Planetarium Use In Introductory Astronomy Courses

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ABSTRACT

Many planetariums are situated at institutions of higher learning, but there is little documentation about how these facilities are being used. We present an analysis of a survey designed to explore planetarium use in introductory astronomy courses taught to undergraduates. The survey asked about 11 learning objectives, which were chosen through an investigation of online course descriptions at 10 universities in the United States. Planetarium users answered questions about what they are teaching, how long they are teaching it, and what media they are using to teach it. We distributed the survey to approximately 289 institutions around the United States which were categorized as institutions of learning in the online Worldwide Planetariums Database. There were 85 responses to the survey with 78 providing enough information to be useful. Results show that college and university planetariums are primarily being used to teach the night sky and that planetarium users at these institutions prefer to teach through unscripted use rather than scripted shows. We discuss potential implications to content development and further research in instructional methodology.

Keywords: Astronomy Education Research; Planetarium; Discipline-based Education Research

Many people can recall a childhood visit to the planetarium where they felt the thrill and emotion from viewing the night sky and listening to the voice of the lecturer. The planetarium has always been a place to entrance and entertain audiences. To begin to understand how planetariums are being used today, we first need to take a trip back in time to unfold what they were originally intended to do. The idea for a hemisphere dome and apparatus for projecting the night sky was first pitched in 1913 by Oskar von Miller, founder of the Deutsches Museum (German Museum) in Munich, Germany. It was not until years later in 1919 that Walther Bauersfeld, working for the Carl Zeiss firm, unveiled the first design for what was known then as a star theater. In 1923, the Model I projector was showcased for the first time and in 1925, it was permanently installed in the Deutsches Museum (History of ZEISS). Walther Bauersfeld's star theater could do two things: First, it produced an immersive simulation of the real sky on an ideal night, a sight that many city dwellers had never seen. Second, it provided an illustrated model of the motion of the Sun and planets, and how these relate to the stars and the universe beyond (Firebrace, 2017). For decades, star theaters continued to be built in museums and other informal settings to provide awe and entertainment to paying customers.

The planetarium was significantly improved with the introduction of digital computer graphics. The first digital projection system was installed at the UNIVERSE Planetarium in Richmond, Virginia by the Evans and Sutherland firm in 1983. This new projection system featured a 4k-by-4k projection of an astronomically accurate 3D universe. By 2002, Evans and Sutherland had sold nearly 100 similar or improved systems (Lantz, 2002). Research into digital planetariums shows that they have certain affordances for learners such as providing a learning environment that is more suitable for some than the traditional classroom (Bishop, 2019).

Today, the planetarium is used for both education and entertainment purposes in informal and formal educational settings. When the Soviet Union successfully launched the first man-made satellite into orbit in 1957, it seemed that the United States was behind in space and astronomy education. One year later, President Dwight D. Eisenhower signed the National Defense Education Act, which provided funding for the building of planetariums in schools (Anderson & Nadworny, 2017). In addition to educating students, planetariums were used to train astronauts during

the space race of the 1950s–1970s (Bieltz, 2015). As the years have progressed, projection systems have become smaller and cheaper, and the potential of the planetarium as a teaching tool has been recognized by many.

Today we see that planetariums have become widespread in colleges and universities as well as K–12 schools. Loch Ness Productions, a multimedia supplier for planetariums, recently reported that of the 685 US institutions in their customer database, more than half were classified as a college/university or school district (Petersen, 2019). We conducted a literature review of research about the planetarium as an educational tool, and we will discuss our findings in the next section. However, we have come to realize that there is little documentation about how planetariums are being used, such as type of media, length of presentation, and what topics are being taught. Our research question stems from the deficit of this information. For this project, we chose to focus on planetarium use in higher education, primarily because it is what we are most familiar with.

LITERATURE REVIEW

Bailey and Slater (2004) published widely cited overview of astronomy education research where they identified several studies on the efficacy of planetarium instruction. Because of the limitations of analog planetariums, these studies focused primarily on the teaching of celestial mechanics and constellations and showed mixed results. For example, Fletcher (1980) and Mallon and Bruce (1982) both investigated a participatory approach versus a traditional lecture and demonstration. One of the studies concluded that the participatory approach was superior while the other observed no difference. It is these sorts of discrepancies that necessitate further study into how planetariums are being used. Additionally, digital systems have dramatically changed the capability of planetariums but there is little documentation regarding how this has influenced the way planetariums are used in teaching.

Slater, Adams, Brissenden, and Duncan (2001) were among the first to be published asking the question "What topics are taught in introductory astronomy courses?" To attempt to answer this question, Slater and his team analyzed 37 online course syllabi to determine which topics are most frequently taught and which topics are less frequently taught. The results from their investigation are shown in Table 1. Column A is a list of topics most commonly taught, while Column B is a list of topics receiving less attention.

Table 1. Table taken from Slater et al. (2001) showing the frequency of topic coverage in the introductory astronomy course. Column A lists topics most commonly taught. The electromagnetic spectrum was by far the most frequently cited topic. Column B lists topics receiving less attention.

