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The Role of Planetariums in Promoting Engagement and Learning – Appendix

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Appendix A: Consent Form



Astronomy & Astrophysics
UNIVERSITY OF TORONTO

I invite you to participate in an education research project which I hope will improve the teaching of astronomy courses at this university and others. Participation in this project will not involve any work on your part and will consist only of allowing us to analyse your grades in an anonymized format. Your decision about whether or not to release your grades for use in this study will not impact your grade in this course.

For more information about this study and your rights, you can consult the [\[link to Appendix B: Research Information Form\]](#).

I give permission for my grades to be used, in anonymized form, for this study.

Yes No

I am willing to be invited to participate in a focus group interview, for which there will be financial compensation.

Yes No

Appendix B: Research Information & Consent Form

Introduction:

I invite you to participate in a project which I hope will improve the teaching of astronomy courses at this university and others. This project will comply with the university's policies on research ethics. It is the purpose of this document to explain how this compliance will be achieved.

This research seeks to explore the use of a digital planetarium as a tool for teaching astronomy. In particular, the study seeks to determine which is the most effective method for teaching astronomical concepts: traditional discussion-based tutorials, planetarium shows led by a teaching assistant, or self-guided planetarium shows led by students. My hope is that the information collected during this study will help me to identify the most effective way of using a planetarium to teach astronomy. The study will take place in AST 101 during the fall semester of 2012. Participating in this study will not require any extra effort on your part, unless you choose to take part in an optional focus group; I am only seeking permission to study grades that will be collected as part of the normal operations of the course. This research is being performed under contract to the Higher Education Quality Council of Ontario (HEQCO), an organization which seeks to evaluate and improve postsecondary education in Ontario. The anonymized results of the study will be published by HEQCO, in peer-reviewed academic journals, and in other academic outlets, for the benefit of astronomy instructors and students internationally. A description of the data I hope to collect from you is provided below, along with my responsibilities as the Principal Investigator.

Data Collection: With your approval, I would like to collect the following for use in this study:

1. Your grades in the various components of AST 101. Members of the research team will be administering three questions before each tutorial or planetarium show and three more during or after each show. By comparing the before and after responses of many students, we can determine which teaching method produced the biggest conceptual gains. These marks will be gathered as usual during this course.
2. You will also be invited to participate in a focus group interview. If you choose to participate you will be asked to participate in a discussion with 4-6 of your peers about your experiences of using the planetarium. Interviews will not be longer than one hour. Audio recordings of these focus groups will be made and later transcribed to text. Names will not be used during the recordings and the recordings will be destroyed after transcription.

Responsibilities of the Principal Investigator (PI): As the main researcher (PI) of this, I will ensure the following if you agree to participate in this research:

1. Anonymity: I will have no knowledge of whether or not you consent to release your grades for use in this study. To protect your privacy, I will not be involved with the recruitment, data collection, or data analysis until final grades in AST 101 have been submitted. Neither will Dr. Matzner or any of the teaching assistants who have access to your grades. After final course grades have been submitted to the university, the grades will be stripped of personally-identifiable information such as names, student numbers, uTORids, and clicker codes. The grades of consenting students will be given to me in this fully anonymous format for use in this study. Particular care will be taken to ensure anonymity. Both in the analysis and in any resulting publications, individual students will be referred to by anonymous tags, such as 'student A', 'student B', and so on.

2. Right of Withdrawal/Refusal: You have the right to refuse to participate in the research described above and may, without giving a reason, withdraw from the study at any time without negative consequences.
3. Risks and Benefits: There is minimal risk in participating in this project. You will not be penalized for declining to release your grades. Data collection will occur as part of the normal operations of the course. Your participation is voluntary. We have no reason to believe that belonging to any particular experimental group will negatively affect you.
4. Destruction of Data: All audio-recordings of the optional focus group interviews will be destroyed after their contents are transcribed into typed text. All data collected will be destroyed not later than five years after the completion of the project.

If you require further clarification about this research, you can contact Dr. John Percy, a co-investigator in this study, or Darren Hoeg, a research assistant associated with the study. Neither Dr. Percy nor Mr. Hoeg are involved with AST 101 and they therefore cannot influence your grades. You may also contact the university's Office of Research Ethics if you have any additional questions regarding your rights as a participant in this research project.

CONTACT INFORMATION FOR PRINCIPAL INVESTIGATOR

[Contact information redacted for publication]

CONTACT INFORMATION FOR CO-INVESTIGATOR

[Contact information redacted for publication]

CONTACT INFORMATION FOR RESEARCH ASSISTANT

[Contact information redacted for publication]

CONTACT INFORMATION FOR OFFICE OF RESEARCH ETHICS

**Office of Research Ethics
University of Toronto
McMurrich Building
12 Queens's Park Crescent West
Toronto ON M5S 1S8**

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| Fax: 416-946-5763 Website: http://www.research.utoronto.ca/ |
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Appendix C: Sample Pre-Test and Post-Test

The following sample shows the pre- and post-test questions used for iteration 2 of the experiment.

