Chapter 8

COUPLING SOCIAL JUSTICE and OUT OF SCHOOLTIME LEARNING to PROVIDE OPPORTUNITIES to MOTIVATE, ENGAGE, and INTEREST UNDERREPRESENTED POPULATIONS in STEM FIELDS

by **Sheron Mark, Dennis DeBay, Lin Zhang, James Haley, Amie Patchen, Catherine Wong, Michael Barnett**

Introduction: Current Status of Ethnic Minorities in STEM Fields

Ten years into a new century and we continue to face significant social changes that are impacting the economy and workforce. To meet these challenges, there has been an increasing emphasis placed on preparing the next generation to be scientifically literate citizens and to be proficient in the skills required to work in Science, Technology, Engineering, and Mathematics (STEM) career fields. For example, the National Science Board's Science and Engineering Indicators (2010) showed that the science and engineering workforce grew 3.2 per cent on average from 2004 to 2007, a growth rate twice as high as that of the total U.S. workforce. The Bureau of Labor Statistics (2009) also pointed out that the workforce in STEM fields will continue to grow and projected that about 2.7 million new science and technology-related jobs will be demanded by 2018. Despite this rapidly increasing demand for STEM-related careers, a shortage of qualified STEM candidates continues to be of great concern (National Academy of Sciences, 2007). Although the reasons for this disconnect are many and varied, educational inequity is identified as one of the major causes of the so-called "leaky STEM pipeline" through which many ethnic minority youths fall through the cracks from science students to STEM career professionals (Oakes, 1990). Furthermore, without the opportunity to learn science in ways that are personally meaningful to them, many ethnic minority students decide that science just is not for them and voluntarily leave the STEM pipeline. Not surprisingly, educational research is replete with studies that show that ethnic minority youth tend to develop negative attitudes towards science and are

considerably less likely to select science-related professions as their future careers compared to their peers (Norman, Ault, Bentz, & Meskimen, 2001). As Parmer (1993) found nearly 20 years ago, African American youth are strongly influenced by their perceived societal barriers and, as a result, develop limited occupational choices. Although statistics show that ethnic minorities have made gains in STEM professions in recent years, the lack of ethnic minorities in STEM fields is still problematic. In the recent report to the President (President's Council of Advisors on Science and Technology (PCAST), 2010), the council specifically pointed out that *African Americans, Hispanics, Native Americans, and women are seriously underrepresented in many STEM fields* (p. vi). The council further argued that "diversity is essential to producing scientific innovation and we cannot solve the STEM crisis the country faces without improving STEM achievement across gender and ethnic groups" (p. 3). This leads us to ask a very important and critical question: How can we create programs that motivate, engage, and capture the interest of low-income, ethnic minority youth such that they choose to study a STEM field? In this article, we discuss the importance and interplay of three constructs: science interest development, learning science for social justice, and out-of-school learning environments. When integrated together, these three constructs serve as a foundation upon which transformative learning environments can be built that support ethnic minority youth in pursuing STEM fields as future careers.

Developing Science Interest

Many low-income, ethnic minority students describe science as a discipline that generates negative feelings such as boredom, anxiety, confusion, and frustration. Even worse, some of these students feel that they are not "smart enough" for science. Yet there are many exciting projects underway that have found that ethnic minority students from urban, low-income communities do, in fact, develop sustained interest in science (Dierking & Falk, 2010); however, what the research also suggests is that interest in science is not always cultivated in traditional venues like school classrooms, and in fact, more often develops in out-of-school learning environments (Dierking & Falk, 2010). Recent work in counseling psychology and educational psychology suggests that the development of science interest occurs slowly and is full of fits and starts, but generally consists of four interrelated phases (Hidi & Renninger, 2006):

- triggered situational interest: short term, a spark
- maintained situational interest: prolonged
- emerging (less-developed) individual interest: personal mind-state, longer term, supported environment
- well-developed individual interest: long term mind-state- enjoy something very much.

