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Transformative undergraduate science courses for non-majors at a historically black institution and at a primarily white institution

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Abstract
We investigated curricular and pedagogical innovations in undergraduate science courses for non-science majors at a Historically Black Institution (HBI) and a Primarily White Institution (PWI). The aims were to improve students' understanding of science, increase their enthusiasm towards science by connecting their prior experience and interest to the science content, and recruit students, especially from underrepresented groups, to science teacher education. Both courses were developed with the same fundamental principles of teaching for all and connection to student interests. We report on the way we used students' interest to increase their enthusiasm towards science and how the instructors established linkages between science and teaching, while introducing their students to scientific research (reading the literature, writing mini-research reports and presenting the data in poster presentations). We discuss the way that the PWI and HBI instructors customized their courses to take into consideration the characteristics of the students' population taking the courses. We assessed our progress in achieving our goals by using researchers' observations, the instructors' perspective, students' feedback, and a reliable and valid survey. Our major insight was that the instructors' perception of their roles within their contexts (HBI or PWI) mediated the way they designed, implemented, and assessed their learners.
Keywords: *Non-major science courses, science teacher education, students' interest, active learning approaches, and diversity.*

Introduction

In this study we investigated curricular and pedagogical innovations in undergraduate science courses for non-science majors in two types of universities: Historically Black Institution (HBI) and Primarily White Institution (PWI). These innovative science courses are part of a longitudinal initiative Project Nexus (PN). PN is a funded project by the National Science Foundation 's Teacher Professional Continuum program (TPC). PN is designed to develop and test a science teacher professional development model that prepares, supports and sustains upper elementary and middle level specialist science teachers. Interested readers are invited to learn more about PN by visiting http://projectnexus.umd.edu/index.html. One of the project's aims is to develop strong relationships and working collaborations between the faculty of the PWI and the HBI. In this article we present how we used the experience from the science course taught in the PWI to build an equivalent course in the HBI. Both courses shared similar goals of attracting students to the sciences and to teacher preparation programs by presenting science as exciting and interesting field. Each course instructor customized the course to take into consideration the characteristics of the students' population taking the courses.

The transformed PWI course, Microbes and Society, was previously taught for several continuous years with emphasis on student-centered learning and active learning strategies (e.g., engagement of student questions, small group activities, whole class discussions, the use of multimedia and instructional technology). However, in Fall 2007, as part of this project, the instructor added a new focus, science for all (Bryan & Atwater, 2002; Fensham, 1985). After careful deliberation, the strategy to promote science for all was by way of student interest. In Spring 2009, informed by the success of the PWI course (Marbach-Ad, et al., 2009 and in press), the HBI transformative course, *Technology and Human Affairs*, was developed with the same fundamental principles of teaching for all and connection to student interest. Both courses focused on topics that highlighted current and global issues that influence our daily lives. In both courses the end-of-semester projects provided the students with the opportunity to choose a topic of interest, research this topic and prepare a group power-point presentation to share their research with the whole class. These presentations were used to represent a framework for understanding science and how science influences and shapes the world around us. In this study we focused on (a) describing the way we used students' interest to increase students' enthusiasm towards science, (b) forming linkages between science and teaching, while introducing the students to scientific research (reading the literature, writing mini-research reports and presenting the data in poster presentations) and (c) discussing the way that the PWI and HBI instructors customized their courses to take into consideration the characteristics of the students' population taking the courses.

Our assumption was that appreciating the unique needs and characteristics of students in undergraduate non-major courses, by connecting to their area of interest, would produce increased interest and appreciation of science and science teaching. We assessed our success in achieving our goals by using researchers' observations, the instructors' perspective and students' feedback. We also used a *belief and attitudes about science and the teaching of science* survey for affective measurement.

Theoretical Background

Recruit students from underrepresented groups to science and science teaching

In 1996, Lewis reported that there were proportionally many more students of color (31%) than teachers of color in the teaching force (13%). More recent data reported in 2004 on US public school populations showed that while, 40% of **students** were members of minority groups (18% Hispanic, 17% Black, and 5% were members of other racial/ethnic group) public school **teachers** were predominantly White, non-Hispanic (83%). Of the remaining proportion, 7.9% were African-American, 6.2% Hispanic, 1.3% Asian American, and 0.7% Native American" (National Center for Education Statistics [NCES], 2004).

Historically, teaching has been a popular career among African-Americans. After World War II, 79% of black female college graduates were employed as teachers. However, as other career opportunities became available, by the mid-1980s, this percentage fell to 23% and the proportion of minority teachers in general had dropped considerably. As result of this negative trend in the diversity of the teaching staff, the gap of ethnic background representation between US students and their teachers is large and widening.

