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Urban Middle-School Teachers' Beliefs about Astronomy Learner Characteristics: Implications for Curriculum

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Abstract

This study addresses the link between urban teachers' beliefs about their students' ability to succeed in astronomy and their instructional decisions and practices in response to those beliefs. The findings suggest that teachers believe that the student characteristics that are necessary for high achievement in astronomy include specific cognitive skills, dispositions, and prior knowledge and experiences with the subject area. These teachers further view their own students as largely lacking in these characteristics and report such instructional modifications as not teaching the prescribed astronomy curriculum, deemphasizing related mathematics, reading and science process skill sets, deemphasizing advanced astronomy topics and laboratory experiences, and reducing the depth of astronomy concepts. The implications of these findings are that urban students might in fact be experiencing an astronomy curriculum that is alienating and does not promote their engagement with the subject area.

1. INTRODUCTION

Urban schools across the United States are confronted by the same complex social and economic problems that afflict the communities that they serve (Ladson-Billings 2008). There is extensive research that provides evidence that urban schools are under-resourced, dolefully underachieving, and populated largely by minority students who live in disadvantageous economic circumstances (Darling-Hammond 2007; Ladson-Billings 2006; Seiler 2001). Seiler (2001) expressed that the manifested science curriculum in urban schools "has very low expectations for student achievement, is poorly constructed, and fragmented" (p. 1001). Additionally, research has shown that significant science achievement gaps between minority and majority students have not narrowed from 1996 to 2005 (National Center for Education Statistics 2006). These gaps have been coupled with complex factors such as race, ethnicity, immigration patterns, and socioeconomic status (Norman *et al.* 2001). Given that urban schools have unique conditions of poverty and social disadvantage in which they operate, a study of classroom experiences of urban children might hold the key to an understanding of the problems of underachievement that distress this population of students.

Accordingly, this study probes one aspect of the classroom experiences of urban middle-school science students. Specifically, the study looked at urban teachers' beliefs about their students' ability to succeed in astronomy, with a view to determining how their beliefs might be linked to their classroom teaching practices. The study is premised on the view that student learning outcomes are determined in large measure by the nature of their learning experiences. The study makes the assumption that the reasons for the underachievement in astronomy seen among urban students are to be found, at least in part, in the nature of their science curricular experiences. It further assumes that an understanding of the curricular experiences that teachers provide for their students cannot be gained apart from an understanding of the beliefs that underpin teachers' instructional decision-making.

2. THEORETICAL FRAMEWORK

This study is framed within a well-established body of literature that affirms the influence of various aspects of teacher thinking about students, and about teaching and learning, on classroom practice and learning outcomes (Brickhouse 1990; Briscoe 1991; Cochran-Smith 2000). Teacher beliefs are among the most widely researched aspects of teacher thinking. Brophy and Evertson (1981) distinguished between beliefs, as statements held to be true; expectations, as cognitive predictions; and attitudes, as affective or emotional responses to objects or people. Nespor (1987) distinguished beliefs from knowledge and asserted that beliefs have strong affective and evaluative components, are rooted in personal history, and are not easily changed. Pajares (1992) placed beliefs within a group of related constructs that includes attitudes, expectations, values, opinions, perceptions, conceptions, and dispositions, all of which exert powerful influences on behavior. Bryan and Atwater (2002) also proposed 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). It is this relationship between belief and behavior that makes the study of teacher beliefs so critical to an understanding of educational outcomes.

Researchers have investigated the effects of teachers’ beliefs about the teaching and learning of science (Bryan 2003; Haney and McArthur 2002; Levitt 2001). The body of research on teacher thinking demonstrates that teacher beliefs about teaching and learning affect many aspects of classroom practice, including lesson planning and the assessment of student learning (Pajares 1992; Richardson 1996; Taylor and Macpherson 1992). Research literature that centers on teachers’ beliefs about science learner characteristics is sparse. However, it is possible that it is this class of teacher beliefs that has the most telling effect on student outcomes. Thus, the present study investigated urban teachers’ beliefs about the learner characteristics of their students in the context of the demands of the astronomy subject matter and examined their reported instructional modifications in response to those perceived characteristics.