Clicker Quiz 1 Pre

In our solar system, the orbits of the planets are arranged:

- A. in a flat disk, with all planets orbiting in the same direction
- B. in a sphere, with planets orbiting in many different directions
- C. in a flat disk, with planets orbiting in many different directions
- D. in a sphere, with all planets orbiting in the same direction

Clicker Quiz 1 Post

Which of the following best describes our solar system?

- A. planets orbit the Sun all in the same plane but in random directions
- B. planets orbit the Sun all in the same plane and in the same direction
- C. planets orbit the Sun in different planes and different directions
- D. planets orbit the Sun in different planes but all in the same direction

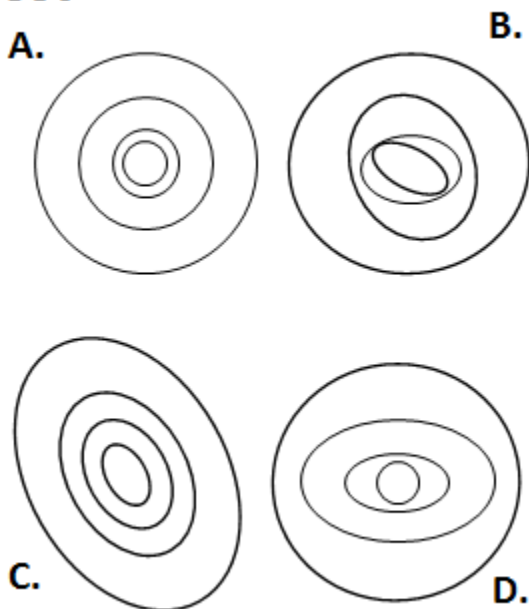
Clicker Quiz 2 Pre

The orbits of the planets in our solar system are:

- A. all perfectly circular
- B. mostly perfectly circular with a few highly non-circular
- C. mostly highly non-circular with a few perfectly circular
- D. all highly non-circular

Clicker Quiz 2 Post

Which of these pictures most accurately represents the orbits of the large planets in our solar system, as seen from the North Celestial Pole (i.e. 'from above')?



Clicker Quiz 3 Pre

Compared to the orbits of larger objects, such as planets and moons, the orbits of smaller objects, such as comets and the outer moons of Jupiter, tend to have orbits which are:

- A. higher in eccentricity and tilted at all different angles
- B. higher in eccentricity and aligned in the ecliptic plane
- C. lower in eccentricity and tilted at all different angles
- D. lower in eccentricity and aligned in the ecliptic plane

Clicker Quiz 3 Post

How do the orbits of **planets** compare to those of **small objects**, such as comets, asteroids, and small moons?

- A. planetary orbits are more circular and aligned in the ecliptic plane
- B. planetary orbits are more circular and tilted at all different angles
- C. planetary orbits are less circular and aligned in the ecliptic plane
- D. planetary orbits are less circular and tilted at all different angles

Appendix D: Sample Planetarium Show Plans

This appendix contains the show plans used to help TAs prepare for and administer the Pt and Ps show styles. The plans shown here are for iteration 2 of the experiment.

The first plan is for the Pt style of show. In the left column, the TA is given a pedagogical goal. The middle column shows the set of actions the TAs use to illustrate the desired concept. The right column is a point-form script for the show, which each TA would adapt to his or her own particular style.

| Pedagogical Goal | Buttons / Planetarium actions | Comments |
|--|--|---|
| | <ul style="list-style-type: none"> -Start Button -Current Time Button -Do the Pre-test. Remember Pre-tests and Post-tests should be done while on the ground. -Turn off the Earth -Highlight the planets -Turn on the planet orbits -Turn on the ecliptic | <p>The show will start at Toronto Current time.</p> <p>Give them an idea of what the show is about, the shape of solar system.</p> <p>Point out Mars and Saturn</p> <p>Point out that the planets' orbits</p> <p>Tell them what the ecliptic is. Point out the orbits of the planets lie close to the ecliptic</p> |
| Describe the overall shape of the solar system and relate this to our theory of its formation. | <ul style="list-style-type: none"> -Turn the Earth on -Fly off the Earth -Fly out so you can see the whole solar system, from the top. -Turn on the ecliptic plane and fly around the solar system to show how flat it is. -Fly so that you are looking down on the solar system. | <p>What we want to get across is the fact that all of the planets' orbits lie close to the same plane and orbit in the same direction. This is what is predicated by the disk-accretion model.</p> <p>Repeat the same thing with Jupiter and its inner moons. It is likely that the inner moons formed in a disk around Jupiter in a similar way to the way planets formed around the Sun.</p> |