Each phase has differing levels of value and affect and is dependent on the person's experience, temperament, and genetics. In terms of value, the first two stages are often externally generated, while the last two are more intrinsic to the individual. This is a novel way of considering interest and is derived from the Model of Domain Learning, specifically Opposing Theory, where expertise in an area corresponds to interest (i.e., if you are an expert on something, you must have an interest in it). Regarding affect, Hidi and Renniger (2006) go on to say that the earlier stages are characterized by affect, whereas the later stages are more cognitive and characterized by curiosity and a desire to return to the subject area. With respect to education, as interest develops, feelings of self-efficacy do as well: We can become more self-sufficient, raising questions and trying to answer them. It is also important to note that interest typically does not develop in isolation, but plays out through experiences, interactions with others, access to opportunities to explore and experiment, and solve problems that are meaningful and personally important (Ainley & Ainley, 2011). In terms of STEM career education, this is important because STEM self-efficacious individuals persist longer to complete a task, particularly in the face of obstacles. Finally, science interest has, indeed, been found to be a predictor for studying STEM (Tai, Liu, Maltese, & Fan, 2006).

Designing a Program to Generate Interest: The Role of Social Justice

In recent years, both policy makers and educators have focused much of their attention and funding on designing and implementing programs that engage youth in locally relevant problems. A number of successful curriculum projects have emerged but few utilize social justice as the lens through which scientific skills and thinking can be brought to bear to solve local environmental problems. Unfortunately, in many classrooms, the exploration of social justice problems for the purpose of learning science is time consuming and involves the interplay of many complex ideas which are difficult to explore in a meaningful way in a typically hour-long class; however, out-of-school time learning environments often have considerably more freedom (from both traditional curriculum and standardized testing), thus being conducive to engaging youth in solving problems that are personally important to them using a social justice lens. When youth are engaged in addressing social justice problems, learning becomes transformative in nature because youth develop skills that allow them to interrogate the world around them by calling out power hierarchies and injustices, moving beyond just solving a problem for class (Buxton, 2010). For the past six years, with funding from the National Science Foundation's ITEST program, we have been engaging urban youth in an out-of-school time program in which they conduct deep exploration of problems that affect their everyday lives. The core

design principle of this work is to empower youth with a sense of competence and accomplishment, building on their strengths, rather than focusing on their academic weaknesses, while enabling them to apply scientific skills and knowledge to help their community. In the following sections, we present our model for urban science education, Social Justice for Talented Emerging Minds (SjTEM) program and present a single case study of a youth participant in our program to provide an example of how the youth navigate and grow through our program.

The SjTEM Program

We currently have 60 students from Boston Public Schools enrolled in the SjTEM program. A student typically joins the program in the 9th or 10th grade and is expected to stay in the program through their high school graduation. We recruit students who are not the best in their class, but are typically considered ***C*** or average students and are likely to be the first generation in their families to attend college. Most students are initially drawn to the program to learn more about college and navigating the college application process with little, if any, initial interest in considering STEM as a potential career. During their time in the SjTEM program, the youth are engaged in exploring science careers, developing scientific research skills, and learning how to better prepare themselves for college. The career development aspect of the program introduces students to the concept of STEM and 21st century skills and the importance of these in today's society. Additionally, they learn about the transferable nature of STEM skills, meaning that they are important and useful in a wide variety of academic disciplines and career fields. To support students in identifying potentially satisfying future careers, they also complete a number of interest and personality profiles such that they can begin to explore a person-environment fit between themselves and developing career considerations. At the core of the curriculum program are the opportunities for youth to apply their cultural resources and scientific skills to social justice issues that are related to problems in their communities. Not surprisingly, many youth often need a hook or a starter to begin the process of solving a complex problem; however, these hooks often emerge from the youth themselves with support from teachers in our program. From there, youth are provided opportunities and resources (e.g. technology) to solve their problem. The end goal of the program is for youth to become change agents for their community and their own lives by using scientific skills and knowledge to challenge injustices that they have either experienced or see in their everyday lives. This model is historically successful with Freire as an exemplar (Freire, 2007).

In one aspect of our program, youth have been learning how to use Geographic Information Systems (GIS) technologies to examine environmental injustices in the city of Boston. In the process of doing this, one set

of youth was encouraged to look at how easy it was for them to access healthy food. This question emerged from a previous idea that low-income urban areas tend to not have the same access to healthy food as more affluent neighborhoods. The youth soon created a visualization that illustrated their limited access to full-service supermarkets (see Figure 2) which led to the difficult challenge of mobilizing change to address the inequitable access to healthy food. To that end, the youth suggested a market in the area which led our project staff to examine ways to support the youth in reaching their solution. This work soon led to a hydroponic food project (growing food with water and minerals as opposed to soil) in which the youth grow food and sell their produce at local area farmer markets.