3. METHODS

This study sought to determine answers to the following questions:

1. What student learner characteristics do urban middle-school science teachers believe to be necessary for high achievement in astronomy?
2. To what extent do urban middle-school teachers believe that the students whom they teach possess those characteristics?
3. What beliefs do these teachers hold about the ways in which they should adapt the teaching of astronomy in response to the characteristics that they perceive their students to have?

3.1. Design

The study employed qualitative methods to explore these questions. Data were collected through the use of a semistructured interview guide. The semistructured interviews allowed me to explore the issues raised by the teachers while still ensuring that all aspects of the inquiry were addressed.

3.2. Data Collection

Project ASTRO is a program run by the Astronomical Society of the Pacific since 1994 to link professional and amateur astronomers with local K-9 teachers and students and to bring inquiry-based astronomy activities to classrooms. In its first 10 years of operation, Project ASTRO has served more than 100 000 students (Fraknoi and Zevin 2003). Project ASTRO is a successful model for astronomer/teacher partnerships (Fraknoi, Bennett, and Richter 1998) and has been listed among the most effective programs in the United States involving scientists and engineers in K-12 education (Connolly 1997). Surveyed teachers participating in Project ASTRO have indicated that their astronomer partners positively influenced their students’ attitudes toward science (Gibbs and Berendsen 2007). Currently, local Project ASTRO networks currently operate in 15 regions throughout the United States. However, the Project ASTRO site utilized in this study provided a unique research opportunity because it specifically focused its educational public outreach effort on a large urban school district.

A total of 12 urban middle-school science teachers was recruited from six partnering Project ASTRO schools in a large urban school district. Two schools were high-achieving, two schools were middle-achieving, and two schools were low-achieving as evidenced by the State’s School Performance Report of 2009 achievement

Table 1. Participant profiles

Pseudonym	Gender	Race	Age	School Achievement	Grade Level Taught	Teaching Experience (years)
Johnny	Male	White	40–50	Low	6 and 8	10
Tasha	Female	Black	30–40	Low	6	4
Amanda	Female	Black	30–40	Low	7 and 8	4
Suzie	Female	Black	50–60	Low	8	21
Martin	Male	White	20–30	Middle	6	2
Becky	Female	White	20–30	Middle	7 and 8	2
Frances	Female	Asian	30–40	Middle	6	3
Han	Male	Asian	30–40	Middle	7 and 8	3
Tracy	Female	White	40–50	High	6 and 8	10
Roland	Male	Black	60–70	High	6 and 8	32
Darcy	Female	Asian	30–40	High	6 and 8	3
Monica	Female	White	20–30	High	7 and 8	2

data (Maryland State Department of Education 2009). Each newly recruited middle-school teacher voluntarily agreed to participate in this study prior to their participation in Project ASTRO the following academic year. All data for this study were collected 6 months prior to these teachers' participation in Project ASTRO. All middle-school teachers are mandated to employ the Maryland Voluntary State Astronomy Curriculum (see Note 1). All middle-school grade levels were represented. Table 1 provides profiles of the study participants with respect to their demographic information, school achievement level, grade level taught, and years of teaching experience. Table 2 provides profiles of the study participants with respect to certification and level of education. This research was supported by the following two grant funding agencies: Maryland Space Grant Consortium and the Jess and Mildred Fisher Foundation.

