But something different happened with Professor R, I opened up a little.

Justin went on to say that he was the first in his family to go to college, and his parents, although well meaning, knew very little about academia especially the opportunities in STEM. Justin had been planning to attend a local city college because that was all he knew until Professor R explained to him the larger opportunities in major research universities that could be open to him.

Subsequently, Professor R arranged for Justin to do summer research at John Hopkins University and guided his transfer to a reputable research college to finish his undergraduate degree. Professor R believes that Justin is well on his way to completing his medical degree and further research. He admits that when Justin came to him he had no clear direction of where to study. Professor R did the networking for him, introduced him to the right people, ushered him into the science community. Here’s how Professor described his UR mentor role.

We [faculty and student] are both students – one is new and I am experienced. Also, we teach them professional behaviors, be on time. We also give advisement, with graduate school, advancement, where to go.

Tosin’s reason for entering college was to get a job and make good money for her and her family. But as a result of her UR experience and her relationship with Professor P, she stills wants that but also sees herself making a contribution through science to humanity and giving to other students the way her UR mentor gave to her.

Tosin’s UR Mentor came from a career in industry before joining academia and had an industry perspective on the uses of an undergraduate chemistry degree. He frequently communicated this to Tosin and other UR researchers.

We also need to help them [students] think about employment, not all will go to graduate school or want to. I don’t think graduate school is essential for everything. With a BA in chemistry, they can do research at Pepsi, other labs, or pharmacies.

Professor P saw part of his job as working with students to see both the employment opportunities in both industry and academic research and having conversations around these STEM opportunities with students.

At the time when Anthony was first interviewed in 2008, he was a sophomore majoring in chemical technology. Two years later he is a pharmacy student at a Boston College. His UR mentor, Professor A, was one of the “counselors” who guided him in his career decision-making process. But he not only guided him, he made the connections that Anthony needed. He made the “right phone calls, spoke to the right people, and wrote the reference letters.”

Particularly for young people of color, this networking is crucial. They often do not have the social capital to negotiate the academic systems. The case can be made that due to unequal
educational opportunity, lack of social capital, and discrimination, we have had a history of
gate-keeping in the sciences rather than door-opening. Therefore this networking and door-
opening role is particularly important.

Anthony has had additional conversations with his mentor in regard to research and Africa;
he is still uncertain and ambivalent about his future but does have someone to discuss these
important career decisions with.

…Something is telling me I should go into research. In Ghana there is no research in-
terest. Should I go back to Africa? This is new thinking that I might want to do re-
search…. Professor A talks to me about how research is fun. How research helps hu-
manity, helps society, the purpose of research. Professor A doesn’t think of money or
to get rich but to help humanity, medicine, goal to help mankind.

Data indicated that this kind of reflective thinking and transformative conversations occurred
frequently between UR students and their UR mentors.

“Science and Life Mesh” – the Affective Nature of UR

The best way to teach physics or computer sciences is to be a guide, and being a
mentor and researcher are inseparable for me. Science and life mesh… There is a mer-
ging all the time. I help them with their personal problems, difficult professors, family
life, finances, textbooks, spiritual advice, their futures.

Professor C

Data analysis, and specifically enumerative analysis of the transcripts, revealed that both
student and faculty spoke about the affective nature of the relationship far more than the
learning of science. The emotional support appeared to be a significant aspect of their UR
experience.

A case in point is from two extensive interviews with Professor C, who spoke far more
about the affective and interpersonal nature of the UR relationship than the academic. Al-
though his students were highly successful academically, doing much of the research through
NOAACrest in partnership with a larger university system and on occasion co-authoring
with him and other scientists, while sustaining high grades; these are not the aspects of UR
that he most spoke about. To Professor C the affective and cognitive were clearly linked in
his mind, with affective learning seemingly paramount.

The students are suffering. Can’t just ignore that. Cannot separate from the “whole”
life. This achieves better results on the research end. I think this relationship is unique.
I think my colleagues do not care about the life experiences. I am very involved in their
lives. Other mentors choose the “crème of the crop”. I don’t always choose the “crème
of the crop”. I build them up.