Researchers (Darling-Hammond, 2000, Kirby, Berends, & Naftel, 1999) hold the responsibility partly on schools of education, accusing them of not taking action to balance the ethnic/racial backgrounds of their students and teachers. The prominent recommendation is to improve schools of education recruiting strategies, especially recruiting teacher candidates from underrepresented groups. The underlying assumption is that teachers from underrepresented ethnic groups, especially African-Americans, bring to the ethnically diverse classes "high expectations, culturally responsive teaching practices, and sensitivity and interest to the concerns of African American students that other teachers might not" (Sorrells, Schaller, & Yang, 2004, p. 510).

Bryan & Atwater (2002) asserted that whether we are talking about prospective teachers from underrepresented groups or other groups of teachers, there is a need to tailor the instruction to improve the teachers' cultural competence so that they will be more responsive to a diverse population of students (Dantley, 2004; Leonard, & Dantley, 2005; Prime, & Miranda, 2006). Bryan & Atwater also emphasize that a major reason for the underachievement of African Americans is due to the failure of the science curriculum to "bridge the gap between the world of the students and the world of science", especially in urban schools (p. 508). Therefore, teacher education programs should focus on contexts that are more relevant to the learners.

Unfortunately, most science courses are content-driven and reinforce students' negative view that science is a collection of facts unrelated to their world. For non-majors and members from traditionally underrepresented groups, experiencing science in a teacher directed manner particularly diminished their interest (Cuevas, et al., 2005; Lee, et. al., 2004). Linking the material to students' lives is not generally promoted in the courses, although an emerging body of research indicates that students who are intrinsically interested in an activity (or topic) are more likely to see challenging tasks as worthwhile, think more creatively, exert effort and learn at a higher conceptual level than students who are not intrinsically interested (Kitchen, et al., 2007, Long et al., 2007).

Using students' interest to promote enthusiasm towards science and science teaching

Almost century ago, Dewey in "Interest and Effort in Education" (1913) emphasized the importance of interest-based-learning, which is meaningfully different from effort-based learning. Schiefele (1991) in his broad review of the literature about learner "interest" suggested that through the years the research about interest was not sufficiently investigated, since it was integrated to the latest research about students' intrinsic motivation. He claimed that researchers of achievement motivation ignored the content to be learned. Sheifele agrees that interest is a directive force that drives intrinsic motivation, however, he extends the definition to include that interest is a content-specific concept, which is "always related to specific topic, tasks, or activities." (p. 301). Empirical studies show that connecting to the learners' interest and using authentic contexts while teaching science improves learners' enjoyment and satisfaction (Dlamini *et al.* 1996; Long et al., 2007; Ramsden, 1992; Schiefele, 1991, 1996). The exploration of interest as a driving force for learner motivation, which was confirmed and validated by research (Renninger, 1992), is very important for educational research and practice (Tobias, 1994). It suggests that adapting instruction to students' interests may have positive motivational characteristics. Tobias clarified that every student has a topic of interest, and the challenge is to tailor the instruction to the students' specific interests. When Tobias describes adapting the instruction to the student interest, she explains that it can be according to the degree of "content specificity" (Tobias, 1994, p. 47) or according to the activities that are used to teach the content. Therefore, when interest or motivation is connected only to a specific topic, educators investigate why students are motivated to learn this topic over others while all the activities appear to have the same value and provide similar challenges (Alexander & Murphy, 1998, Alexander, Murphy, Woods, Duhon, & Parker, 1997).

Alexander, et al. (1997, 1998) explored the relationships between student academic learning, student interest, and students' learning strategies. In their research, they characterized different clusters of students. For instance, the low-profile group, who scored the lowest performance on the criterion measure (i.e., text comprehension task), exhibited poor knowledge, reported low interest in the topic and had difficulties in recalling what they had learned. The high-profile group were the most knowledgeable, most interested in that field, and most skilled at learning from demanding texts. Between these two clusters was a mixed profile, consisting of skillful novices who seemed rather capable of learning from demanding exposition, but possessed poor knowledge. These students were not highly interested in the specific content.

> *Forming linkages between science and teaching, while introducing the students to the way scientific research is done (i.e., reading the literature, writing mini-research reports and presenting data, analysis, and conclusions in poster presentations)*

A major concerted goal of science education is to use the investigative and inquiry approach while teaching science at all levels. The central tenet of inquiry is for students to learn in a similar manner as to how scientists learn through research. Scientists ask questions, make observations, take measurements, analyze data, read the literature and communicate with other scientists. Students should be taught the way scientists think about the world, and how they analyze a scientific problem in particular (Mulnix, 2003; Handelsman, et al., 2004). The National Research Council's BIO2010 report (NRC, 2003) states that instructors of science courses should encourage students to think independently, introduce them to authentic scientific questions and incorporate cooperative learning. This is true for science majors who might proceed to science research, but it is also important for non-majors, especially those who are coming from education and are planning to become school teacher.