Table 2. Participant certification and education level

Pseudonym	Certification	Level of Education
Johnny	6–12 Science	B.S. Geology, M.S. Systems Management
Tasha	Alternative ^a	B.S. Biology B.S. Physics, M.Ed. Administration and Supervision
Amanda	6–12 Science	B.S. Chemistry
Suzie	Alternative	B.S. Finance
Martin	Alternative	B.S. Biology, B.A. Psychology
Becky	Alternative	B.S. Elementary Education, M.A. Special Education
Frances	6–12 Science	B.S. Special Education, M.A. Special Education
Han	6–12 Science	B.S. Biology, M.Ed. Curriculum and Instruction
Tracy	6–12 Science	B.S. Physics, M.Ed. Curriculum and Instruction
Roland	6–12 Science	B.S. Biology
Darcy	Alternative	B.S. Chemistry
Monica	Alternative	

^aGraduates of accredited colleges or universities whose bachelor's degree was not in education, and who have not yet earned a traditional teaching certificate, can still receive an alternative teaching certificate by satisfying certain requirements. Typically teacher education programs consist of a combination of curriculum and fieldwork. The curriculum often includes instruction on foundational knowledge and skills, pedagogy, and preparing students to research, design and implement learning experiences in their field of study. The fieldwork component can include field observations, student teaching, and an internship. The website address for Maryland approved alternative preparation programs is http://www.marylandpublicschools.org/MSDE/divisions/certification/progapproval/maapp_10_07.htm.

3.3. Interviews

Prior to the beginning of the study, the researcher contacted and visited all teacher participants for the purpose of building rapport and trust, removing any perceived status differences between the researcher and participant, and building a store of tacit knowledge about the setting. Once rapport and trust were established with a study participant, an initial interview and a follow-up interview were scheduled and conducted at a site that was most convenient for that participant. Each participant was interviewed using a semistructured interview guide. The four preplanned questions on the interview guide were specifically formulated to incite participants to reflect on their own experiences. However, I asked probing questions as needed to clarify participants' meanings and, where relevant, to ask participants for concrete examples to substantiate their espoused beliefs. The following is the semistructured interview guide:

1. In general, what characteristics do you think middle-school students need to have in order to do well in astronomy?
2. Tell me now about your own students in this school. How would you describe your students with respect to those characteristics that you say are essential for helping students to learn astronomy?
3. Do you think that teachers might have to modify what or how they teach the prescribed astronomy curriculum in response to the characteristics of their students?
4. Please describe an astronomy lesson that you taught recently. Did you have to make any adjustments to your teaching of the prescribed astronomy curriculum in response to the characteristics of your students?

Terms used in the semistructured interview guide also were defined and clarified for the study participants to ensure that they understood the context in which the questions and words were being used. Each interview lasted approximately 50–75 min. All interviews were audio-taped and transcribed verbatim. Immediately after each interview, I listened to the tapes and documented the first impressions of the issues raised by the participants in a research journal.

3.4. Data Analysis

As is typical of grounded theory methodology, constant comparative analysis, as described by [Corbin and Strauss \(2008\)](#), was used to analyze the transcripts and researcher journal entries to seek patterns in the data. These patterns were then arranged in relationship to each other in order to develop characterizations of urban middle-school teachers' beliefs about astronomy learner characteristics. Patterns also were arranged to determine the extent to which urban middle-school science teachers' modified the prescribed astronomy curriculum, in terms of how or what they teach, because of the characteristics of their students. The themes that emerged from the data were formulated in relation to the research questions. Throughout the analysis, the input, reflections, and feedback of all study participants were sought to ensure the authenticity of the interpretation of the data.

4. RESULTS

4.1. Necessary Learner Characteristics for High Achievement in Astronomy

In addressing the first research question, there are a number of student characteristics that urban middle-school science teachers believe were necessary for high achievement in astronomy. These can be categorized into three groups of student characteristics. They are cognitive skills, dispositions, and prior knowledge and experiences with the subject area.

4.1.1. Cognitive Skills

Urban middle-school teachers elaborated on a range of cognitive skills that they considered to be indispensable to success in science. The most frequently mentioned cognitive skill by teachers was that students should possess an ability to read. These teachers expressed that their best astronomy students enjoyed reading and were able to comprehend what they read. One teacher from a low-achieving school also indicated that students need to be advanced and articulated, "The advanced students are so much more interested in it [astronomy] than the slower students; I mean some of the slower students look at me like I'm from another planet." Other teachers pointed out that students need to have an ability to do mathematics. In line with this view, Becky commented, "In astronomy, there are all these calculations involved, so they need to be able to do math." Other teachers remarked that students need artistic ability. Reflecting on his own astronomy teaching, Johnny

explained that “students need to have artistic talent to construct a model of the Solar System.” Thus, for this group of teachers, these cognitive skills are, in effect, ways of thinking that astronomy requires and that students need to have.