In another project, students use CommunityViz (an extension of ESRI's popular ArcGIS software), coupled with field site visits and their own knowledge of the city, to propose development plans for vacant lots or rundown properties. CommunityViz allows youth to make interactive three-dimensional (3-D) models of real places as they are now and as they could be in the future based on specific site designs. Finally, the CommunityViz program is capable of providing a powerful visual interface which is valuable for communicating the urban planning process across the many groups of people who become involved in making decisions about the future of a place. This work was done with a local community development corporation, Madison Park Community Development Corporation (CDC), which led the youth to become the GIS experts for the Madison Park CDC, which in turn led the city of Boston to approve the Madison Park CDC's proposal for redeveloping a parcel of land located in the home neighborhood of many of the youth. Next, we present a case study of one of the youth participants. Sonya is representative of many of the youth in the SjTEM program being an ethnic minority, speaking multiple languages, and being from an educationally limited background, but highly motivated to attend college and attain a successful and satisfying career. Importantly, like many of the students, Sonya entered the program more interested in college exploration and preparation than science and had many of the same preconceived, unfavorable notions about science as described earlier (i.e. difficult, dull, boring, frustrating, etc.). Sonya had undergone the sort of transformation that we aim to see in our youth and, as such, is selected as the case exemplar for this paper.

The Case of Sonya

Sonya was a high school freshman, Latina female from a working- to lower-middle class socioeconomic status with parents from limited educational backgrounds. Neither parent had graduated from high school.

In reflecting on her time in the SjTEM program, however, Sonya clearly stated her initial lack of interest in science, although she did enjoy math: I hated science and technology . . . I thought engineering was about trains . . . but I love math.

During her early time in the program, Sonya's participation and interest in the SjTEM program was driven by enjoyable peer interactions and an expansion of her social circle. She had her established peer group, but also socialized often and comfortably with other students in the program. Academically, however, the social justice, urban planning and development focus, based on caring for and improving the local environment, appealed to and maintained Sonya's interests and facilitated her new engagement with science and technology. These experiences resulted in her changed perspectives regarding science and technology, including a newly found interest in and enjoyment of science, increased science confidence, and an understanding that she can use science to help others. These changes also influenced her most recent career interests which shifted to a number of service-oriented science and technology careers. In particular, regarding her growing interest and enjoyment of science, Sonya said:
Science could actually be fun. You can be outside, do graphs that you don't do in school. In school, [for math, you use…] only calculators and pencils. When you do work that is fun, it is easier to memorize. At school, you just get nagged to do things that aren't fun.

Importantly, Sonya attributed her new interest and perspective on science to the opportunity to engage in student-driven, hands-on, inquiry-based scientific activities which were unlike what she would be required to do in school science. Secondly, Sonya always considered herself smart and knowledgeable. These feelings of confidence and competence were now, however, extended to science. In the activity below, Sonya progressed through the work successfully and engaged her instructor to show the high quality of her work:
Sonya to Instructor: *Excuse me. Look, I did that.* [Sonya points to her computer screen].
Instructor: OK.
Sonya: *No pollution.*
Instructor J: Wow! Got more energy. More commercial energy. . . Looks like you got more jobs, too. Jobs and housing. Energy, water, barely any. And energy use...[Sonya points at the screen, leading Instructor J through each output indicator].
Sonya demonstrated great personal responsibility and investment in the quality of her work, including a PowerPoint presentation documenting her group's redesign of the city block, the environmental and social

impacts of their design, and documentation of their research team's activities. She showed pride in her work, not only the aesthetics of the design for the parcel of land, but the STEM-related results, such as level of pollutants and energy use. Throughout her time in the SjTEM program, Sonya emphasized that she "care[d] about the people," especially as many other students focused on tree plantings, neighborhood clean-ups and other actions intended to repair the physical environment. Meanwhile, Sonya intended to undertake actions meant to improve the lives of others. These altruistic interests reappeared, along with Sonya's newly developed science interest, and influenced her future career considerations which then included a number of people- and service-oriented science and technology careers. Sonya said:

I want something to do with medicine. . . . I [also] wanna be like a forensic, like, if someone dies, I wanna be able to know like how long ago was it. [Student: Like an autopsy]. Yea. And I also wanna see like, if there's a dead body, I want to be able to just look at it and be like, "Oh, this and this…" and basically make a story out of what happened by just looking at it. . . . I also want to study psychology . . . 'cause basically I took a class at [the university] in psychology . . . and they were talking about like little kids and when they have problems and I told the teacher that, honestly, all I think they do here is give little kids a whole bunch of medicine for no reason. They just want little kids to get an overdose which makes them even more crazy.