According to the above discussion of the literature, we therefore believe that it is necessary to consider the research about learner interest and motivation when we are planning our science courses. This is especially true when we teach non-science majors that might not see immediate or direct connection between their science course and their future career. Campbell and Lubben (2000) suggest that in order to connect to students' interest and motivation they need to see how the topic or the activity is relevant to them. He distinguishes between relevancy to workplace and relevancy to society. Science courses relevant to workplace may encourage the development of skills, attitudes and routines applicable to the workplace, while science courses relevant to society may emphasize socially and politically contentious content and encourage reasoning and decision-making skills appropriate for active citizenship (Mayoh & Knutton, 1997). In the HBI transformative course *Technology and Human Affairs* the focus was on environmental science; in the PWI transformative course we decided to concentrate on *Microbes and Society.* Throughout the semester, students in both courses collaborated with their classmates to explore their topic of interest and eventually presented it to the whole class.

In this study we contribute to this body of literature by reporting on the pedagogical innovation and its impact on undergraduates' beliefs in the HBI course, and briefly describe the PWI course (More details about the PWI course can be found in Marbach-Ad, et al., 2009 and in-press).

Context of the study

<u>The HBI and the *Technology and Human Affairs* course</u>

Coppin State University (CSU) is a model urban, residential liberal arts university located in the northwest section of the city of Baltimore (http://www.coppin.edu/). The undergraduate population comprises on 79% women; 86% African-American, 4% international students, 1% white and 9% unknown. The average age for the undergraduate students is 26 (39% are 25 years old or older). The transformed HBI course, Technology and Human Affairs, was a 3-credit course, with 150 minutes class sessions once a week. The course helped students develop an understanding of both positive and negative impacts of science and technology on human development and ultimately on human survival, including discussion of environmental issues, consumption of resources, population growth, health, nutrition, food production, energy sources, nuclear proliferation, pollution, technology transfers in developing nations and other subjects of current interest in the context of both national and international political structures and institutions. The HBI instructor extensively used active learning strategies, such as group study, open discussion and current events.

In the beginning of the semester the instructor allowed the students to come up with 3 to 5 topics of interest about an environmental issue that they may be interested in pursuing. The instructor collected all of those and compiled a list of topics (e.g., Air pollution, land and water pollution, political issues with waste management, HIV and AIDS in the local community affecting the elderly and the young, and environmental stewardship). The list was used for two purposes. First, the students were allowed, as a group, to choose one topic from the list to research during the semester and eventually to present it to the whole class, and a different topic on which to write a mini research paper. Second, this list was used by the instructor to inform him about students' topics of interest. This allowed him to revise his syllabus to include or emphasize these topics. Each group presented the PowerPoint presentation to the class reporting on their research results, while engaging the class in an activity or discussion related to the presented topic. A content rubric was used to evaluate the group's presentation, the PowerPoint content, engagement of the topic and materials presented to the class. Another course assignment was to individually write a mini research paper on an approved environmental science topic that was different from the group work. The students were required to explain the basic theory underlining the scientific principles that they researched and to ensure that they link the topic to a current environmental issue. The assignment also required the students to include a valid reference list and each was graded for thoroughness, content, writing and grammar and clarity.

The PWI and the *Microbes and Society* Course

The University of Maryland (UMD) is the flagship campus of the University System of Maryland (http://www.umd.edu/). The undergraduate population comprises on 48% women and 43% of students from underrepresented groups (13% African-American, 15% Asian; 6% Hispanic and 9% unknown). The average age for the undergraduate students is 21 (6% are 25 years old or Older). The transformed PWI course, Microbes and Society, was a 4-credit course, with 75 minutes twice a week lecture sessions and one-hour twice a week laboratory sessions. The course helped students develop an understanding of basic concepts in biology: the unity of life, evolution, disease, antibiotic resistance, the roles microbes play in providing food and recycling waste, and roles that cultural and societal influences play in the spread control of microbial diseases. In the laboratory part, students designed experiments, researched microbial related information, discussed how science is used to solve problems, and experienced the world of microbiology through the lens of their own personal interests. In the lecture sessions, the instructor extensively used active learning methods (e.g., group study, open discussions, video-tapes and current events).

During the first two labs, students were asked to choose an independent project topic which most interested them, from a list of set categories: diet/nutrition; health/disease; your environment; language of life (DNA/genetics); technology/business/money. For the next six weeks students worked to research a question related to the topic they chose and examined the existing knowledge and debates about it. Following the individual scientific project, students collaborated to work in six groups on their final research project. Groups included students with similar topic of interest. They used some of the lab sessions to research the topic online and develop ideas as a group. The students were asked to be creative and present their project in an interesting way for different types of audiences. Each group prepared a twenty minutes presentation, which included PowerPoint presentation. Following each presentation the class teammates and the instructor asked questions and reflected on the project orally and on written feedback sheets.