| | | |
|---|--|--|
| | <ul style="list-style-type: none"> -Turn off the ecliptic plane and increase the time rate to 100 days per second -set time rate to normal -Turn off planet orbits -Fly to Jupiter and turn on the moons. Fly around and show that the orbits are circular and coplanar. -Set time rate to 1 day per second. And fly so that you are looking down on the Jovian system. -Set time rate to normal | |
| Identify the high circularity (low eccentricity) of the planetary orbits and relate these to our theory of the formation of the solar system. | <ul style="list-style-type: none"> -Turn on the planet orbits. -Zoom out so you are looking down on the solar system. -Turn on the reference circles. -Zoom into show the inner solar system | <p>Here we want to show that most of the planets have circular orbits. There are reference circles for each planetary orbit; they represent the ideal circular orbit.</p> <p>As well as pointing out how close most of the planets orbits are to the circles point out the Mercury is the exception.</p> |
| Note that the bodies in the solar system which have highly inclined or eccentric orbits tend to be small moons, dwarf planets and comets and identify them as exceptions to the nebular theory of planet formation. | <ul style="list-style-type: none"> -Zoom out so that you are looking down on the solar system. -Turn on the dwarf planets -Turn on the asteroid orbits -Turn on the TNOs orbits. -Fly around the solar system -Turn dwarf planets, asteroids and TNOs off. -Fly to Jupiter and turn on the outer Moons. Fly around Jupiter. -Jump back to Toronto | <p>What we want the students to understand is that small bodies can be the exception to the orderliness of the solar system. The small mass of these objects means that they are more affected by interactions with planets, close approaches or collisions with other small bodies. These effects change the orbits of the small bodies.</p> <p>Again do a similar thing for the Jovian system. The cloud of small moons around Jupiter is most likely captured asteroids and comets.</p> |
| | Post-test | |

The next version of the plan is for the Ps shows. In this version, the left column gives questions rather than goals. These are questions that the TAs would frame for the students. The middle column gives suggestions for approaches the students can use to try to find an answer to the questions asked by the TA. The right column suggests prompts the TAs can use to help students who are struggling, without actually taking control of the shows themselves (as they would have done in the Pt shows).

| Driving Questions | Things Students Might Want to Try | Comments/Prompt Questions |
|--|--|--|
| Pre-show | <ul style="list-style-type: none"> -Start Button -Current Time Button -Do the Pre-test; use Planetarium View to show the slides. Use the Planetarium class in iClicker and restart after every show. | The show will start at Toronto Current time. |
| <p>What is the overall shape of the solar system?</p> <p>What patterns in the motions of solar system objects can you discern?</p> | <ul style="list-style-type: none"> -Leave the surface of the Earth -Turn on the orbits of the planets. -Zoom out of the solar system far enough to see the whole thing. -Tilt the view of the solar system back and forth. -Zoom in to the Earth-Moon system and advance time. -Fly to Jupiter | <p>What words would you use to describe the shape of the solar system?</p> <p>DO NOT judge or correct their answers. Try to draw out many possible answers.</p> <p>How would you describe the motions of objects in the solar system?</p> <p>If they jump immediately to textbook-style answers, such as 'counterclockwise' ask them from what perspective this is true?</p> <p>Are there patterns in the rotational motions of objects in the solar system?</p> <p>Are there patterns in the orbital motions of objects in the solar system?</p> <p>How do these patterns compare to one another?</p> |
| How would you describe the shapes of the orbits of the planets? | <ul style="list-style-type: none"> -Turn on the orbits of the planets -Turn on reference circles -Zoom to Mercury's orbit | <p>What word best describes the shape of planetary orbits?</p> <p>Roughly what is the eccentricity of Earth's orbit?</p> |

| | | |
|---|--|---|
| | -Zoom to Pluto's orbit -Turn on the orbits of a few small bodies (comets/asteroids) | Are there any exceptions to the general pattern governing the shapes of planetary orbits? |
| How do the orbits of small bodies compare to those of large bodies? | -Zoom out of the solar system and examine the orbits of the dwarf planets -Zoom in and examine the orbits of the asteroids -Zoom out and examine the orbits of the TNOs -Fly to Jupiter and examine the orbits of its outer moons compared to its inner moons | How do the orbital shapes of dwarf planets compare to those of proper planets? Specifically, how do the eccentricities of small bodies compare to those of large ones? How do the orbits of smaller, outer Jovian moons compare to those of larger, inner Jovian moons? |
| | Post-test | |

For each iteration of the experiment, the planetarium controller was customized to give fast and easy control over the most relevant planetarium functions. The following graphic explaining the configuration of the controller was shown to the TAs before and during the Pt shows, and to the students during the Ps shows.





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