Sonya expressed an interest in medicine, a scientific career often identified by underrepresented females given the opportunities to interact with and help other people (Johnson, 2007). Similarly, with forensics and child psychology, there was the underlying motivation to engage with and help others. Overall, the social justice design of the curriculum and instructional activities of the CB program engaged Sonya's existing concerns about others and required student-driven, hands-on inquiry activities that appealed to Sonya's learning preferences. These positive experiences in science and technology resulted in notable changes in Sonya's interest and enjoyment of science, confidence in her science skills, and consideration of satisfying science and technology-related careers.

Needed Directions: Social Justice and Out-of-School Time

Many scholars (Moses & Cobb, 2001; Tan & Calabrese-Barton, 2010; Tate, 2001) have argued that it is a civil right for all youth to have the opportunity to learn science and mathematics. Utilizing social justice issues as an anchor around which science content is structured provides a unique way to empower youth to not only learn science but to become more interested in creating positive change by pursuing science as a career. Further, by challenging the assumption that school is the primary

place where youth learn science, we, as educators, unlock an often under-utilized time in youth's lives, namely out-of-school time experiences. In closing, by creating educational spaces where students can truly implement a solution and be able to follow that solution through to a conclusion is extremely valuable for youth. The reason for the value is that, more often than not, youth, in school, are often asked to generate a solution to problems, yet are unable to implement the solution; as a result, the entire exercise loses meaning and simply becomes another school activity. Yet, when youth are engaged in projects that are community-based and they can take actionable steps to make their community a better place to live, science content is no long disconnected from their lives but becomes an integral part of, not only their learning, but of their lives.

Acknowledgements
This work was supported in part by a National Science Foundation, Innovative Technology Experiences for Students and Teachers (ITEST) grant (DRL #083362). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Ainley, M., & Ainley, J. (2011). A cultural perspective on the structure of student interest in science. ***International Journal of Science Education,*** **33** (1), 51-71.

Bureau of Labor Statistics. (2009). ***Occupational outlook handbook,*** 2010-11 edition. Washington, DC: U.S. Department of Labor.

Buxton, C. A. (2010). Social problem solving through science: An approach to critical, place-based, science teaching and learning. ***Equity & Excellence,*** **43** (1), 120-135.

Dierking, L., & Falk, J. (2010). The 95 per cent solution: School is not where most Americans learn most of their science. ***American Scientist, 87*** (November-December), 486-493.

Freire, P. (2007). ***Pedagogy of the oppressed*** (3rd ed.). New York and London: The Continuum International Publishing Group Inc.

Hidi, S., & Renninger, K. A. (2006). The Four-Phase Model of Interest Development. ***Educational Psychologist,*** **41** (2).

Johnson, A. (2007). Unintended consequences: How science professors discourage women of color. ***Science Education,*** **10,** 805-821.

Moses, R. P., & Cobb, C. E. (2001). ***Radical equations: Civil rights from Mississippi to the Algebra Project.*** Boston, MA: Beacon Press.

National Academy of Sciences. (2007). ***Rising above the gathering storm: Energizing and employing America for a brighter economic future.*** Washington, DC: National Academy Press.

National Science Board. (2010). ***Science and engineering indicators 2010.*** Arlington, VA: National Science Foundation.

Norman, O., Ault, C. R., Bentz, B., & Meskimen, L. (2001). The black - white "achievement gap" as a perennial challenge of urban science education: A sociocultural and historical overview with implications for research and practice.***Journal of Research in Science Teaching,*** **38** (10), 1101-1114.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. ***Review of Research in Education***, **16**, 153-222.

Parmer, T. (1993). The athletic dream - But what are the career dreams of other African American urban high school students? ***Journal of Career Development,*** **20** (2), 131-145.

President's Council of Advisors on Science and Technology (PCAST). (2010). ***Report to the President Prepare and Inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future.*** Washington, D.C.: Author.

Tai, R., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. ***Science,*** **312**, 1143-1144.

Tan, E., & Calabrese-Barton, A. (2010). Transforming science learning and student participation in sixth grade science: A case study of low-income, urban, racial minority classroom. ***Equity & Excellence,*** **43** (1), 38 - 55.