Professor C expressed that the way other faculty treat the students angers and frustrates him.
In his mind, they are not giving them the affective and caring support they need. Particularly
when he spoke of young men of color in the sciences, he felt they needed particular affective
support because they were hurting and did not always come with the same academic preparation as others.

From a student’s perspective, Justin explained that other professors saw promise in him but never “pushed”. Professor R made the effort. Justin describes Professor R as an advisor, mentor, friend, a mixture of student, teacher, and colleague.

Tosin describes herself as the teacher/assistant to her mentor in the UR lab having the keys to the lab, and the professor’s cell phone. She stated that Professor P told her she could call him at home about the research, if needed. She defines her UR relationship “as a long-term academic relationship, daughter, and mentor for the future.” She understood her relationship with her mentor to be of father/daughter nature.

According to Tosin, she had conversations with Professor P around race, culture, career, gender, and conflicts she was having at home. At the time of the initial data collection, Tosin was living at home with her parents and was having heated arguments, particularly with her father, around coming home late at night from studying, a woman’s role, and a woman’s career, and science study. Tosin spoke with Professor P about differing cultural traditions in Africa and America, and Tosin’s responsibility to herself and her STEM career, plus her responsibility to her family both in America and Africa.

When first interviewed Tosin met a new boyfriend, a STEM major also. Tosin said Professor P was one of the first to meet her boyfriend. Professor P, and others, helped her navigate the many contrasting cultures – academic, research, familial, ethnic – and the contrasting mores, expectations, and meanings these contexts presented. There were many conflicts and contradictions for Tosin as she studied science and grew as a student researcher, but she said she was growing through it all.

Anthony was clear about the impact that Professor A and the research relationship had upon him. Interview data reports him describing this impact.

More than a mentor. Wow! He guides then leaves you and gives you space to try yourself. Professor A comes to my level. Talks to me. Sometimes personal things. We talk about music, philosophy, Socrates besides the research. Ushering you in [academic world], building confidence…. I have not shared certain personal problems like a counselor, but I feel I could if I wanted to. Oh yes, I could go to Professor A with a personal problem.

In fact, the second interview in 2010, Anthony reports that he did discuss a personal problem with Professor A – the ramifications on family and his wife of his being separated from them during graduate school.

Because all participants were people of color, accept for Professor P who is White, data around the race of the faculty mentor as it regarded the affective nature of the UR relationship was broached. Justin stated that he has had three mentors in his life, Professor R being the most recent. The first was a junior high White male science teacher, and the second was in high school, a Black male. When asked if race or gender mattered, his response was:

No, it doesn’t matter. It could be anybody. It could be anybody who is looking out for me.
No, it doesn’t matter.
However having stated this, he went on to refer to his Caribbean-American background and mentioned the importance of family, structure, and the church to him and that sometimes that could be hard to juggle with his research. He talked about his mentor understanding this background because he is Black.

I am able to trust people more. UR has helped me to relax, stay focused, encouraged and not flustered. I guarded myself a lot but with Professor R I began to trust, learned to trust.

Professor R concurred with Justin and admitted helping his students with personal problems. In the case of Justin, he helped him negotiate his family and church life and how science and chemistry can fit in with a background and understanding of faith. They appeared to bond emotionally and intellectually.

When asked about gender and race, Tosin said she feels more comfortable with men in UR relationships because she says “men are steadier with their emotions. Men leave the feelings, but still are close.” When asked if race mattered in mentoring relationships. Tosin responded.

I get better grades with a White professor. The Black professor gave less to the class, race does matter a lot. I prefer to have a White professor, definitely. Black professors are less hands-on in experience. White professors are more hands-on. Right now I prefer White professors.

Neither Anthony nor Matthew thought that race mattered, but what mattered was caring, nurturing and supporting. When asked whether race mattered in the mentor/student relationship. Anthony said “no” but he qualified his answer and elaborated on what he did feel helped.