Column A	Column B
Nature of light and the electromagnetic spectrum	Pulsars
Techniques in astronomy	Globular clusters
Cosmology and the Big Bang	Aristotle
Tools and telescopes	Einstein
The Solar System	Elementary particles
Our Sun	Missing mass and dark matter
Motions in the Solar System	Nebulae
Moon phases	Formation of the elements
Stellar evolution	Plate tectonics
Characteristics of the Milky Way	Space exploration
Naked-eye astronomy	Fundamental forces
Stellar magnitudes	Grand Unification Theories
Stellar spectral classification	

A search of literature since 2004 using keywords associated with planetariums in universities and colleges did not return any results about what content is currently being taught using a planetarium. Everding and Keller (2020, 2021) conducted a survey of the academic use of planetariums for undergraduate education. They determined that undergraduate learners in a planetarium environment are primarily novice, non-STEM majoring students receiving instruction from a live presenter approximately once per month. They also discovered that students enrolled in

introductory astronomy courses are learning principally general astronomy content. However, the study did not investigate specific learning objectives within general astronomy.

From what documentation is available, we can gather only a small amount of information about how planetariums are being used. Some early studies showed mixed results about the type of presentation, something that we also investigated and will present on later. We only found one study about what is being taught using a planetarium in higher education and since technology has changed so much in recent years, we find it necessary to ask the same question again. Some recent studies have given us an idea of who is being taught in a college or university planetarium and how often, but still no answer to the question of how. In the following section, we describe the instrument we used to gather this information.

METHODS AND INVESTIGATION

Learning Objective Selection

In constructing our survey, we worked with an experienced statistician and followed principles of good design by simplifying and shortening the questions in the survey, where possible, to maximize response rates. We grouped what is commonly taught in introductory astronomy courses into a distinct set of learning objectives. This allowed us to limit the survey without omitting anything that an instructor may be teaching in their course. We also designed the survey to allow for participants to insert anything they were teaching that was not included in the distinct set of learning objectives.

We based our selection of learning objectives after what was reported by Slater et al., (2001). To verify that these results represent current practice in colleges and universities housing planetariums, we compared the list of objectives from Slater with online course descriptions of 10 universities selected at random from the Worldwide Planetariums Database.

Using the information we gathered from course descriptions, we determined a list of topics taught at each institution. Next, we grouped similar topics together, resulting in 11 learning objectives. The grouping of topics is shown in Table 2. Later, we present a graphical representation of the frequency of these learning objectives in course descriptions. The resulting learning objectives are similar to what was reported by Slater et al. (2001). The only topic they reported that we did not find in our investigation was “techniques in astronomy.”

Table 2. Groupings of topics from online introductory astronomy course descriptions at 10 universities. These 11 learning objectives were used in the survey design to help achieve research objectives. Specifically, these groupings helped to shorten and simplify the survey without omitting anything an instructor may be teaching.

Topic(s)	Learning Objective
Naked Eye Astronomy	Night sky as viewed from Earth
Motion of celestial objects Spherical Trigonometry Kepler's Laws Eclipses Newton's Laws Gravity	Celestial Mechanics (how and why celestial objects move)
Physics and properties of light Spectroscopy	The nature of light and how it is used to observe the universe
The history of astronomy	The history of astronomy
Galaxies Milky Way	Galaxies, including the Milky Way
Black holes Quasars Pulsars Exoplanets Dark matter Dark energy	Contemporary topics such as dark matter, exoplanets, and black holes
Stars Stellar evolution Thermodynamics Virial Theorem	Evolution and life cycle of stars
Cosmology Evolution of the universe Nucleosynthesis	Cosmology and the evolution of the universe
Solar System	Overview of the Solar System, including planets, moons, and minor bodies
The Sun	The Sun
Telescopes Tools of astronomy	Telescopes and other instruments used in astronomy

Survey Design

Using the 11 learning objectives, we designed a 10-question survey with a variety of questions about current teaching practices. We developed the survey using Qualtrics. We validated the survey using a test group of faculty and colleagues at Brigham Young University and Utah Valley University. We conducted interviews with the test group asking them to identify anything about the survey that was confusing or overly intrusive. Additionally, since we were already familiar with the teaching practices of the test group, we were able to determine if their answers to survey questions were accurate, indicating that they had interpreted the question correctly.

In the survey, we first asked respondents which learning objectives they are and are not teaching. We followed up by asking which they are using the planetarium to teach. Next, we asked respondents why they are not using the planetarium to teach certain learning objectives. We provided respondents with three possible scenarios to choose from:

1. I have not searched for a way to teach this using a planetarium.
2. I searched for a way to teach this using a planetarium but found nothing I could use.
3. I searched for a way to teach this using a planetarium but chose not to use what I found.

We carefully crafted these scenarios to provide information about whether materials needed to teach the learning objective are avaliable and if they are of high enough quality that instructors want to use them.