Tate, W. (2001). Science education as a civil right: Urban schools and opportunity-to-learn considerations. ***Journal of Research in Science Teaching***, **38** (9), 1015-1028. doi: 10.1002/tea.1045

About the authors

Sheron Mark is a post-doctoral Keck fellow within the Center for Urban Resilience in the Seaver College of Science and Engineering at Loyola Marymount University. Her research interests include science interest and career development amongst K-12 students and students' use of science as a space for academic and personal development. She earned the PhD at the Department of Teacher Education, Special Education, and Curriculum and Instruction within the Lynch School of Education at Boston College, along with a Master of Science in Chemical Engineer-

ing and a Bachelor of Science with honors in Biochemistry at Syracuse University. Contact her as follows: ***Sheron Mark, Keck Fellow***
Center for Urban Resilience, Seaver College of Science and Engineering, Loyola Marymount University, Los Angeles, CA 90045
e-mail: Sheron.Mark@lmu.edu

Dennis DeBay is a Mathematics Education doctoral candidate at Boston College. His research interests are related to technological learning environments as a mediating factor between the teaching and learning of mathematics, including, graphing technologies to explore student understanding of real-world data. He graduated with a combined honors degree in mathematics and music from Dalhousie University in Halifax, Nova Scotia, Canada. He is a member of both the National Council of Teachers of Mathematics as well as the American Educational Research Association. Contact him as follows:
Dennis DeBay, Assistant Professor of Mathematics Education
Department of Curriculum & Instruction, Manhattanville College
2900 Purchase St., Purchase, NY 10577
e-mail: dennis.debay@mville.edu

Lin Zhang is a PhD candidate in Science Education, Lynch School of Education at Boston College. She is interested in students' STEM-related career choices. Her recent paper examines how urban high school students envision their career pathways. Contact her as follows:
Lin Zhang, Department of Teacher Education, Special Education, and Curriculum and Instruction, Lynch School of Education
Boston College, Chestnut Hill, MA 02467
e-mail: lin.zhang.3@bc.edu

James Haley is a doctoral student in curriculum and instruction at Boston College. He earned the BS with distinction in chemistry and the MT at the University of Virginia. He has taught high school chemistry at The American School in Switzerland and San Francisco University High School. He currently serves as the Director of the TASIS Summer Program in Lugano, Switzerland. Contact him as follows:
James Haley
Department of Teacher Education, Special Education, and Curriculum and Instruction, Lynch School of Education
Boston College, Chestnut Hill, MA 02467
e-mail:jim.haley@bc.edu

Amie Patchen is a graduate student in Curriculum and Instruction at Boston College. She earned the MSEd in Literacy Grades 5-12 from SUNY Cortland, 2012, MAT in Secondary Science Education at National Louis University, 2008, and the BA in Biochemistry at Oberlin College

in 2006. She taught high school chemistry and Earth science in Chicago from 2006-2008. She worked on nutrition research, education, and outreach projects at Cornell University from 2008-2009, 2010-2012, and at the Museum of the Earth in Ithaca, NY from 2009-2010. Contact her as follows: ***Amie Patchen***
Department of Teacher Education, Special Education, and Curriculum and Instruction, Lynch School of Education
Boston College, Chestnut Hill, MA 02467
amie.patchen@bc.edu

Catherine Wong is Director of Urban Outreach Initiatives in the Lynch School of Education at Boston College. Her work focuses on empowering students to become positive change agents in their schools and communities through the integration of social justice and STEM. By enhancing youth's capacity to work at the boundaries of disciplines, they bring multiple perspectives and knowledge to bear that arise from their own lived experiences, cultural identity, and scientific research. She also specializes in cross-cultural consulting, training, and action research that provides interdisciplinary teams with the knowledge and skills to build coalitions that address the need to forge institutional change, and create leadership opportunities that focus on multicultural education, cultural competency, intercultural dialogue and conflict transformation. Contact her as follows: ***Catherine Wong, Director of Urban Outreach Initiatives***
Lynch School of Education, Boston College, Chestnut Hill, MA 02467
e-mail: catherine.wong.2@bc.edu