4.1.2. Dispositions

A range of student dispositions was identified as being necessary for success in astronomy. Most frequently mentioned was motivation. Speaking of a group of students who had done well in astronomy, Frances affirmed, “I believe that the students themselves have to have that inner motivation to be able to perform well in an astronomy class.” Other student dispositions that teachers mentioned were inquisitiveness, good behavior, dedication, willingness to learn, and self-discipline.

4.1.3. Prior Knowledge and Experiences

The prior knowledge and experiences that students need to do well in astronomy were, for the most part, the school experiences that develop their understanding of the nature of science. Teachers also believed that students need to have a background and hands-on laboratory experience with basic astronomy concepts and the ability to present and communicate astronomy to their classmates or in a science fair.

4.2. Beliefs about the Characteristics of Their Own Students

Teachers were asked to describe their own students with respect to those characteristics that they had identified as being necessary for high achievement in astronomy. Without exception, the teachers were overwhelmingly negative in their beliefs regarding their students’ cognitive skills, dispositions, and prior knowledge and experiences. It was evident that teachers perceived their students as lacking cognitive skills needed for astronomy. However, for most teachers though, it was not that these urban students were incapable of doing well but that they lacked a number of other characteristics needed to do well.

The most frequently mentioned characteristic that teachers perceived their students to be deficient in was their ability to learn. It was surprising that regardless of school achievement level, all 12 teachers referred to their students as slow learners and frequently described them as having limited knowledge in astronomy and science in general. Several teachers also viewed astronomy as being particularly too advanced for low-achieving students. A teacher with 10 years of experience in a low-achieving school expressed, “They don’t even have any rudimentary knowledge at all about astronomy. They don’t even understand in some cases what a moon is, you know, or a planet. They don’t even know what the stars are.”

Teachers believed that their students were constrained in their ability to grasp astronomy concepts because they lacked the ability to read or comprehend what they were reading. Students also were viewed as not having the necessary mathematical problem-solving skill sets to determine or comprehend specific astronomy concepts such as “speed of light,” “light-years,” or “the scale of the solar system.” The students were further described as having short attention spans and no long-term memory, both characteristics that were thought to be needed to do well in astronomy.

Teachers viewed their students as having poor attitudes, which seriously undermined their achievement in astronomy. The lack of motivation was a consistent theme in all of the interviews. Students were described as “lacking desire,” “not trying,” and “not interested.” The lack of motivation manifested itself in several ways, including disengagement in class and failure to take responsibility for learning.

Inappropriate and emotional behaviors were consistently cited as being responsible for underachievement in astronomy. Another aspect of the perceived lack of discipline was the students’ preoccupation with having fun, which took precedence over school-work. One teacher from a middle-achieving school explained, “Their concept of fun is like, I will fool around in the classroom; you will laugh at me; you laugh at what I will do; and that’s cool, and they like that.”

All of the teachers perceived their students as coming to middle-school with limited prior knowledge and inadequate prior experiences in astronomy. Their scientific process skills were poor. They had no knowledge of experimental design and could not interpret data. These teachers often placed blame on elementary teachers for not covering astronomy topics from the prescribed astronomy curriculum with students in grades K-5. Reflecting on his students’ characteristics, Han expressed, “When I first started working, I was advised by

someone here that they are not performing very well, so don't make them do the experiment." Han further articulated, "Giving them only the objective and the materials and letting them do the procedure is good, so they might say, but I don't think that these children are ready for that." Thus, without exception these 12 teachers described their students as not being prepared intellectually, not being accustomed to conducting experiments, and not having enough knowledge, exposure, or preparation in astronomy prior to middle-school.