In a later question, we asked participants how much time they are spending teaching each learning objective. We provided four options:

1. The learning objective is briefly mentioned in one or more planetarium shows and/or presentations.
2. The learning objective is taught in a 10–30-minute planetarium show and/or presentation.
3. The learning objective is taught in a 30–60-minute planetarium show and/or presentation.
4. The learning objective is taught in one or more planetarium shows and/or presentations totaling over 60 minutes.

We allowed participants to select more than one option for a single learning objective. This design choice allowed for the likely scenario of instructors using multiple presentations of different lengths.

Lastly, for each learning objective, we asked participants what type of media they are using to teach. Again, we provided four options:

1. It is a commercial (paid-for) planetarium show.
2. It is a public domain (free) planetarium show.
3. It is a scripted planetarium show created by my institution.
4. It is an unscripted presentation, open discussion, or Q&A given live.

It may be unclear what is meant by an unscripted presentation and we will discuss this with our results later.

Distribution and Response

The goal of our survey distribution was to gather the maximum number of quality responses. In mid-November 2020, we embedded a Qualtrics link in an invitation email including some basic information about the purpose of the study. From a list of 289 colleges and universities housing a planetarium found through the Worldwide Planetariums Database, we first invited approximately one third of the institutions to participate in the survey. We grouped the institutions by state in alphabetical order and the one third we selected were top of the list. We followed up in two weeks from the first invitation with a reminder email to encourage survey completion. We evaluated the quality of responses to determine if our questions were meeting research goals and if the responses made sense. Once it was clear that our survey questions were being interpreted as desired, we sent an invitation email to the remaining institutions. We again followed up with a reminder email in two weeks. Overall, there were 85 responses to the survey with 78 respondents either completing the survey or providing enough information to be useful. Respondents were associated with approximately 73 different colleges and universities around the United States. This means that our survey response was around 25%.

RESULTS AND DISCUSSION

What is Being Taught

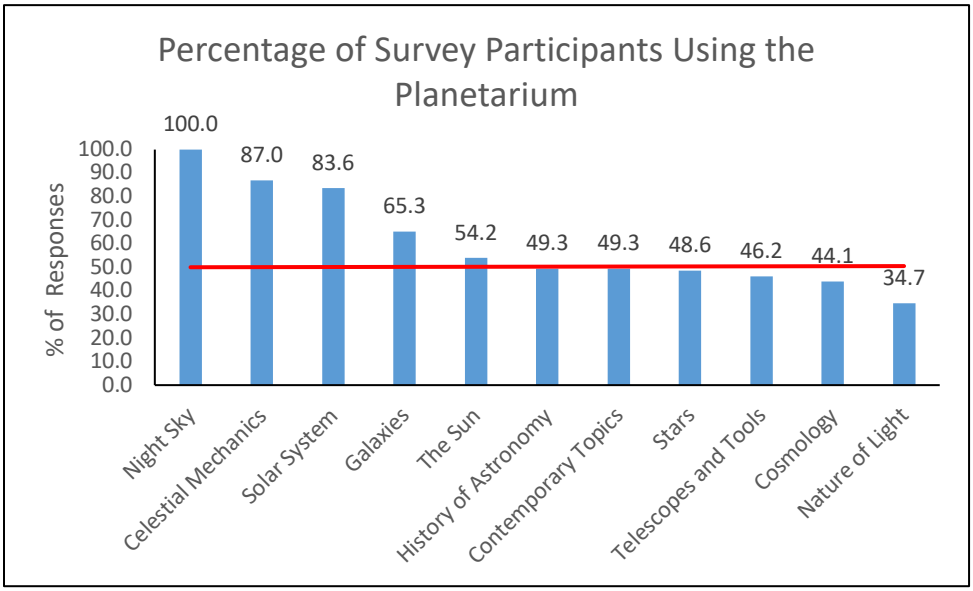
In this research effort, we sought to gather information about how planetariums are being used to teach introductory astronomy to undergraduates. In the survey, we asked participants what learning objectives they are teaching and which they are using the planetarium to teach. Table 3 shows percentages of survey responses to these questions. The 11 learning objectives used in the survey are listed in the column on the left. The middle column shows the percentage of survey respondents who indicated that they are teaching the specific learning objective. The column on the right shows the percentage of survey respondents who indicated they are teaching the learning objective using a planetarium.

Table 3. Learning objectives being taught in introductory astronomy courses and how often the planetarium is being used for the teaching. Numbers represent the percentage of respondents who selected specific answers in the survey.

Learning Objective	% Teaching	% Using Planetarium
The night sky as viewed from Earth	100.0	100.0
Celestial Mechanics (how and why celestial objects move)	98.7	87.0
Overview of the Solar System, including planets, moons, and minor bodies	93.6	83.6
Galaxies, including the Milky Way	92.3	65.3
The Sun	92.3	54.2
The history of astronomy	91.0	49.3
Contemporary topics such as dark matter, exoplanets, and black holes	91.0	49.3
Evolution and life cycle of stars	92.3	48.6
Telescopes and other instruments used in astronomy	92.9	46.2
Cosmology and the evolution of the universe	87.2	44.1
The nature of light and how it is used to observe the universe	92.3	34.7

Results of the survey show that college and university planetariums are primarily being used to teach the night sky. All survey participants indicated that they are teaching the night sky in their introductory astronomy course. This is shown Table 3 as well as Figure 1, which is a graphical representation of the right column of the table. However, not all learning objectives are being taught using a planetarium a high percentage of the time. A line is provided on Figure 1 to illustrate that 6 of 11 learning objectives are being taught less than half of the time using a planetarium. We investigate the reasons why instructors are not using the planetarium to teach these learning objectives in a later section.

