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Urban Middle-School Science Teachers Beliefs about the Influence of Their Astronomer-Educator Partnerships on Students' Astronomy Learner Characteristics

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Abstract

This qualitative study investigates the extent to which urban middle-school science teachers' beliefs about their students' astronomy learner characteristics were influenced by their partnership with an astronomer in their classroom. Twelve urban middle-school science teachers were interviewed after their participation in Project ASTRO during the 2009–2010 academic year using semistructured, in-depth interview techniques. Constant comparative analysis was used to analyze the interview transcripts. Themes that emerged from the data were formulated in relation to the study's grand tour research question. The findings suggest that teachers believed that their partnership with an astronomer largely influenced their students' level of motivation and increased their students' level of questioning. Teachers also believed that their astronomer partner positively enhanced their students' learning experiences in astronomy by making the subject area more realistic, relevant, and scientifically rigorous. Additionally, the study showed that teachers believed that their partnership with an astronomer in their classroom positively affected their students' behaviors and attitudes in middle-achieving and high-achieving schools. The study further revealed that partnering with an astronomer had a relatively minor impact on urban middle-school science teachers' beliefs about their students' mathematical cognitive ability. The implications of these findings suggest that astronomer-educator partnerships may enhance urban middle-school students' learning experiences in astronomy and promote their engagement with science. However, new educational approaches need to be developed and assessed to help bolster students' understanding of astronomy, especially in low-achieving urban school settings.

1. INTRODUCTION

Over the past two decades, scientist-educator partnership programs have rapidly emerged across the United States with the goal of enhancing the teaching and learning of science to students in our nation's schools. [The National Research Council \(1996\)](#) has evoked that scientists play a critical role in achieving a vision of a scientifically literate populace. Reports also suggest that K-12 science education could be strengthened if scientists partner with teachers in local area schools to share their knowledge, passion, and expertise in science with students ([Linn *et al.* 1999](#); [Munn *et al.* 1999](#); [Wheeler 1998](#)). Although many published articles and reports often describe the outcomes of scientist-educator partnership programs anecdotally, the influence of scientist-educator partnerships on the teaching and learning of science to students, especially in urban settings, has not been well documented in the extant research literature. Given the lack of empirical evidence, a more comprehensive understanding of the influence of scientist-educator partnerships is vital, especially for designers and facilitators of such educational programming.

Accordingly, this study is premised on the view that student learning outcomes are determined in large measure by the nature of their learning experiences. Thus, a study of the classroom experiences of urban children might hold the key to an understanding of the problems of underachievement that commonly afflict this population of

students. This study probes one aspect of the classroom experiences of urban middle-school students. Specifically, this qualitative study investigates the extent to which urban middle-school science teachers' beliefs about their students' astronomy learner characteristics were influenced by their partnership with an astronomer in their classroom.

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; Cochran-Smith 2000). Teacher beliefs are among the most widely researched aspects of teacher thinking. 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, especially in urban settings.

This study is also situated within research that centers on teacher beliefs about student science learner characteristics and classroom practice. Herwitz and Guerra (1996) found that teachers generally view science as a fixed, somewhat daunting, body of knowledge. Consequently, the content of science curricula is often perceived by teachers as reserved for the elite few (Herwitz and Guerra 1996; Prime and Miranda 2006). However, research has shown that scientist-educator partnerships can construct change in teacher beliefs and associated values in science (Rutherford and Ahlgren 1990) and can also affect classroom practice (Herwitz and Guerra 1996).

Research has further revealed a range of student learner characteristics that urban middle-school science teachers believe to be necessary for high achievement in science, and astronomy in particular (Miranda 2010). These can be categorized into three groups of student astronomy learner characteristics. They are cognitive skills, dispositions, and prior knowledge and experiences with the subject area. Regarding cognitive skills, teachers frequently mentioned that students need to possess an ability to read and do mathematics. Pertaining to dispositions, teachers believed that students should be motivated, dedicated, willing to learn, self-disciplined and exhibit good behavior. Concerning prior knowledge and experiences, teachers believed that students need to have a background and hands-on laboratory experiences with basic astronomy concepts and an ability to present and communicate astronomy to their classmates, or in a science fair. Conversely, Miranda (2010) found that urban middle-school science teachers viewed their own students as largely lacking in these characteristics and reported such instructional modifications as (1) not teaching the prescribed astronomy curriculum, (2) deemphasizing related mathematics, reading and science process skill sets, (3) deemphasizing advanced astronomy topics and laboratory experiences, and (4) reducing the depth of astronomy concepts.