4.3. Reported Instructional Modifications

Teachers were asked to give their views on whether their teaching of the prescribed astronomy curriculum should be modified in light of the characteristics of their students. They were then asked to describe any instructional modifications that they themselves make in either content or delivery of the prescribed astronomy curriculum in an effort to address the needs and characteristics of their own students. They were further prompted to give examples of these instructional modifications by referring to the actual astronomy lessons plans that they had taught. It was clear that the teachers recognized the need to adapt their teaching of the prescribed astronomy curriculum in response to the characteristics of their students. An analysis of teacher responses to this issue revealed that teachers modified their instruction of the prescribed astronomy curriculum in response to two groups of factors. These were school conditions and learner characteristics.

The school conditions that necessitated teaching modifications of the prescribed astronomy curriculum were time and availability of resources. The majority of the 12 teachers described time as a major constraint. Notably, a third of the science teachers without any formal training or background in astronomy acknowledged that they did not teach the prescribed astronomy curriculum. These teachers articulated that this was the main reason for why they wanted to participate in Project ASTRO the following academic year. Several other teachers, who adapted to their students' needs by slowing down the pace of teaching, divulged omitting more advanced astronomy topics in the prescribed astronomy curriculum due to a lack of time. When resources were in short supply, or lacking, teachers reported deemphasizing laboratory experiments and simulations, and disclosed using class discussions as their main pedagogical strategy for teaching astronomy.

The learner characteristics that necessitated teaching modifications of the prescribed astronomy curriculum were the students' deficiencies in prior knowledge and their perceived lack of motivation. In response to these perceived learner deficiencies, teachers reported de-emphasizing mathematics and reading in astronomy lesson plans, modifying the amount of time given on tests and class assignments, and reducing the depth of content coverage and the amount of laboratory experiments in astronomy. When students were judged to be lacking in motivation or interest in science, teachers attempted to engage them by contextualizing the science in experiences that were familiar to them. Real-life application of the astronomy concepts was the teaching strategy used. Motivation was deemed by these teachers to be an important determinant of their students' success in science, and teachers sought to foster this by making the astronomy content more relevant.

Teachers also reported reducing the level of difficulty of astronomy topics. Specifically, one teacher reported removing the difficult mathematics to ensure that the students' lack of mathematics skills did not hinder the learning of the astronomy concepts. Teachers also reported de-emphasizing astronomy laboratory experiments with students that were perceived to behave inappropriately. One teacher from a low-achieving school explained, "If they can't do the procedure, and they are going to play around, then I can't afford to have that." Teachers further made judgments about their students' ability level. One teacher from a high-achieving school commented, "With the poor performing ones, I wouldn't go too much past the Solar System." Another teacher from a middle-achieving school explained that she eliminated more complex astronomy content for her low-achieving students.

In response to their students' perceived characteristics, teachers reported employing manipulatives and instructional aides. These include models, diagrams, technology, process charts, graphic organizers, and outlines. Following are two examples of this viewpoint: "If I am going to introduce a concept to them, you have to show process charts, and if they have to answer something, it should be in a graphic organizer, or give them a step-by-step procedure with illustrations (Han)." "I give them some outline, especially if I am going to give a test. I make it boldly written, and underline important words (Molly)."

5. DISCUSSION

The purpose of this study was to uncover urban middle-school teachers' beliefs about astronomy learner characteristics and the links that teachers make between their beliefs and their instructional decisions and

practices. Specifically in this study, teachers viewed astronomy as a difficult subject, and as requiring students with special characteristics. Astronomy also was more difficult than other science content areas and only those who recognized that and who naturally had or acquired good “cognitive skills” could be successful. This leads one to wonder whether these teachers subscribe to a somewhat elitist view of astronomy and science in general. Although these teachers were not motivated necessarily by an intention to be exclusive, they might be functioning to exclude these students from full access to science, and astronomy in particular.

