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Presentation title: Beam Us Up Scottie! – Creating and Using Planetariums for STEM Learning

Conference tracks: Educational technologies, STEM education, Instructional strategies

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Author biography: Stephen Gareau is a professor and coordinator of the graduate educational technology program at SUNY Buffalo State. He teaches courses, and conducts research, in a wide range of educational technologies and media, such as text design, graphic design, educational video and television production, animation, Web development, audio and radio production, etc.

Abstract: Decreased student motivation is ongoing challenge for many K-12 teachers nowadays. Many K-12 students seem reluctant to study STEM, and knowing how to pique students' interest is a critical skill. .A planetarium can be described as a theatre built primarily for presenting educational and entertaining shows about astronomy and the night sky, or for training in celestial navigation. The purpose of this research was to explore how relatively low cost planetariums (and associated planetarium multimedia programs) can be designed, developed, and implemented to help engage K-12 students and promote learning in various K-12 subject areas, including STEM subject areas. The researcher used a case study research approach, with the planetarium at a northeastern U.S. state university as a case for study. Various classes of educational technology graduate students (many of them K-12 teachers) were taken on field trips to the planetarium. The researcher also employed a participatory action research (PAR) methodology in completing a planetarium seminar course that included topics on planetarium operation, and planetarium multimedia program design and development. This presentation will report on the results of the research, including relevant background theory, various types of planetarium designs, and ideas for implementing planetariums into K-12 curriculum.

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Beam Us Up Scottie! – Creating and Using Planetariums to Promote STEM Learning

by Stephen Gareau (2016)

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"Somewhere, something incredible is waiting to be known."

(*Carl Sagan*)

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Outline

- Introduction
- Research problem and question
- Theoretical framework
- Methodology
- Results

a. Creating a portable, in-house planetarium
b. Designing & producing digital multimedia planetarium programs
c. Feedback from students
d. Ideas on curriculum uses of planetariums

- Conclusions

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Introduction

- The purpose of this research was to explore how relatively low cost planetariums (and associated planetarium multimedia programs) can be created and implemented to promote learning in various K-12 subject areas, including STEM subject areas.

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What is a Planetarium?

- "A theatre built primarily for presenting educational and entertaining shows about astronomy and the night sky, or for training in celestial navigation" (Wikipedia, 2015)

Bishop Planetarium, South Florida Museum

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Common Features of a Planetarium

- Large dome-shaped projection screen onto which scenes of stars, planets and other celestial objects can be made to appear and move to realistically simulate the night sky.
- Ability to display the night sky at any point in time, past or present, and from any point of latitude on Earth.
- Celestial scenes can be created using a wide variety of technologies, such as precision-engineered *'star balls'* that combine optical and electro-mechanical technology, a slide projector, video and full-dome projector systems, and lasers.

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Planetarium Projection Systems

Zeiss Universarium Mark IX starball projector

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Where to Find Planetariums?

- Planetariums can be standalone organizations.
- They can also be found in science museums, K-12 schools, colleges, universities, and public libraries.

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Rio Tinto Alcan Planetarium, Montreal, Canada

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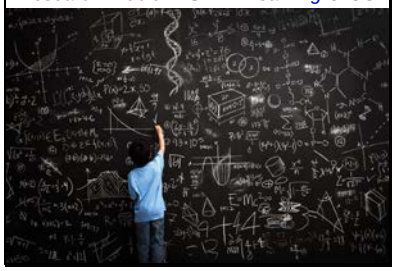
Research Problem: STEM Learning Crisis



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Research Problem: STEM Learning Crisis

- **Lack of motivation:** "Kids seem reluctant to study STEM, and no one seems to know how to pique their interest" (Lylah Alphonse, U.S. News, 2013).
- 58% of high school graduates are not ready for college-level math; 64% of high school graduates are not ready for college-level science.
- 38% of students who enter college intending to major in a STEM field complete a STEM degree (President's Council of Advisors on Science and Technology, 2012).
- **Organization for Economic Co-operation and Development (2009):** U.S. 15-year-olds were ranked 17th in the world in science and 25th in math.

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Research Questions

- How might a relatively low cost planetarium—and its associated multimedia educational programs—be created and implemented to promote learning in various K-12 subject areas, including STEM subject areas?
- What is the range of curricular uses of a planetarium?