Keeping in line with this growing area of research, the present study investigated the extent to which urban middle-school science teachers' beliefs about their students' astronomy learner characteristics were influenced by their partnership with an astronomer in their classroom. The significance of this exploratory study of teachers' beliefs and how their beliefs might be influenced lies in its orientation toward praxis. This study also responds to the call by Bryan and Atwater (2002) for research that addresses science teachers' "beliefs about issues of multiculturalism and its impact on science teaching and learning" (p. 834). Moreover, the findings and implications of this study are vital for designers and facilitators of scientist-educator partnership programs and for science teacher education programs that prepare both in-service and preservice teachers to be culturally responsive in their classroom practice.

3. METHODS

Qualitative researchers often begin interviews with a grand tour research question. Grand tour research questions are open ended questions that allow the interviewee to set the direction of the interview. The interviewer then follows the leads that the interviewee provides. The interviewer can always return to his or her preplanned interview questions after the leads have been followed. Specifically, this qualitative study sought to investigate the following grand tour research question: To what extent do urban middle-school science teachers believe that their partnership with an astronomer in their classroom influences the astronomy learner characteristics of the students whom they teach?

3.1. Design

The study employed qualitative methods to explore the grand tour research question. 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 had served more than 100 000 students (Fraknoi and Zevin 2003). Project ASTRO is a successful model for astronomer-educator partnerships (Fraknoi, Bennett, and Richter 1998) and has been listed among the most effective programs in the US involving scientists and engineers in K-12 education (Connolly 1997). Surveyed teachers participating in Project ASTRO have also indicated that their partnering astronomer in their classroom 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 within a large urban school district.

A total of 12 urban middle-school science teachers were 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 2010 achievement data (Maryland State Department of Education 2010). Each middle-school science teacher voluntarily agreed to participate in this study. Prior to the academic school year, the educator and astronomer partners collaboratively chose four Project ASTRO activities that were in-line with their school's science curriculum (see Note 1) during a Project ASTRO introductory workshop. Each educator facilitated these four Project ASTRO activities with their astronomer partner on four separate school days throughout the academic school year in their own formal classroom.

All data for this study were collected 2 weeks after their participation in Project ASTRO during the 2009–2010 academic school year. 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.

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, a postparticipation interview was scheduled and conducted at a site that was most convenient for that participant. Each participant was interviewed using a semistructured interview guide. The three 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. Following is the semistructured interview guide:

1. In general, how has your participation in Project ASTRO impacted your students?
2. Please describe the Project ASTRO activities that you and your astronomer partner facilitated with your students during the academic school year. How have these activities impacted your students?
3. How has your partnership with an astronomer influenced your students' astronomy learner characteristics?

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 1 h. 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.

Table 1. Participant profiles

Pseudonym	Gender	Race	Age	School achievement	Grade level taught	Teaching experience
Johnny	Male	White	40–50	Low	6 and 8	10 Years
Tasha	Female	Black	30–40	Low	6	4 Years
Amanda	Female	Black	30–40	Low	7 and 8	4 Years
Suzie	Female	Black	50–60	Low	8	21 Years
Martin	Male	White	20–30	Middle	6	2 Years
Becky	Female	White	20–30	Middle	7 and 8	2 Years
Frances	Female	Asian	30–40	Middle	6	3 Years
Han	Male	Asian	30–40	Middle	7 and 8	3 Years
Tracy	Female	White	40–50	High	6 and 8	10 Years
Roland	Male	Black	60–70	High	6 and 8	32 Years
Darcy	Female	Asian	30–40	High	6 and 8	3 Years
Monica	Female	White	20–30	High	7 and 8	2 Years

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 science teachers' beliefs. Patterns were arranged to determine the extent to which urban middle-school science teachers' beliefs about their students' astronomy learner characteristics were influenced by their partnership with an astronomer in their classroom. The themes that emerged from the data were formulated in relation to the study's grand tour research question. Throughout the analysis, the input, reflections, and feedback of all study participants were sought to ensure the trustworthiness of the data and authenticity of the interpretation of the data.