No, race doesn’t really matter. [But] common experience and background helps. Professor A lived in Africa and had experience in a “third world” country. Then he could lead, relate and transfer.

Students seemed to suggest that they thought the relationships would be long-term continuing long after the actual UR experience and extending into their graduate work and beyond. Indeed, faculty spoke fondly of their undergraduate mentors of twenty and more years ago. For students, these relationships provide significant role models that speak to them of how they want to mentor their own students in the future. These presumably long-term affective and cognitive relationships are summed up by Matthew’s mentor.

Relationship is huge, sense of care, guidance, somebody cares – [they are an] apprentice… we are mentoring them more for careers and life not so much about science. We are responsible for that person’s success. The commitment is life-long.

“Being a Black Scientist” – Identity Development
Throughout the data collection, faculty spoke about the development of a research identity, and faculty saw one of their roles as ushering the student into the academic community and
nurturing the development of a research identity. Justin feels he is now part of a research community and is more determined than ever to be a doctor and researcher. His mentor concurred stating,

Personally, he (Justin) has changed. I can see him thinking as a chemist. Ownership, seeing the world, self-confidence, feel like a chemist, think like a chemist, real world.

Professor R has been mentoring students for fourteen years and has had an average of five to seven students a year. At the time of the research, he had two – Justin being one of them. Of the students he has mentored, he states that easily 80% go “somewhere” else to study after being with him after their sophomore year; some have gotten their PhD’s. He stated that one of his former students is now a professor and “wants to do for minority students what you [Prof. R] did for me.” Professor R, himself, had his own undergraduate mentors. They still email each other after twenty years.

Data indicated that although all respondents felt that generally race did not matter in the relationship, it may matter when it comes to developing an identity as a scientist of color. Professor R explained it this way.

Race doesn’t matter. I have had all types of students… Race is not a major component. What matters is caring, somebody cares. But I will say that a Black scientist does give a sense of somebody I [the student] can emulate, most had never heard of a Black chemistry professor.

Another mentor, Professor C, stated it this way.

Our young Black men are wounded, need healing. They are in pain, especially young Black men. Not many Black scientists doing physics research. The young men see themselves in me.

Professor C’s student, Matthew, confirmed much of what Professor C stated. Matthew began as a student in Professor C’s physics class, and Professor C asked Matthew if he wanted to participate in a research project. The project was on climate change, and its impact on one urban location. Matthew’s goals are to teach technology, obtain his master’s degree, and open his own school – a middle school or high school. He intends to maintain contact with Professor C in the future, as he works toward these goals. Matthew said he wanted to emulate Professor C with his future students.

I’d like to be half as good as him [Professor C]. He instilled a love for research. I want to be like this person.

As a female person of color, Tosin faced obstacles due to gender and race which she grappled with in conversations with her mentor and then described the transformation in her identity as researcher and scientist. As mentioned previously, she shared a great deal about supporting her family and grandmother financially in Africa, her conflicts over differing cultural traditions that her father held, particularly as it related to women and working. She is the first member of her family to attend college and having a career and going to school is a big change for
her family. She discussed her changing identity and here evolution as a college student and researcher

Now I am a scholar, I have changed my major, I have changed the way I think, behave, and have new hope and inspiration. Having mentors – show you your potential, don’t limit yourself.

Through UR, Anthony learned to do what scientists do. He reported an incident with his mentor that encapsulates this process. One day in the chemistry lab, he was extremely frustrated not understanding the results he was getting, and he reported that Professor A directed him to the library to research journals, and research literature. Professor A guided him to additional library resources that he never knew existed. Anthony stated he did not know that this is what scholars do, he did not know that all this material was written, and he did not know how to access it. He stated that he now understands and is able to apply what he has read and feels a part of a research community.