Sample

Technology and Human Affairs course. Twenty-one students enrolled in the course, mostly females (13) and eight males, mostly African Americans (20) and one Hispanic student. The age range was broad, spanning from18 years old to late fifties; the age average was around 26 years.

Microbes and Society course. Twenty-seven students were enrolled in the course. Twenty-four students reported on demographic background, 15 females and nine males, mostly Caucasians (13), three Asian, two Hispanic, one African-American, and five others. The age range was 17-23 (only two over 20).

Data collection and analysis

In this study we used complementary methods. For the qualitative data, representative class sessions of the HBI and PWI class sessions were videotaped and observed by members of the research team (three university science educators with science expertise in earth and life sciences). As a research team we took extensive notes that focused on documenting and interpreting the nature of the classes and the degree to which the instructional objectives were achieved. The instructors of the courses and a sample of their students were interviewed. We collected students' reflective assignments and class artifacts. We also collected students' end-of-semester feedback survey. For the qualitative analysis of the open ended questions in the students' end-of-semester feedback we used a modified content analysis strategy (Ryan & Bernard, 2000). The quantitative data was obtained from administration of the *Beliefs and Attitudes about Science and Science Teaching* survey (A copy of the survey could be obtained from the authors). Attitudes and beliefs are typically difficult to define and distinguish from one another. We defined attitudes as affective constructs, influenced by experiences that include aspects such as interest, enjoyment, confidence, and valuing (Jones & Carter, 2007). We draw on Bryan and Atwater's (2002) definition of beliefs which posited that "Beliefs are part of a group of constructs that describe the structure and content of a person's thinking that are presumed to drive his/her actions" (p. 823). Researchers (McGinnis, 2002, 2008; Haney & McArthur, 2002; Yerrick, Parke, & Nugent, 1997) have investigated prospective science teachers' beliefs about constructivist teaching practices, nature of scientific content knowledge, and teaching and assessment practices. This body of research revealed that teacher beliefs about teaching and learning affect many aspects of classroom practice, including lesson planning and the assessment of student learning (Haney, Lumpe, Czerniak, & Egan, 2002; Pajares, 1992; Prime and Miranda, 2006; Richardson, 1996; Taylor & Macpherson, 1992).

The *Beliefs and Attitudes about Science and Science Teaching* survey was crafted from several existing valid and reliable surveys. Survey data were reported in the National Science Board's 1998 Science & Engineering Indicators (NSF, 1998) and specifically measure: Teacher beliefs about the nature and teaching of mathematics and science: 1994-95 (Williams, et al., 2000); Teacher perceptions of student skills required for success in mathematics and science: 1994-95 (Williams, et al., 2000); Teachers' knowledge of the standards: 1994-1995 (Williams, et al., 2000); Percentage of science and mathematics teachers implementing reform activities: 1996 (National Center for Education Statistics,1997, 2000). Upon inspection, we determined that these instruments were based on items used in the TIMSS study. The combined survey was used in our previous studies and rigorously validated through comparison to previously reported results and experts face validity. The full process is detailed in several published research studies (NSF, 1998; McGinnis, 2002; McGinnis & Marbach-Ad, 2007; Marbach-Ad, & McGinnis, 2008). In the current study the instrument aimed to measure the change in students' attitudes and beliefs towards science and science teaching (for validity purposes we asked the students to respond to all questions in the survey, but here we present only the questions that concerned our current research, see Table 2 in the Finding and Discussion section). We used Chi square tests to detect significance of difference between the groups.

Finding and Discussion

We analyzed all data according to our three major areas of interest: (a) describing the way we used students' interest to increase students' enthusiasm towards science, (b) forming linkages between science and teaching, while introducing the students to scientific research (reading the literature, writing mini-research reports and presenting the data in poster presentations) and (c) discussing the way the PWI and HBI took into consideration the characteristics of the students' population taking the courses.

Our primary data sources were:

1.Interviews with the courses' instructors

2.Students' end of-semester feedback (interviews and survey).

3.Students' responses to questions from the attitudes and beliefs survey.

For heuristic purposes we report our findings by the data collection sources. Methodologically, to develop our interpretative themes that constitute our narrative we inductively coded our "free-flowing texts" data (i.e., transcriptions of interviews) (Ryan & Bernard, 2000. p. 769).

The instructors' perspective

We asked both the HBI and the PWI instructors the same questions. We report here on excerpts from their answers that relate to our three areas of interest. To the question "What were your plans and goals for the course?" The HBI instructor responded that the most important thing for him was to customize the course to the diverse population in his class, "Those that have a variety of knowledge in science and those that may not." He pointed out that he wanted the students to understand how science relates to their everyday life experience. The instructor also emphasized his desire to connect through the students to their families and their community,

> …make their personal experience with the content where they could relate to it… taking a topic of understanding and to be able to have them go home and to talk about it amongst their family and friends, or to see it being discussed in their community or environment and to be able to weigh in on the conversation…

The PWI class instructor responded that he planned to make the class time interactive, spending only a small amount of time lecturing to the students. His hope was that the interactions would lead the students to the key concepts presented in the course. He explained his intention to guide the students to an understanding of microbiology that would allow them to appreciate how it might apply to their lives and how they may keep informed through the use of popular literature.