Michael Barnett is the 2012 CASE/Carnegie Foundation for the Advancement of Teaching Professor of the Year for Massachusetts and is an Associate Professor of Science Education and Technology in the Lynch School of Education at Boston College. He is the Principal Investigator of several National Science Foundation grants that focus on engaging urban youth in learning and becoming interested in science. He has been an editor of the International Journal of Science Education and currently serves on a number of boards and advisory committees for non-profits and other organizations that serve under-represented populations in STEM fields. Contact him as follows: ***Michael Barnett***
Department of Teacher Education, Special Education, and Curriculum and Instruction, Lynch School of Education, Boston College, Chestnut Hill, MA 02467. e-mail: barnetge@bc.edu

APPENDIX on the following pages:
Figure 1: SjTEM Implementation Model.
Figure 2: Visualization of access to supermarkets compared to grocery stores for urban youth.

Figure 1: SjTEM Implementation Model.

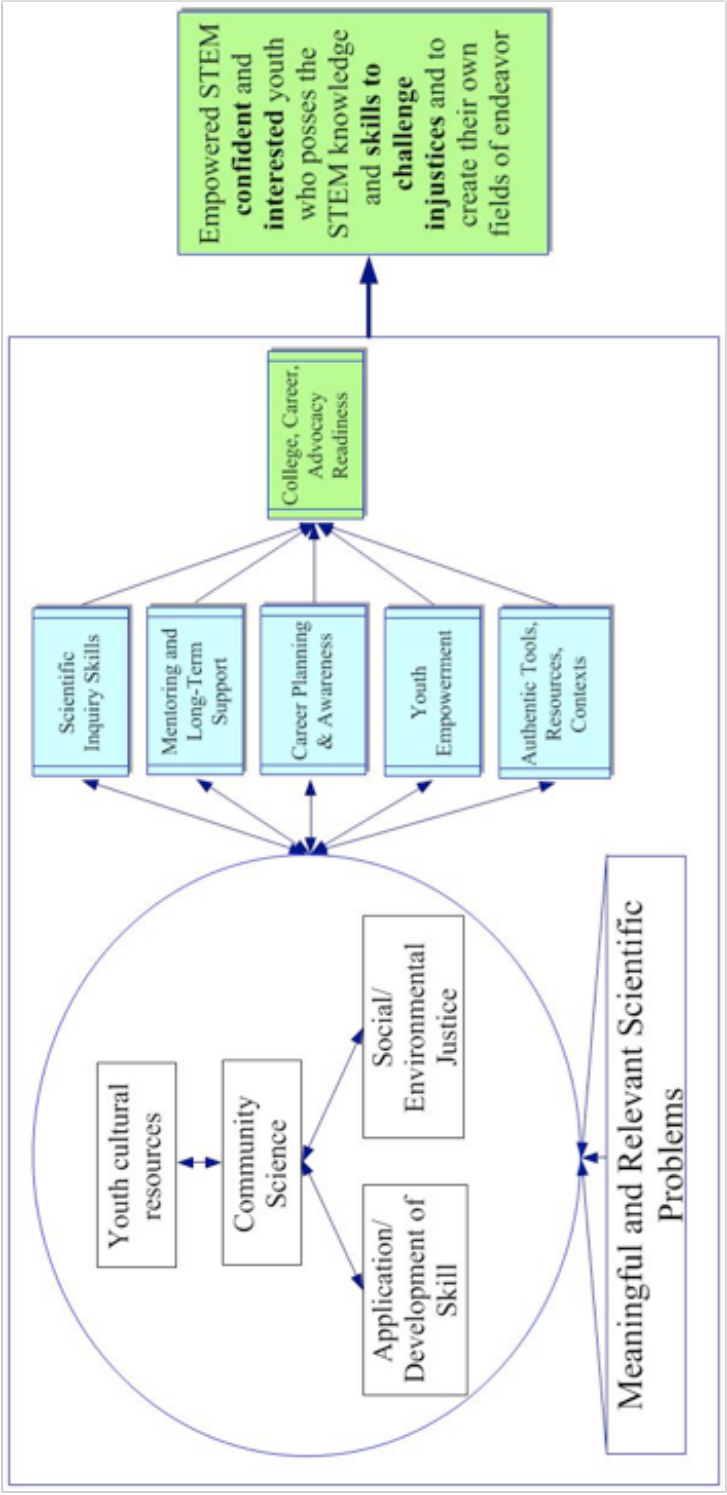

Figure 2: Visualization of access to supermarkets compared to grocery stores for urban youth.