4. RESULTS

4.1. Influence of Partnerships on Teachers' Beliefs

In addressing the study's grand tour research question, urban middle-school science teachers believed that their partnership with an astronomer in their classroom influenced their students' astronomy learner characteristics to

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
Amanda	6–12 Science	B.S. Physics; M.Ed. Administration & Supervision
Suzie	Alternative	B.S. Chemistry
Martin	Alternative	B.S. Finance
Becky	Alternative	B.S. Biology; B.A. Psychology
Frances	6–12 Science	B.S. Elementary Education; M.A. Special Education
Han	6–12 Science	B.S. Special Education; M.A. Special Education
Tracy	6–12 Science	B.S. Biology; M.Ed. Curriculum & Instruction
Roland	6–12 Science	B.S. Physics; M.Ed. Curriculum & Instruction
Darcy	Alternative	B.S. Biology
Monica	Alternative	B.S. Chemistry

^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.

a certain extent. The themes that emerged from the data focused on the following students' astronomy learner characteristics: mathematical cognitive ability, motivation, inquisitiveness, behaviors and attitudes, and prior knowledge and experiences with the subject area.

4.1.1. Influence of Partnerships on Mathematical Cognitive Ability

Urban middle-school science teachers believed that their partnership with an astronomer in their classroom had a relatively minor impact on their students' mathematical cognitive ability. Regardless of school achievement level, urban middle-school science teachers expressed that their partnership with an astronomer only influenced a limited number of their students' understanding of astronomy concepts involving mathematics. For instance, Tracy, a teacher with 10 years of experience in a high-achieving school explained, "After one of my students had done the circumference calculation four times, she said, 'Wow! This isn't as hard as I thought!'" Tracy, reflecting on all of her students, further commented, "Once in a while, you'll get little glimmers of that." Similarly, after describing an astronomy activity involving mathematics that she facilitated with her astronomy partner, Suzie, a teacher in a low-achieving school articulated, "There are typically only two or three shining stars in every class who will actually understand that astronomy concept (light-years)."

When incited to explain why they thought the majority of their students exhibited difficulty understanding astronomy concepts involving mathematics, urban middle-school science teachers offered several reasons. Amanda, a teacher in a low-achieving school expressed, "It is too difficult for urban students to follow a set of instructions or set of tasks." Similarly, Roland, a teacher in a high-achieving school acknowledged, "Having students record data is a really difficult task." Reflecting on an activity that she facilitated with her astronomer partner, Becky remarked, "We put up all the equations and we gave them everything they needed, you know, tape and their calculators and stuff, and we gave them choices such as A, B, C, and D as well to make it even easier for them, and they just didn't get it." Other urban middle-school science teachers pointed out that "urban kids are just not particularly motivated by mathematics," or "mathematics has always been a constant struggle for my students." Thus, a major theme that emerged from the postparticipation data is that urban middle-school science teachers for the most part retained their initial perception that their students are constrained in their ability to grasp astronomy concepts involving mathematics primarily because they lack the necessary mathematical problem-solving skill sets (Miranda 2010).

4.1.2. Influence of Partnerships on Level of Motivation

Prior to their participation in Project ASTRO, urban middle-school science teachers held the belief that their students lacked motivation and often described them as lacking desire, not trying, and not interested in learning (Miranda 2010). However, after participation in Project ASTRO, the majority of urban middle-school science teachers believed that their partnership with an astronomer in their classroom had a large influence on their students' level of motivation, especially in low-achieving schools. Johnny, a teacher with 10 years of teaching experience in a low-achieving school remarked, "Whenever my astronomer partner visited my classroom, there were a lot of interested students and they actually began to ignore the students who were goofing off." Similarly, Monica, a teacher in a high-achieving school described a noticeable improvement in her students' dispositions and mentioned, "My students were much more motivated and much more attentive whenever my astronomer partner visited the class." Moreover, Frances, a teacher in a middle-achieving school acknowledged, "I knew that my students were interested in what we were doing because it was after school and they did not want to leave the classroom or go home. They wanted to continue working on the activity that my astronomer partner and I were facilitating." Of the 12 teachers participating in the study, only Roland, a sixth and eighth grade teacher with 32 years of teaching experience in a middle-achieving school believed that his students' level of motivation remained unchanged after his participation in Project ASTRO. Roland openly placed the blame on his students for their underachievement in science and astronomy in particular and articulated, "In my experience, eighth graders are just motivationally challenged and are done being in school."

4.1.3. Influence of Partnerships on Level of Questioning

Urban middle-school science teachers believed that their partnership with an astronomer in their classroom had a large impact on their students' level of questioning. After their participation in Project ASTRO, all urban middle-school science teachers mentioned that they noticed an increase in the quality and frequency of questions that their students asked. For example, Tasha, a teacher in a low-achieving school expressed, "There were definitely a number of kids who became really curious about astronomy and asked a lot of questions." In a

similar manner, Han, a teacher from a middle-achieving school acknowledged, “Since my partner specializes in astronomy, they really had a lot of questions for him.” Darcy, a teacher from a high-achieving school further remarked, “They were asking my astronomy partner a lot of intelligent questions.”