Figure 1. Percentage of survey respondents indicating that they are using the planetarium to teach. A line is provided on the figure to illustrate that 6 of 11 learning objectives are being taught less than half of the time using a planetarium.

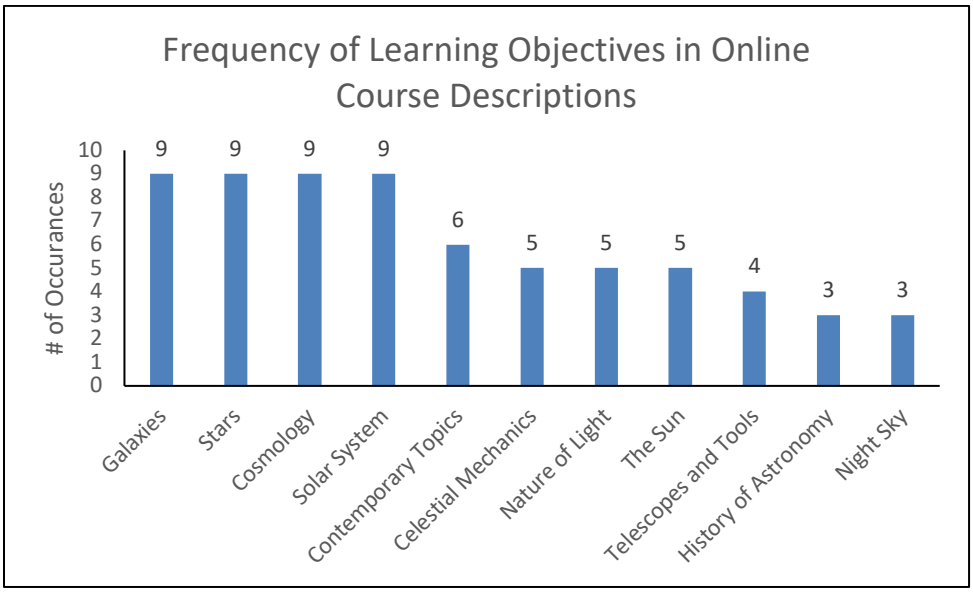


Possible Discrepancy

From the analysis of our data, we found that there is a mismatch between what is being taught to undergraduates in introductory astronomy courses and what is reported in online course descriptions. As we explained earlier, we investigated online course descriptions at 10 universities in the United States that were chosen at random. We grouped the topics used in the course descriptions into 11 learning objectives. From Table 3, which lists learning objectives and the percentage of institutions teaching that objective, we expect each learning objective to show up in course

descriptions 87.2–100% of the time. Figure 2 shows the number of occurrences that each learning objective showed up in a course description. This figure shows that some learning objectives, such as the night sky as viewed from Earth, show up in course descriptions as low as three out of 10 (30%) occurrences. This does not match our expectation. We are not sure why this is the case as we have reason to believe, from our own experience, that most universities housing a planetarium are teaching the night sky. One possible explanation is that it is so obviously taught that it is omitted from course descriptions to make room for other unique topics. Another possible explanation is that course descriptions are being used to report what is being taught in lecture but not what is being taught using the planetarium.

Figure 2. How often specific learning objectives appeared in 10 online course descriptions. We expect 8 to 10 occurrences for each learning objective based on survey responses, but this is not the case.

