Introduction

After the launch of the Soviet's Sputnik in 1957, the United States experienced a renewed interest in space science and a boom in planetarium construction occurred. NASA was formed in 1958, approximately 1200 school and community planetariums were built across the United States, and astronomy course offerings increased in the science curriculum. The planetarium became a valuable tool used for teaching students about planets, moons, stars, and how objects move and interact in space. University, high school, and community-based planetariums became a popular site for research to examine how this type of informal environment was being used in education and whether planetariums had positive effects on learning. According to Sunal (1976), "The planetarium experience can change student performance in most, if not all, of the goal areas of planetarium education" (p. 348).

Several studies have been conducted since the 1960s on the effectiveness of planetarium instruction compared to traditional classroom instruction. Dean and Lauck (1972), Tuttle (1966), and Wright (1968) found positive results supporting planetarium instruction while data from Reed (1970), Rosemergy (1968), and Smith (1966) supported classroom instruction in teaching astronomy. Although early studies yielded conflicting results, more recent studies have shown planetariums have beneficial effects on students and should be used in space science education (Baxter & Preece, 2000; Palmer, 2007). Present day researchers agree with Sunal (1976) but continue to point out that planetarium research is lacking a standardized instrument to assess student learning, there continues to be difficulty in comparing studies, and measuring the long-term effects of learning has not been answered.

The purpose of this research is to study how informal education in a planetarium influences students' thinking, students' attitudes toward astronomy, and whether their learning persists over time. The study will be guided by the following research questions:

1. How do the rich visualizations of a planetarium shape students' thinking of astronomical concepts?
2. How do students' attitudes toward science change after a planetarium experience?
3. Does planetarium instruction contribute to the persistence of conceptual understanding of astronomy concepts over time?

Methods

A mixed methods approach will be used in this case study of how a planetarium impacts students. A case study is an appropriate research design because the primary focus of the project will be to explore how the planetarium shapes students' thinking at this particular high school with students enrolled in a specific science course. Both qualitative and quantitative data sources will be collected in order for triangulation to occur and strengthen the findings.

This study will include students from two high schools within a large school district in a semi-suburban area of the Midwestern United States. Being in the same district, both schools offer a tenth grade earth and space science course. One school works in collaboration with a university planetarium during their astronomy unit and the other does not. At the conclusion of the nine-week unit students take a common formative assessment (CFA) test that was co-designed by the science departments of each school.

Students enrolled in the same class at both schools will be administered a pre-

course attitude survey and a post-planetarium/end of unit attitude survey. This will allow for a comparison of any changes in the students' attitudes during the course and whether exposure to a planetarium during the earth and space science unit contributed to the changes. CFA results from both schools will be analyzed to compare any differences in student's performance and student interviews will give insight into their feelings as to whether their performance on the CFA was based on the planetarium program. Although there is no validity to the CFA outside of this district, it is an instrument created by educators at both schools and allows for a comparison of student's scores between the two schools.

Additional data will be collected through small focus group interviews with students. In order to answer the research question about how the planetarium shapes students' thinking interviews will take place inside the actual planetarium. The planetarium setting will allow for use of the stimulated recall technique where students will be shown dynamic visualizations on the dome to elicit discussion. The focus group interviews will capture students' learning, understanding, and attitude toward astronomy while also allowing them to build off of each other and collaborate to think through the visualizations they observe on the dome. Further data will be gathered from teacher interviews where information will be obtained about student progress, comments in class, and changes in attitude that may have occurred over the course of the astronomy unit.

A difficult aspect of planetarium research is obtaining an accurate measurement of what and how much students actually learn from the informal experience. Many studies collect data immediately and do not measure the long-term retention of astronomy concepts. A concern is that immediate assessment does not necessarily measure what

was learned during a specific program. This study will include measurement of knowledge at the conclusion of the school's astronomy unit and months after the astronomy unit and planetarium program. Furthermore, a second round of focus group interviews will be conducted months later in attempts to measure how much conceptual knowledge of astronomy students have retained over time.

The quantitative data will be collected through classroom teachers and their use of Google Docs. The CFA data will be analyzed by simply comparing the scores of students in both schools. Additionally, a subset of CFA questions will be examined in-depth based on their direct relation with the planetarium program and whether students at the school with the embedded planetarium program outperformed their counterparts. The CFA will act as a guide to design stimulated recall interview visuals and to gather insight into the process of student thinking about specific astronomical concepts. The pre-unit and post-unit content assessments will be analyzed for any statistically significant changes by using a dependent t-test. These results will allow for a comparison of students between schools and the impact of the planetarium on students in the case study school.

The qualitative data collected will be analyzed through audio and/or video recording, followed by transcribing the data, and finally coding it for emerging themes. The goal of the study is to explore how the planetarium shapes the process of thinking and learning of astronomical concepts, therefore any generated codes will come from specific mention of their thinking, comments about changes in thinking before and after the planetarium, and real-time connections made while being interviewed within the planetarium environment.

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