To the question "What did you consider when developing your course so that would benefit those who would become science educators?" The HBI instructor explained that many of the students at his institution tended to stay within their local proximity after they finished their academic programs at the University, and for those who are becoming teachers, he wanted to make the science experience meaningful so that they could make it meaningful for their own students with their teaching. The instructor also talked about his unique population, "my population of students, mostly African-Americans… for them to have motivation and interest in science is that they have to be able to relate to it. They have to find something that relates to their everyday experience." The instructor also highlighted the importance of making his students understand their personal responsibility to the environment through teaching the class, "… not only are we teaching science, and the understanding and knowledge of that, but we're also making them good people-- good citizens, and we talk about the stewardship of science." The PWI class instructor responded that he strived to make the course explicitly connect with teacher education. He planned to explain the pedagogy behind his teaching methods and assignments, so that the students would always be aware of the learning goals. In his words, "I make, whenever possible, explicit and transparent, the pedagogy I'm using and why I'm using it. Why we put students into groups, why we do discussions…"

To the question "What teaching strategies do you wish the students will take to their classes if they teach science?" The HBI instructor described how he adjusted his teaching style to his students' learning style using multiple ways to present a topic,

> …This is a very visual group too. Another thing that I knew is that instead of just talking about the topic we would find multiple ways to deal with that same topic. There would be a newspaper clipping. There would be an introductory hands-on activity where they had to talk and develop ideas. Then we would show a video on the same topic, or perhaps a movie, and then they will do a PowerPoint on it.

The HBI instructor further elaborated on the advantages of giving the students the opportunity to choose their own topic of interest and how he changed his teaching accordingly,

> …I also decided that to make the class interesting, I would allow them to come up with 3 to 5 topics of interest about an environmental topic that they may be interested in, but in a very safe environment. I wanted them to write it down on index card, five topics-- no one else saw them, and what I did is, I collected all of those and I compiled a list of them and I came back in class and I shared it with the entire class. Then two things happened with that list. The students were able to, as a group, come up and do a PowerPoint presentation on one of the topics, different and apart from doing a paper on the topic. As well as, informing myself as an instructor of all the kinds of things that maybe I should be thinking about in terms of environmental topics that I maybe should cover in the class. …[I] changed my lecture styles and times and all the experiences to make sure that I'm covering this list. So I used that as a means to kind of fuel the next steps.

The HBI instructor, who serves as associate vice president of institutional effectiveness and planning in his university, also talked about his institution and the background of his students

> …the average age is 29. And that tells me that they start doing other things first right out of high school. Many of them have families and have to go to work immediately and have to take care of relatives and other folks. And then to immediately improve their economic status they go to a university, and it's truly a means to an end. Now, I had a young man that was 17 years old, and I had a student in her 50s, all in the same classroom. So as a professor I have to think about that, in terms of just engaging, and the difference in the two populations of students. And how does that play out in the kinds of experiences that I want. I want to build on the individual who has been working for 10 years first and have that kind of insight in my classroom. I want the young person who just got out of high school to hear those experiences, but also offer their perspective because they have came up to an age of AIDS where it was already here, whereas the person who is most much older was living first when it came about… So listening to that perspective adds a very rich conversation to a topic. [name removed] also, as an urban school, most of ours students come from inner-city [name removed] which has one of the lowest graduation rates… about 33% of students graduate from high school. That's where [name removed] gets almost 85 to 90%. So if you think about that, and you think about this traditional student who's almost 29 going into college, they haven't had any mathematics since the time they graduated from high school, they may have had their last math class in the ninth or 10th grade… And as our mission, as an institution… The state considers us as *access* university. We provide access to students to get an education-- to have an immediate economic growth…

To the same question "What teaching strategies do you wish the students will take to their classes if they teach science?" the PWI instructor and the Teaching assistant responded,

> I make, whenever possible, explicit and transparent, the pedagogy I'm using and why I'm using it. Why we put students into groups, why we do discussions, why is it that I allow them after taking a test to retake the test in a window of time for an average of the two grades. So we consciously make the course learning-centered and not content-centered… (Instructor).
>
> [A]s we move on throughout the semester it's definitely geared towards activities of what a teacher would do. They're going to be designing an experiment, and doing a research project and these are all tools that, really when it comes down to it, are professional tools that you would use as a teacher. (Teaching assistant).