4.1.4. Influence of Partnerships on Students’ Behavior and Attitudes

Prior to participation in Project ASTRO, urban middle-school science teachers believed that their students’ inappropriate and emotional behaviors were the main reason for their underachievement in science and astronomy in particular (Miranda 2010). However, after participation in Project ASTRO, urban middle-school science teachers in middle-achieving schools and high-achieving schools believed that their partnership with an astronomer in their classroom positively affected their students’ behaviors and attitudes. Frances, a teacher in a middle-achieving school articulated, “I teach all sixth grade boys and they gave me nothing but trouble every day, but from the time we went from my class to the auditorium to do an activity with my astronomer partner, I didn’t hear a word from them, or even see a student misbehave. I could tell that they really wanted to do the activity.” Martin, another teacher from a middle-achieving school expressed, “There was a large noticeable percentage of kids that did act much, much better whenever my astronomer partner came to the classroom because it was something new; something different; something exciting.” Tracy, a teacher from a high-achieving school mentioned, “There was an increase in the number of my students that wanted to go to other science outreach events at my astronomer partner’s workplace.

Conversely, urban middle-school science teachers’ beliefs about their students’ attitudes and behaviors in low-achieving schools remained unchanged after their participation in Project ASTRO. Teachers in low-achieving schools expressed that their students: “were easily distracted and rude,” “would sleep,” “craved attention,” “laughed and giggled,” “were disrespectful to people of authority,” “talked out of turn,” “had sidebar conversations,” and “lacked self-discipline.” Consequently, teachers in low-achieving schools acknowledged that their astronomer-educator partnership tended to focus only on students that were readily engaged in the Project ASTRO activity. Moreover, Amanda, a teacher in a low-achieving school offered the following explanation for why their astronomer partner decided not to return to her classroom the next academic year: “I guess that she found that particular age group and that particular level of kids in an inner city school just wasn’t worth the effort that she put into it.”

4.1.5. Influence of Partnerships on Prior Knowledge and Experiences

Prior to participation in Project ASTRO, urban middle-school science teachers perceived that their students came to school with inadequate prior experiences in astronomy and limited prior knowledge and scientific process skills (Miranda 2010). However, after participation in Project ASTRO, these science teachers believed that their partnership with an astronomer in their classroom positively enhanced their students’ learning experiences in astronomy by making the subject area more realistic, relevant and scientifically rigorous.

Urban middle-school science teachers acknowledged that their astronomer partner assisted them in linking astronomy activities to the state’s curriculum and to the state’s middle-school achievement test and made the astronomy content more realistic for their students. Urban middle-school science teachers expressed that their astronomer partner helped them to facilitate a wide range of engaging, realistic astronomy activities that focused on topics such as rockets, telescopes, the scale of the solar system, the International Space Station, gravity, aliens, constellations, water on the moon, comets, moon phases, moons of Jupiter, Rings of Saturn, the reason for seasons, solar cycle, lunar cycle, planetary formation, and snow on Mars.

Urban middle-school science teachers also articulated that their astronomer partner helped them to make astronomy content more relevant to students by linking it to things that they could relate to such as music, movies, stories in newspapers and magazines, astronomy pictures, constellations, star maps, stars, horoscopes, iPods, television shows, and cell phones. The majority of urban middle-school science teachers mentioned that their astronomer partner exposed students to information about college and to various career paths in science, technology, engineering, and mathematics.

Urban middle-school science teachers expressed that their astronomer partner helped them to make astronomy content more culturally relevant to students by linking it to cultural mythology stories and cultural role models such as African-American astronomer Benjamin Banneker; African-American abolitionist Harriet Tubman; African-American astrophysicist Neil DeGrasse Tyson; African-American astronaut Robert Curbeam; and Hispanic astronaut Ellen Ochoa.

Urban middle-school science teachers further explained that their astronomer partner helped them to make the astronomy content more rigorous for students by allowing them to conduct a range of inquiry-based activities. Urban middle-school science teachers frequently mentioned that their astronomer partner allowed students to collect data and explain what they learned using scientific evidence. Suzie, a teacher in a low-achieving school mentioned, “This is the first time that they are doing hands-on experiences.” Similarly, Frances, a teacher in a middle-achieving school articulated, “My astronomer partner always designed activities to be discovery activities for my students.”