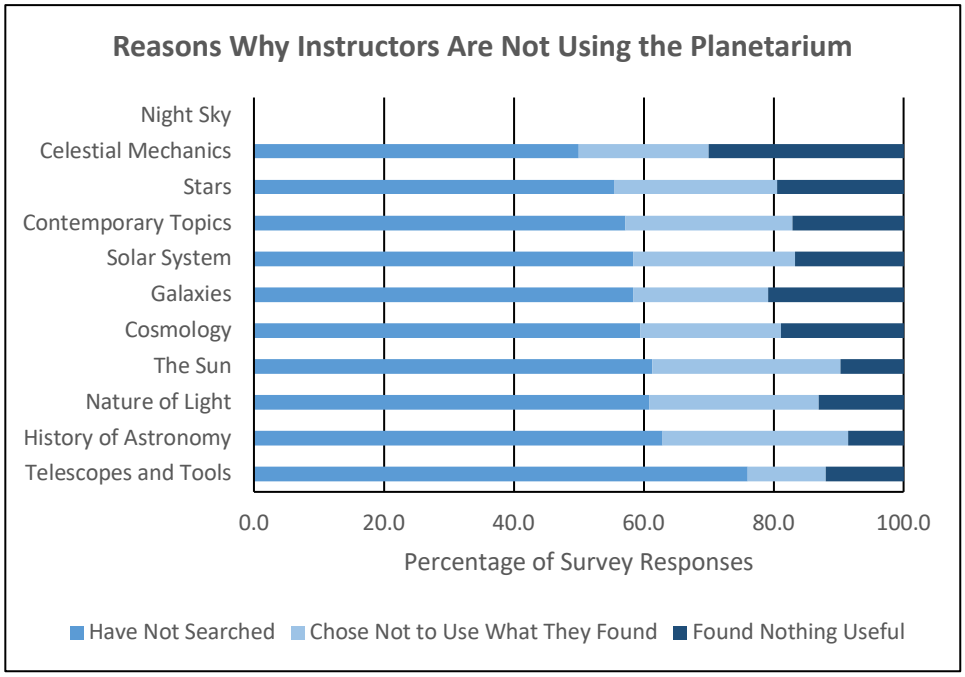


The purpose of this study was not to determine the difference between reported learning objectives and instruction, nor were we attempting to determine how access to a planetarium influences what is being taught in introductory astronomy courses. Our sample size is too small to make any conclusions in regard to these questions, but we find the apparent discrepancy interesting and point it out so that further work can be done to confirm if a discrepancy really exists.

Reasons for Not Using a Planetarium

If instructors are not teaching a learning objective using the planetarium, they have likely not searched for a way to do so. Figure 1 shows that 6/11 learning objectives are taught less than half of the time using a planetarium. We analyzed survey responses to try to understand why instructors are not using a planetarium. We present a graphical representation of our analysis in Figure 3. Each bar of the figure representing all survey responses is divided into three parts where each part corresponds to a specific answer chosen in the survey. There is no data associated with night sky because all survey participants indicated that they are teaching the night sky using a planetarium. The figure shows that 50% of all survey respondents not using a planetarium to teach have not searched for a way to do so.

Figure 3. Reasons why instructors are not using the planetarium to teach learning objectives. Each bar of the figure representing all survey responses is divided into three parts where each part corresponds to a specific answer chosen in the survey. The figure shows that 50% of all survey respondents not using a planetarium to teach have not searched for a way to do so.



While it is not the focus of this study to make such claims, there may be evidence that some learning objectives are better taught without using a planetarium. Our survey specifically asked why instructors are not teaching some learning objectives using a planetarium. Looking at Figure 3, we see that 50% of all respondents, who are not teaching a learning objective, have not searched for a way to do so. One possible explanation for this is that respondents feel that the learning objective is taught as well or better without using a planetarium. A better understanding of the affordances of a planetarium will help to determine which learning objectives are and are not suitable for being taught using a planetarium. There is room for further work to uncover other possible explanations for when an instructor favors a planetarium over other delivery methods.

Instructor Wish List

Digital systems have allowed planetariums to be used to teach a wider range of topics, but they are not being used to teach everything. One possible reason for this is that planetarium media does not exist on every topic. We attempted to identity trends in what is missing in the content through one of our survey questions.

We asked survey respondents if there was something that they wish they could teach using a planetarium. 57 of 77 (74.0%) respondents left the question blank or otherwise indicated that there was nothing. A selected number of other responses are given in Table 4. We found no patterns in what instructors wish they could teach using a planetarium. A few respondents (3 of 77) indicated that they are limited because their planetarium houses an analog system instead of a digital system. However, we collected no data about the type of system planetarium users have available to them. Thus, further work is needed to determine if a correlation exists between the type of planetarium system and what learning objectives are being taught using the planetarium.