Students' feedback

One question from the end of-semester feedback survey applied to the "teaching for all by connecting to students' interests" thrust of the course. The question was: "*One goal of the course was to encourage students to feel connected to the science subject matter by use of active learning (i.e., "student-centered") and by taking into* *consideration students' backgrounds and interests (i.e., "science for all"). What elements of the course would you identify as aligning with this course goal*?" In the HBI course, almost all of the students (12) referred to the topics that were taught in the class ("Science affects us all. I believe that various topics [presented in the class] would relate to at least one person in the class", "By relating the "sections" to our daily lives"). One student referred to the teaching methods of open discussions and group work that were used in the class ("Open discussions allowing us to work in groups to get feedback from one another").

In the PWI course, 13 students answered that the lab reflective assignments and projects (mostly in groups) aligned with the course goals ("I thought they helped keep me engaged in learning", "They were good and interesting"). Seven students mentioned the ability to choose an area of interest ("Letting us pick topics, asking for feedback – [it was a] good communication"). Four students mentioned the lab work groups ("I thought they helped keep me engaged in learning"). Three students mentioned the wet labs ("I learned a lot because it was hands-on"). A few students suggested that there should be more wet labs in future versions of the course. Other students mentioned the positive value of the lecture, discussing the videos and the opportunity to design a lab and present it to the class.

One open-ended question applied to the connection between science and teaching. We asked only students who were considering teaching science to answer to the following question: *What teaching practices/techniques did you see modeled in this course that you think would benefit your science teaching? Explain.* In the HBI course, four students answered this question, all of them related to the importance of connecting the topics to students' "real life". In the PWI course, seven students answered this question. Responses included: "Peer-to-peer learning, working in groups", "I would provide feedback to my students as well as facilitate discussions in lecture"; "I liked how the videos [in the lecture] illustrated the information. It made it easier to understand certain material"; "The best way for your students to learn is if they are invested and see it done hands on"; "Relating science with everyday life." To probe students' thoughts about the course, at the end of each course we interviewed a group of students (focus group interview).

The HBI focus group consisted of three males and one female. The PWI focus group consisted of two males and one female. The interview protocol was semi-constructed survey that included same major questions. In each interview we added clarification questions as needed. Table 1 summarizes the students' responses in the interviews. In response to the question "What the instructor did that was different than any other undergraduate or high school science course that you have taken?"

The HBI students referred mostly to the way that the instructor made the course interesting and relevant to the students' everyday life ("…Brought it home… Made it personal… as far as stewardship… Highlighted things I could do to sustain the resources that we have.").

Students also related to the importance of student presentations in the class and taking ownership on their own research ("He [The instructor] made you think about also another side of class participation, so you're reading your PowerPoint, relating to it and then getting class participation involved with it too…. It puts you in front of the center stage and lets you have the floor, you know you've got to speak…. Taking ownership on your research.") In response to the same question, one PWI student mentioned the use of video and discussion around the video ("…I really like the videos because I think I'm a visual learner… But also how we would watch them in sections and then have a discussion about it…"). Another student mentioned the variety of learning styles that were used in the course ("…All the different types of learning... I think this is one of the only classes I've taken in college so far that really, there was a little bit of lecture and discussion also hands on things, and the presentation."). Students also related to instructor enthusiasm towards the material ("The instructor was very enthusiastic and you could tell he loved material and I think that's really important in teaching."). To the question "What the instructor did to relate to your interest?" both groups related to the opportunity to choose their topic of interest.

Table 1: Comparison of students' responses to questions in the focus group interview in both institutions

Questions/Topics	HBI (Coppin State University)	PWI (University of Maryland)
What the instructor did that was different than any other undergraduate or high school science course that you have taken?	· The course was less technical than other courses and more personal. ·The instructor taught things that apply to everyday life. ·Expand teaching beyond the textbook. ·The need to participate in class, to present your research to the class and Take ownership to your own research.	· The videos and the discussions around the video sections. ·The variety of learning styles: lecture, discussion, hands on activities and the presentation. ·The instructor's enthusiasm towards the material that was taught in class.
What the instructor did to relate to your interest?	·Taught us current issues that relate to our everyday life (e.g., using current news articles). ·Articulated the topic for the presentation. · Making the class related to urban life.	· Choosing topic of interest for the project ·The instructor made the connection between the class topics and our own topic of interest.
What teaching practices did you see modeled that you think could benefit you in your own thinking of teaching?	. The instructor modeled how to relate to the learner interest and consider the learners' background.	.The instructors modeled how to present information and make the teaching interesting.
Challenges		. It was difficult to navigate through the course web-site.