5. DISCUSSION

The purpose of this study was to investigate the extent to which urban middle-school science teachers’ beliefs about their students’ astronomy learner characteristics were influenced by their partnership with an astronomer in their classroom. The main themes that emerged from the data suggest that there are several urban middle-school science teachers’ beliefs that were both transformed and retained.

5.1. Transformed Urban Middle-School Science Teachers’ Beliefs

Urban middle-school science teachers believed that their partnership with an astronomer in their classroom positively enhanced their students’ learning experiences in astronomy by making the subject area more realistic, relevant and scientifically rigorous. Urban middle-school science teachers also believed that their partnership with an astronomer in their classroom largely influenced their students’ level of motivation and their students’ level of questioning. The implication of these findings is that establishing partnerships with scientists, such as astronomers, might help to increase the pipeline of underrepresented students pursuing careers in science, technology, engineering, and mathematics. Additionally, these findings suggest that astronomer-educator partnerships might help to enhance students’ learning experiences in astronomy and promote their engagement with science, especially in urban settings. These findings also help to refute [Ennis’ and McCauley’s \(2002\)](#) argument that the lack of motivation and the lack of engagement with learning are evidence of a lack of trust in the educational system on the part of urban minority children. Another implication of these findings is that astronomer-educator partnerships may help to foster open-inquiry based teaching strategies in urban science classrooms, in which students generate questions themselves and develop ways to determine the answer to those questions. The ramification of this finding suggests that astronomer-educator partnerships might help to begin to specifically address [Settlage’s \(2007\)](#) argument that open-inquiry, in particular, is difficult to use in the classroom and is impractical for teachers to regularly implement.

This study further showed that urban middle-school science teachers believed that their partnership with an astronomer in their classroom positively affected their students’ behaviors and attitudes in middle-achieving and high-achieving schools. The implication of this finding suggests that the enacted astronomy curriculum experienced by urban middle-school students might also be positively impacted. Additionally, this implication is congruent with research that suggests that scientist-educator partnerships can construct change in teacher beliefs and can also affect classroom practice ([Herwitz and Guerra 1996](#)). Moreover, this finding further suggests that astronomer-educator partnerships can help to transform urban middle-school science teachers’ prior beliefs about how students’ inappropriate and emotional behaviors are primarily responsible for their underachievement in astronomy and requires teaching modifications of the prescribed astronomy curriculum ([Miranda 2010](#)).

5.2. Retained Urban Middle-School Science Teachers’ Beliefs

This study revealed that astronomer-educator partnerships had only a relatively minor impact on urban middle-school science teachers’ beliefs about their students’ mathematical cognitive ability, or their students’ behaviors and attitudes in low-achieving schools. The teachers in the present study are not unique in retaining these beliefs. [Nespor \(1987\)](#) asserted that beliefs have strong affective and evaluative components, are rooted in personal history, and are not easily changed. This observation is also similar to research that affirms that teachers believe that minority students often do not come to their classes with the proper frame of mind or dispositions to attend fully to instruction ([Gross 1993](#)). In this study, the teachers’ characterizations of their students’ constrained ability to grasp astronomy concepts involving mathematics because of their perceived deficiencies in mathematical problem-solving skills also reflect widely held stereotypes that tend to lay the blame on minority students with low performance in school subjects, especially in science and mathematics ([Steele 1999](#)). Thus, the corollary of these teacher beliefs on student outcomes suggests that these teachers’ retained beliefs about their students’ astronomy learner characteristics are likely to have a profound negative effect on their instructional

decisions. This implication is parallel with Pajares (1992) who 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. Thus, new educational approaches need to be developed and assessed to determine how to specifically help bolster students' understanding of astronomy, especially in low-achieving urban school settings.

5.3. Next Steps

Future studies could focus specifically on determining the extent to which mathematics concepts that are taught by astronomer-educator partnerships are appropriate for urban middle-school students. Additional studies could examine what constitutes a successful astronomer-educator partnership, as well as the extent to which these successful partnerships influence urban middle-school teachers' instructional decisions and practices. Future investigations could also potentially examine astronomers' beliefs about astronomy learner characteristics. Additionally, it would be interesting to conduct observational studies that examine the level of inquiry at which astronomer-educator partnerships facilitate Project ASTRO activities, as well as the level of cognitive demand astronomer-educator partnerships places on students. Future research could further focus on identifying specific Project ASTRO activities that are successfully helping to transform urban students' understanding of astronomy, especially in low achieving schools. Moreover, it would be interesting to examine students' beliefs about participating in Project ASTRO to determine how astronomer-educator partnerships have directly impacted urban learners' understanding of astronomy concepts, science experiences and career choices.

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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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