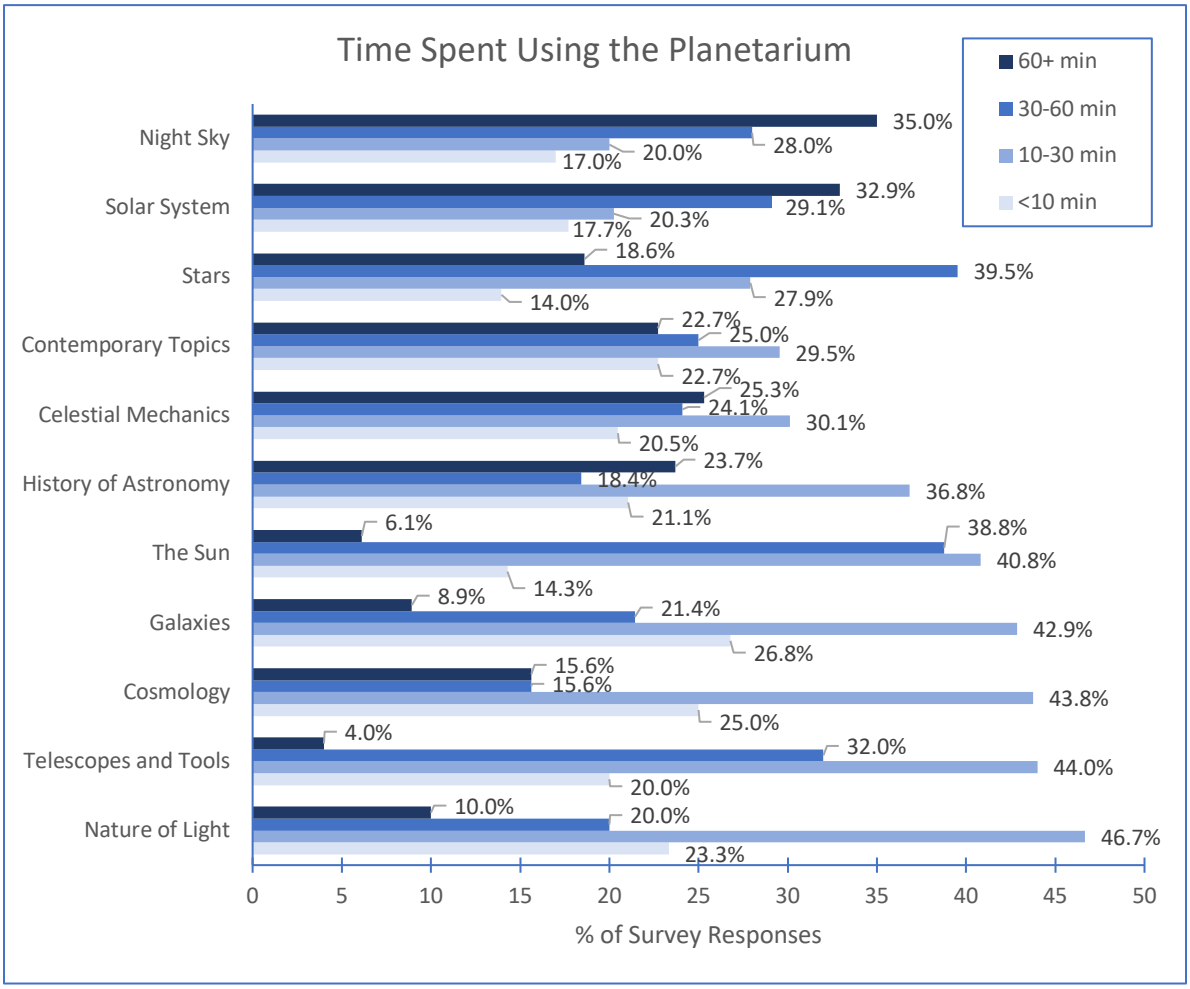
Table 4. The instructor wish list: selected responses to a survey question asking what instructors of undergraduate introductory astronomy courses wish they could teach using a planetarium. Pseudonyms were constructed for each institution. We found no visible patterns in the responses.

Pseudonym	Wish List
Institution A	"More on galaxies"
Institution B	"More cosmology"
Institution C	"I'm constantly looking for full-dome examples of what it is like to BE an astronomer, either at an observatory or at an institution doing research. Compelling stories featuring real astronomers from around the world, women and men, from all cultures and backgrounds."
Institution D	"Exoplanets (discovery methods plus math)"
Institution E	"Programmable celestial mechanics using VPython (for example)"
Institution F	"Orbital dynamics as it pertains to spacecraft"
Institution G	"Celestial navigation"
Institution H	"The role of mathematics in astronomy"
Institution I	"Stellar proper motions of 3-D distribution of stars"
Institution J	"Gravity and Relativity"
Institution K	"Spectrum acquisition and spectral analysis"
Institution L	"Geography, geology, and biology"
Institution M	"Geospace physics – Earth/solar wind interactions"
Institution N	"Cosmology, specifically galactic evolution"
Institution O	"Observing variable stars"

Time Spent Using the Planetarium

We collected data on the amount of time instructors of introductory undergraduate courses are using the planetarium in their teaching. As we explained previously, we asked survey respondents how much time they are spending using the planetarium to teach each learning objective. We display the results of the survey in Figure 4. The learning objectives are along the vertical axis at the left. Each of the four nearby bars corresponds to a choice of answer in the survey. The length of each bar on the graph represents the percentage of survey respondents choosing that answer. A legend is provided on the figure.

Figure 4. Survey results showing how much time instructors are using the planetarium to teach 11 learning objectives in introductory astronomy courses. The data shows a slight preference for 10–30-minute segments as this received the most responses for eight of the 11 learning objectives.