The HBI students also mentioned that the instructor made the connections to urban life. To the question "What teaching practices or techniques did you see modeled that you think could benefit you in your own thinking of teaching, especially in science?" The PWI students related mainly to the instructor's way of presenting information ("… because I'm early childhood [Major], especially with the presentations, because if we are structuring them for an elementary grade level, it's really helpful in learning how to break the information down so they can get it, and to make it interesting to them."?). The HBI students emphasized the importance of adapting the teaching by relating to their background and connected the experience to their family and community ("…. I've got a little girl and like I said with the urban matters, I wanted it to be related to her so that she would understand as opposed to someone else foreign or who is just sticking straight to the book and not speaking to what goes on in life as we speak.") Regarding the challenges in the course, students in the HBI course did not mention difficulties in this specific course. PWI students mentioned that it was difficult to navigate through the course web site, one student explained, "It got easier as, as you would learn to navigate around the web site. I mean still I would have preferred not to have to use the web site because I think the way it's designed is ineffective".

Students' responses to questions from the attitudes and beliefs survey
Table 2 shows results from the attitudes and beliefs survey. We used chi square test to compare between the PWI results and the HBI results. We found that significantly more students in the HBI course reported that they are "looking forward to taking more sciences courses" (74% vs. 38%) and that they "like science" (95% vs. 58%) than in the PWI course. The low enthusiasm of the PWI students to take more science courses could be because they are not required to take any more science courses for their major. It was encouraging to see that most HBI students finished the course with a good impression about science courses. We didn't collect data about the students' attitudes and beliefs towards science prior to the course, however, in the end-of-semester interviews one of the students from the HBI course (African-American male) reported on how he changed his attitudes towards learning science due to the course content and the way that the course was taught,

> …when I went to my advisor, whoever makes the schedule and she told me I had to take a science class and I was like "ooh I don't know my first semester here, if I want to take a science class." And the first day in class I thought about it, but actually after the first two weeks, I was good. …as far as relating it to everyday life and things that we're doing, I actually loved the class. I can actually say I love science! (laughs).

In the HBI course, more students (4) agreed with the "negative" (undesired) statement "Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner" than in the PWI course (2 students). In both courses the instructors tried to convey the message that in most cases the steps that are leading to a problem solution are more important than getting the correct answer. Similar pattern was seen regarding to the "positive" (desired) statement "Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary." In the HBI course fewer students (5) agreed with this statement than in the PWI course (15 students). These results could relate to the fact that the HBI course did not have a lab component while the PWI course did include a lab component. However, these later results gave an important feedback to the HBI instructor to stress in his class the importance of how science should be taught in class. Regarding the statement, "I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in science," significantly more students in the HBI course (95%) reported that they agree with the statement than in the PWI course (58%). Indeed, in the interview the PWI students referred to the challenge to navigate through the course website. In both institutions, most of the students (above 80%) were aware of the importance of small group activities.

Table 2: Percentage of students who strongly or sort of agree with the statement

Statement	HBI (N=19)	PWI (N=24)
I am looking forward to taking more science courses.	74*	38
I like science.	95*	58
Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.	21	8
Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary.	26**	63
Small group activity should be a regular part of the science classroom.	84	83
I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in science.	95**	58

*P<0.5 **P<0.01

Discussion and Conclusions

In this study we described two innovative undergraduate science courses for non-science majors. The courses were taught in two different types of institutions. One was a PWI, which was a Research I large university. The other was a HBI, which was relatively small urban, Residential Liberal Arts University. The courses were different in many aspects. The PWI course consisted of two sections: lab and lecture. The HBI course consisted only on a lecture session. The courses were focused on different subject matter and taught by different instructors. The courses' population was different in terms of age (older students' in the HBI) and ethnicity (more students from underrepresented groups).

Table 3: The instructors' views about their courses (an interview)

Questions/Topics	HBI	PWI
Plans and Goals	Make sure that the course was taught with best practices. Plan the course to present high standards Teach some science knowledge and explain how that particular topic plays out in the students' understanding. Personalize the course for the students, that they could go home and to talk about it amongst their family and friends.	Make the class time interactive Spending only a small amount of time lecturing to the students. Working in groups Guide the students to an understanding of microbiology and apply the material to their lives Teach the students how they may keep informed through the use of popular literature.
Assessment	Use multiple means of assessment.	Use multiple means of assessment.
Teaching science for all	Let the students choose their topics of interest. Use basic common topics in science Find multiple ways to deal with the same topic.	Responding to students' interest Use student-center, active learning approaches.
Recruiting for teacher preparation programs	Model the need to incorporate technology as a means of delivering new topics in the	Explaining the pedagogy behind the teaching methods and assignments, so that the students

	classroom.	would always be aware of the learning goals.

We find it particularly important to study different populations from different types of institutions. Little is presently known about how higher education science instructors with similar aims customize their courses to meet the needs of their learners at PWIs and especially HBIs, and how results may compare. A major insight from this study was that the way the instructors designed, implemented, and assessed their learners was greatly influenced by their perceived roles within their contexts, HBI Residential Liberal Arts or PWI Research I large university. Table 3 shows a comparison between the instructors' views and plans for their courses.