5.1. A Deficit Model

It is evident that for the most part these teachers employed what has been described as a deficit model for understanding the problems that urban children face with respect to astronomy achievement. Teachers’ explicitly stated beliefs about their students, with respect to the characteristics needed for high achievement in astronomy, and revealed that they viewed the students as deficient in many of the cognitive skills, dispositions, and prior knowledge and experiences that were required. The students lacked motivation, were not interested, and often did not comply with the teachers’ demands. Teachers in the present study were not unique in holding these beliefs. Gross (1993) reported that teachers found that minority students often “did not come to their classes prepared to work or in the proper frame of mind to attend fully to instruction” (p. 281).

In the view of teachers in this study, students did not measure up to the high intellectual and attitudinal demands of astronomy. The deficit model can be used to explain the low levels of astronomy achievement of minority students as one that absolves the school of any complicity in the students’ underachievement and places the blame on the students. In this view, as is the case with the teachers in this study, the students are seen as not having what it takes to succeed. Their characterizations reflected widely held stereotypes that charge minority students with a lack of interest in academics and low performance in school subjects, especially in mathematics and science (Steele 1999). In a similar vein, Ennis and McCauley (2002) suggested that the lack of motivation, the failure to comply with school demands, and the lack of engagement with learning (all of which were described by teachers in this study) are evidence of a lack of trust in the educational system on the part of urban minority children. The literature cited earlier in this article on the impact of teacher beliefs on student outcomes suggests that these beliefs about their students are likely to have a profound effect on their instructional decisions.

5.2. Curriculum Implications

Teacher variables including their beliefs, judgments, and values serve as filters through which the astronomy curriculum is experienced by students. In this study, teachers were explicitly asked to report on how they modified their instruction of the prescribed astronomy curriculum in response to their beliefs about the learning characteristics of their students. They reported not teaching the prescribed astronomy curriculum, reducing the depth of astronomy concepts, and deemphasizing reading, mathematics, and science process skills. It is possible that these adaptations in fact amount to a watering down of the prescribed astronomy curriculum and might well be an indication that what these urban children were being offered was a “pedagogy of poverty” (Haberman 1991). Indeed, if the students were seen as being “deficient,” then reducing the complexity of the science content is the appropriate response.

In summary, the urban science teachers who participated in this study, prior to their participation in Project ASTRO, held the view that their students were, for the most part, ill-prepared for middle-school science and lacked the cognitive skills, dispositions, attitudes, interest, and motivation needed to attain a high level of achievement in astronomy. On their part, the teachers only reported making instructional modifications that were accommodations to the deficiencies that they perceived in their students. The implications of these findings suggest that urban students might in fact be experiencing an astronomy curriculum that is alienating and does not promote their engagement with the subject matter. If these students are then assessed by the same measures as their counterparts in nonurban settings, then the much publicized achievement gap between urban and nonurban students in science, and astronomy in particular, should come as no surprise.

The implications for science teacher education programs, both preservice and professional development, are obvious. Teachers must first understand the ways in which their teaching has been culturally insensitive and confront the beliefs that underlie their practice. Without this understanding, teachers’ beliefs will remain unexamined and their teaching becomes “a process in which selective perception enhances what the teacher believes at the start” (Haberman and Post 1998; p. 101).

5.3. Next Steps

Future investigations could potentially examine the aspects of Project ASTRO that contribute to a successful astronomer-educator partnership, as well as the extent to which these partnerships influence urban astronomy learner characteristics and teachers' instructional decisions and practices. Moreover, it would be interesting to examine stereotype threat and use diagnostic tests to determine if there are student learning gains and determine whether these gains are happening where the teachers think they are occurring. It also would be interesting to determine how astronomer-educator partnerships make the learning of astronomy culturally relevant to urban learners.

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NOTES

Note 1: The Maryland voluntary state curriculum for astronomy for middle-school is listed under Standard 2.0 Earth and Space Science, Section D. The website address is http://mdk12.org/instruction/curriculum/science/standard2/grade_6_8_info.html.

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