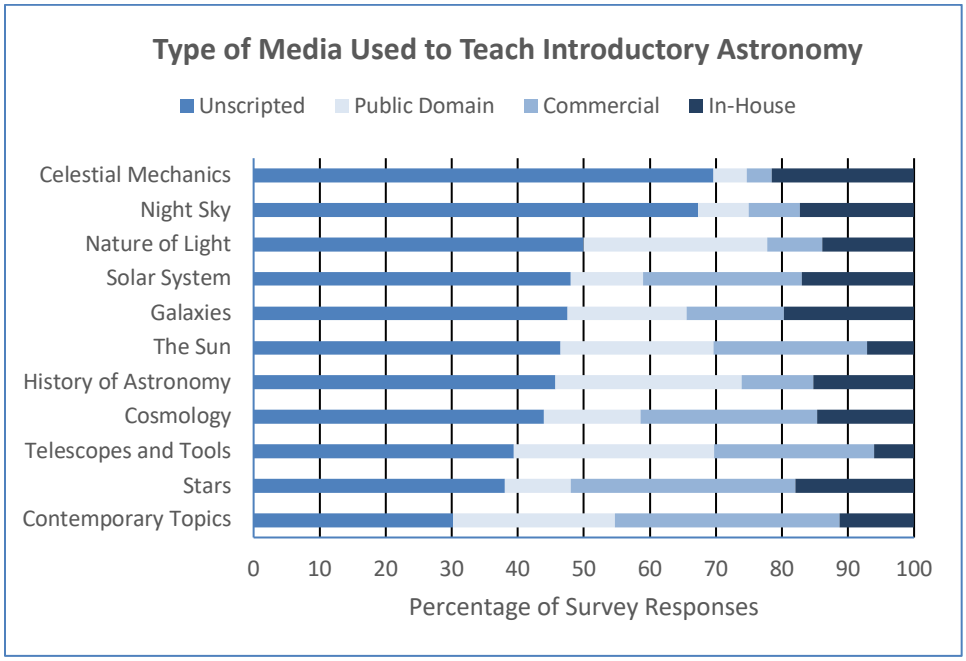
Some learning objectives are being taught for longer periods of time than others. Figure 4 shows that the length of instruction using the planetarium depends on which learning objective is being taught. For all learning objectives, each length of presentation included in the survey was reported by at least one respondent; however, survey respondents indicated that they are teaching some topics, such as the night sky and the Solar System, for longer lengths of time. Since planetariums were originally designed for displaying the night sky and motion of planets, we are not surprised that they are being used in length for this purpose. There could be various reasons why other learning objectives are being taught for longer lengths of time and we can conclude that the planetarium is providing some advantage in these cases. Further research beyond the scope of this project could be conducted to determine reasons why instructors are teaching some learning objectives in longer segments than others.

For eight of the 11 learning objectives, the top choice was 10–30-minute segments. Thus, we can conclude that instructors have a slight preference for this length of presentation. The possible reasons for this range from classroom logistics to instructional methodology, but regardless of the reason, this finding has implications to content development. Furthermore, it can inform further research into the impact of the planetarium on the creation of active learning environments. Further work could also determine if a specific type of planetarium media correlates with shorter show times.

Type of Media

Survey responses show that instruction for introductory astronomy courses that utilizes the planetarium consists mostly of unscripted presentations. Survey respondents were asked what type of media that are using to teach each of 11 learning objectives. Figure 5 shows a graphical representation of the data. The 11 learning objectives are to the left on the vertical axis. The bar next to each learning objective is divided into four segments showing the percentage of survey responses corresponding to each choice of answer. Respondents were given the choice of public domain, commercial, in-house (meaning created by their institution), or unscripted presentations. By unscripted, we mean a more informal interaction where not everything has been prepared or anticipated. Often, this type of presentation is more participatory in nature. For most learning objectives, the most used type of media was unscripted shows. For celestial mechanics and night sky, the percentage of survey participants indicating that they are using unscripted presentations was exceptionally high. We present the possibility that unscripted media is most common because it is most conducive to creating an active learning environment, but we can make no conclusions in this regard.

Figure 5. Graphical representation of survey responses regarding the type of media used by instructors when teaching introductory astronomy to undergraduates and using a planetarium. All types of media are currently being used, but for each learning objective defined in the survey, unscripted media was the most common.



Some public domain media exists as a useful alternative to in-house and commercial shows. Not all planetariums have the capacity to create their own media or purchase a commercial show. Figure 5 shows that public domain presentations exist on each of the 11 learning objectives included in the survey. However, since these shows are not being widely used, the question arises whether they are accessible or of high enough quality. Additionally, more commercial shows are being used than public domain shows to teach the Solar System, contemporary topics, cosmology, and stars. One possibility for this is that not enough quality public domain materials exist on these topics. One other possibility is that the media that exists in the public domain is not suitable for active learning environments. These findings act as a steppingstone for further research into why instructors choose to use certain types of media.

CONCLUSION AND NEEDED FURTHER WORK

From our analysis of our survey responses, we were able to gather information about how planetariums are being used to teach introductory astronomy to undergraduates. We uncovered that college and university planetariums are primarily being used to teach the night sky; all survey respondents indicated that they are teaching this learning objective in their introductory astronomy course. When we combine this with data from our investigation of online course descriptions, we see a possible discrepancy between course descriptions and what is being taught. Survey responses also revealed that for certain learning objectives, less than half of respondents are utilizing the planetarium as part of their instruction. Survey responses also revealed that the planetarium is being used less than half of the time to teach some learning objectives. In cases when instructors are not using a planetarium, they likely have not searched for a way to do so. One possible explanation for this is that respondents feel that the learning objective is taught as well or better without using a planetarium. Furthermore, we saw no trends in what instructors wish they could teach using a planetarium. Additionally, survey results suggest that when instructors use a planetarium, they have a slight preference for 10–30-minute teaching segments. Also, most instructors are using the planetarium as part of unscripted presentations. We also found that public domain shows exist on all the 11 learning objectives, although they are not being utilized as much as other types of media.