Students reported on the development of scientific jargon, learned procedures, and the need to talk about their research. They spoke of the “consuming” and extremely engaging nature of research. For some students, in order to join the scientific community their transformative learning is manifested in new friendships, expanded experiences, and broader opportunities. These transformations can also be counted as costs or cultural losses to students as the data recorded they admitted to internal emotional misgivings, family conflict, and identity development struggles. In all cases, students stated that faculty had either talked or counseled them around these personal issues as they related to continuing their education, or that if they had a need to talk to someone they would feel comfortable speaking with their mentor. Faculty concurred that they often spoke with their students around personal issues that were either in conflict with, contradictory to, or confusing for their continued work in STEM. Anthony talked about the consuming nature of research and its effect on family and friends.

Time goes so fast [with research]. I had a friend who was doing Ph.D. research, and I could never understand why he was so busy and didn’t have time for the friendship and why he was consumed. Now I understand my friend. There is a need to talk about the research. It is engaging to my wife to a degree, she does not understand it, but she tries to listen. It is always in your head, and you want to talk about it a lot. All engaging – a high level of engagement.

This need to talk about research seemed to also assist Anthony in his taking on his new identity. These conversations with his mentor were apparently very significant to him. Findings from this study suggest that for students of color, negotiating a mainly White culture in the STEM community can be difficult and that UR seems to assist in the development of an identity as a researcher. Findings also indicate that although the race of the faculty mentor did generally not seem to matter to students, it may matter in terms of developing an identity as a Black scientist or scientist of color.
Conclusion and Implications

Consistent with UR literature in the field, the data strongly suggests that the benefit to students is transformative (Mesirow, 2000), and this was certainly true for the young people of color in this study. By its nature, UR provided the four young researchers with hands on experience, career guidance, affective as well as cognitive support, and assisted them in developing their identity as scientists, and this study suggests that this is particularly important for young students of color.

On completion of the two years of data collection, all Justin, Tosin, Matthew and Anthony were still in college. Justin, Tosin and Anthony had transferred to four year research universities of very prominent status in the STEM disciplines. All three intend to go to medical or pharmacy schools and Justin and Tosin intend to have careers in research. Matthew remained at the local college and was completing a four year degree in math education with a goal to go to graduate school and eventually design and start his own school with an emphasis on the STEM disciplines for marginalized students. Three of the four have received full scholarships to complete their undergraduate study.

If colleges are serious about retaining students of color in the STEM disciplines and ultimately addressing inequity of opportunity in science education (Hrabowski, 2009), re-imagining how this powerful pedagogical tool, undergraduate research, can be woven into science education departments and college-wide is crucial.

Espinosa raises the question, especially for community colleges and four year colleges with STEM majors but undeveloped research programs to which a majority of our students of color are attending (2010), is academia willing to make the investment to not only enroll these students but to see them succeed through four years and beyond? Espinosa states it this way.

As the education community has said again and again—an emphasis on college access at the expense of attainment is a faulty proposition. Taking this argument a step further, educators are right to focus on helping students succeed in meeting the goals they have set out for themselves; in this case, a STEM bachelor’s of science degree with the encouragement and support to pursue graduate or professional study (2010).

Taking Espinosa’s argument in the context of this study, UR seems to be a viable pedagogical tool to retain students of color in STEM and see them meet the goals they have set for themselves. Discussions around how academia can further institutionalize and support both students and faculty in UR relationships seems reasonable and responsible.

It is this author’s intent to complete a longitudinal study and follow Justin, Tosin, Anthony and Matthew in the years to come as well as their faculty mentors and the impact that participating in UR research mentoring has had on their careers. With these future studies, it is hoped that we will find all of these students in academic or successful STEM professions mentoring a new generation of scientists. The final word belongs to a student. Anthony in the course of his reflections on the transformative nature of his UR experience now understands that there is a “new world out there” and it is science.

Chemistry covers everything in a different way when you do UR research. I learn about myself. I learn science. I am proud of myself. I see myself as a researcher in the future. I see chemistry and science as life.
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About the Author

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