The plans and goals of both the HBI and the PWI instructors for their courses were very similar. Both instructors highlighted the importance of maintaining a high level of teaching, "Teaching with best practices…present high standards" (HBI) and "Make the class time interactive" (PWI). Both instructors stressed the goal to teach a scientific content with close attention to students' everyday life experience, "Explain how that particular topic plays out in the students' understanding" (HBI) and "Apply the material to their lives" (PWI). Both instructors also referred to their hopes that the course would have an impact beyond the class time. The PWI instructor emphasized the potential impact on the individuals that participated in the course, "Teach the students how they may keep informed through the use of popular literature." The HBI instructor emphasized that he wanted through his students' to impact their families and their community, "Personalize the course for the students, that they could go home and talk about it amongst their family and friends." Throughout all conversations with the HBI instructor, he emphasized how important it is for him that his students will be ambassadors of knowledge and values to their community, especially since most of them will stay in the university area, which is classified as an area with low high-school graduation rate.
Regarding the course assessment, both instructors reported on using multiple means of assessment. The HBI instructor explained that he used traditional tests for comparability, but since he was aware that most of his students are older than students in other universities, he thought that traditional tests only would be too intimidating for them. The PWI explained that he used authentic assessment mainly because he wanted to model good teaching practices. Both instructors emphasized their desire to teach for *all* and made an effort to tailor the course for their diverse population. To do this, in both courses the instructors decided to respond to students' interest and let the students choose their topic of interest within the boundaries of the course topic. The PWI instructor emphasized that in order to respond to the diversity he used kept the students heavily engaged in their learning, using small group discussions, individual's participation and multiple in-class and out-of-class assignments.

The HBI instructor reported that he responded to the diversity by choosing topics from students' everyday lives and presenting each topic in multiple modes of teaching, such as, PowerPoint presentations, current events and internet websites. Both instructors reported that one of the course goals was to recruit students to science teacher preparation program. The HBI instructor emphasized that it was important for him to "Model the need to incorporate technology as a means to delivering new topics in the classroom", since many of the students finished high-school many years ago when such technologies weren't available and developed enough for high-schools. The PWI instructor stressed that he repeatedly explained to his students what the pedagogy behind his way of teaching.

While the two instructors were comparable in the way that they designed, implemented and assessed their students in their undergraduate science courses, they differed in their perception and recognition of the diversity in their classroom. They manifested the difference in how they adjusted their science teaching to respond to their perception of their students' needs as determined by their contexts. For example, the HBI instructor acknowledged that his students were older than usual and were far removed from high school experience, therefore he sought to make the content understandable by using less technical terminology than typically presented in an undergraduate science course. One of his students explained that the instructor taught in an "elementary way", which he interpreted in a positive way since he felt that the instructor was making a strong attempt to make the science understandable to the students by not using technical language exercise -- something they had experienced negatively in earlier science learning experiences in high school and college. The HBI instructor also make concerted efforts to link the science content to his African American learners' local community, because he believed that his students tended to stay in their communities after graduation. A strong commitment to contributing to their local community in a caring manner distinguished them. Contrary to the PWI instructor, the HBI instructor did not use formal assessment as a way to motivate the learners to excel in science. Instead he used his knowledge about his students' desire to help their local communities as the key to motivate them to engage in science learning while he assisted them by translating the more technical language of science into language they could more immediately understand. The PWI instructor perceived his students as a far less diverse population, and therefore, he primarily adjusted his teaching to serve the needs of a predominately White, typical non-major student population who needed to be literate in science as it was presented in the popular media. He placed attention on the need to maintain their interest in science by connecting the course's content to current events in the news. He did not feel the need to link his course with their local communities because they came from diverse communities geographically and they expressed no stated desire to return to those communities after graduation. As mentioned earlier, these two innovative science courses are part of a funded National Science Foundation project [name removed]. One goal of the project is to recruit a diverse student body for science preparation programs. The goal is in accord with national calls (Darling-Hammond, 2000, Kirby, Berends, & Naftel, 1999) for recruiting a diverse population, especially from underrepresented groups. The shortage in highly qualified science teachers is an issue in general; however, for some populations the problem is even worse. For example, large urban schools are plagued with high numbers of unqualified and poorly prepared teachers, in spite of the awareness that these schools need the most effective teachers and resources (Dantley, 2004).

Innovation in transformative undergraduate science education that includes a focus on teaching for all is of high priority for higher education institutions, particularly for those learners who may become teachers in high need areas (such as science), and, for those who come from underrepresented groups in teaching, such as African

Americans. Our study contributes to the emerging body of literature on this important topic by providing a detailed example of how two undergraduate science courses were taught to a high standard in two different contexts (HBI and PWI), while the instructors used their understanding of their students' backgrounds to customize the courses. Encouragingly for our specific project and for the science teaching profession, in general, a number of the undergraduate participants (both African American and White) indicated in the post-course survey that they are now planning on teaching as a career.

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