Further work is needed to expand upon the results of this project. We asked survey participants why they were not teaching using a planetarium and found that most had not searched for a way to do so. Additional research is needed to determine motivations for choosing not to use the planetarium. It is possible that instructors are not aware of the possibilities the planetarium offers as a teaching tool. It is also possible that some learning objectives are better taught without using the planetarium. Structural barriers may exist that make using a planetarium difficult. We collected no data about what type of planetarium system (analog or digital) respondents use and whether the planetarium is being used as a classroom or is only being visited occasionally. These factors could influence what learning objectives are being taught using a planetarium.

Similarly, more research is needed to determine why instructors are teaching some learning objectives for longer lengths of time than others. Our results show that there is a slight preference for shorter teaching segments when using a planetarium to teach introductory undergraduate astronomy courses. Further research could be conducted to determine if a specific type of media correlates with shorter teaching segments. As part of our analysis of the data, we uncovered a possible discrepancy between what is reported in course descriptions and what is taught in the planetarium. One possible explanation is that course descriptions are used to report what is being taught in lecture but not what is being taught using the planetarium. While this study was not intended to investigate the differences between course descriptions and teaching practice, our findings present an interesting topic for further investigation. Lastly, data from our survey shows that instructors prefer using unscripted presentations in the planetarium. Further research could investigation why this type of media is preferred and if and how it contributes toward creating an active learning environment.

Further work is also needed in instructional methodology pertaining to planetariums. In this project, we provide a survey of current teaching practices using a planetarium in introductory undergraduate astronomy courses. We make no attempt to discuss what best practices may be, and we collected no data regarding efficacy. However, the data that we have collected could inform efforts to develop content for planetariums as well as efforts to train instructors on possibilities allowed by the planetarium. Furthermore, the preliminary results of the study can be used as a base for further research into best practices for teaching using a planetarium.

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APPENDIX

Complete Text of Survey

Note: Survey was administered using Qualtrics. User experience varied based on selected answers.

In this survey you will be asked to provide information about how you use a planetarium to teach introductory astronomy. We anticipate that it will take around 5 minutes to complete. Your response is greatly appreciated.

1. We need some basic information to get started.
    a. Your name:
    b. Your institution:
    c. Your email address:

2. Below are some learning objectives for introductory astronomy. Read each choice carefully. Then select **all** that you teach using a planetarium. (Do **not** select learning objectives that you teach **without** any use of a planetarium).
    a. The night sky as viewed from Earth
    b. Celestial Mechanics (how and why celestial objects move)
    c. The nature of light and how it is used to observe the universe
    d. The history of astronomy
    e. Galaxies, including the Milky Way
    f. Contemporary topics such as dark matter, exoplanets, and black holes
    g. Evolution and life cycle of stars
    h. Cosmology and the evolution of the universe
    i. Overview of the Solar System, including planets, moons, and minor bodies
    j. The Sun
    k. Telescopes and other instruments used in astronomy
    l. Other (please use box below):

3. For each learning objective you selected, help us to understand how you teach it using a planetarium. (Please only include time spent using a planetarium). For example, if you teach the night sky using a 30-minute scripted presentation and then mention it again in a planetarium show at a later date, you would select answers in the first and third columns. (Select all that apply)
    a. Briefly mentioned in one or more planetarium shows and/or presentations
    b. Taught in a 10-30 minute planetarium show and/or presentation
    c. Taught in a 30-60 minute planetarium show and/or presentation
    d. Taught in one or more planetarium shows and/or presentations totaling over 60 minutes

4. For each learning objective you selected, please select **all** that apply to the planetarium show and/or presentation that you use. For example, if you teach the night sky using a 30-minute commercial show and then have an **unscripted** discussion, you would select answers in the first and last columns. (Select all that apply)
    a. It is a commercial (paid-for) planetarium show
    b. It is a public domain (free) planetarium show
    c. It is a scripted planetarium show created by my institution
    d. It is an unscripted presentation, open discussion, or Q&A given live

5. For each learning objective that you are **not** teaching using a planetarium, please choose the best answer. (Choose the best answer)
    a. I am not teaching this learning objective at all
    b. I teach this learning objective without using a planetarium

6. For each learning objective that you are teaching but not using a planetarium, please choose the best answer. (Choose the best answer)
    a. I have not searched for a way to teach this using a planetarium
    b. I searched for a way to teach this using a planetarium, but found nothing I could use
    c. I searched for a way to teach this using a planetarium, but chose not to use what I found

7. Is there anything you are not teaching using a planetarium that you wish you could use a planetarium to teach? If so, please indicate the topic in the box below, otherwise leave the box blank.

8. Please indicate whether you are willing to discuss your answers to this survey in more detail over email or phone or not at all.
    a. Phone or email
    b. Email only
    c. Phone only
    d. Neither

9. Please enter your phone number and hours of availability.
    a. Your phone number:
    b. Your hours of availability:

We thank you for your time spent taking this survey. Your response has been recorded.

NOTES