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Theoretical Framework

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Planetariums & Learning

- Planetariums are learning spaces that can provide formal and informal learning opportunities.
- According to Hannu (1993), educational activities carried out outside the framework of formal education make learning more enjoyable and efficient.
- This includes activities carried out in informal learning environments such as science centers, planetariums, observatories, museums, zoos, botanical gardens, parks, nature preserves, libraries, aquariums, etc.

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Planetariums & Constructivist Theory

- According to 'constructivism', the learner is not a passive recipient of knowledge but, rather, actively constructs their own new knowledge, thereby adding to their mental schema.
- Also, according to 'social constructivism', groups of people can construct knowledge collaboratively creating a culture of shared artifacts that can have shared meanings.
- Planetarium programs—if designed to be sufficiently interactive—can apply constructivist principles.

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Planetariums & Learner Motivation

- Planetariums can help to promote learner motivation.
- According to John Keller's (1987) ARCS Model of Learner Motivation, there are four factors that can help to improve learner motivation in any learning situation:
  1) Attention
  2) Relevance
  3) Confidence
  4) Satisfaction
- Planetarium programs—if designed effectively—can include all four factors.

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Zone of Proximal Development (ZPD) Theory

- Learning theory originally developed by Lev Vygotsky (1896-1934), a Soviet psychologist
- **ZPD** = Area of learning that occurs when a person is assisted by a teacher or peer with a skill set higher than that of the subject.
- The person learning a new skill set typically cannot complete it without the assistance of a knowledgeable teacher or peer.
- An effective teacher helps the student attain the skill the student is trying to master, in hopes that the teacher will no longer be needed for that task.
- There is a point, then, at which we all need some external assistance, in one form or another, to be able to learn.

Learning in a planetarium often requires the assistance of a knowledgeable guide/facilitator.

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Planetariums and DIY

- **DIY** = Design-It-Yourself, Do-It-Yourself, Learn-It-Yourself
- Growing interest in DIY (and open source) initiatives
- Revival of post-war spirit of 1950s when resources were scarce.
- Examples of DIY trend:

- A DIY approach might also be applied to the design, development, and implementation of planetariums.

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Methodology

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Case Study Approach

- Case study: 'Research approach that investigates a person, group, object, or situation within its real-life context over a period of time.'
- 'A particular instance of something that is analyzed in order to illustrate a thesis or principle about the larger set.'
- The case under study was the *Whitworth-Ferguson Planetarium* at SUNY Buffalo State, Buffalo, New York.

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Case Study Approach (cont'd.)

- Participant inquiry: In investigating the Whitworth-Ferguson Planetarium at SUNY Buffalo State, the researcher enrolled in, and completed, the following graduate course in the Department of Earth Sciences and Science Education: *GES 590—Planetarium Seminar.*
- Field trip + Survey: The researcher also brought two classes of educational technology graduate students (12 students in all) on a field trip to visit the planetarium and experience a multimedia program delivered there.

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Case Study Approach (cont'd.)

- The students were mostly working K-12 teachers.
- The multimedia program consisted of two parts:

a) Instructor-led, 30-minute look at: (1) various noteworthy features of the planetarium itself; and (2) various features of the current night sky above Buffalo, the Equator, and the North Pole.

b) Pre-developed, 20-minute multimedia program examining the history and mechanics of the telescope, and what it has enabled us to view through the ages.

- The students were administered an attitude survey upon completion of the field trip.

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Results

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1. Creating a Portable, In-house Planetarium:
(a) Planetarium Components & Costs

(Assume seating for 25 persons)

Component	Cost (approx.)
Portable canvas planetarium dome	$ 16,000
Spitz portable projection system (including high resolution dome projector, 2 computers, teacher station, Starry Night software, ATM-4 software)	$ 80,000
Air pump	$ 500
Air conditioner	$ 500
Carpet	$ 300
Chairs (25)	$ 400
LED floor lights	$ 200
Miscellaneous (signage, flashlights, etc.)	$ 100
Total (approx.):	**$ 98,000**

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1. Creating a Portable, In-house Planetarium:
(b) Setting Up a Planetarium

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2. Designing & Producing Digital Multimedia Planetarium Programs

- **Designing** a multimedia planetarium program typically includes the development of the following design tools:

a) Program concept
b) Storyline or content outline
c) Script
d) Storyboard

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2. Designing & Producing Digital Multimedia Planetarium Programs

- **Producing** a digital multimedia planetarium program can benefit from a variety of types of media production software, such as:

a) Authoring software—e.g., Microsoft PowerPoint, etc.
b) Image creation and editing software—e.g., GIMP, Adobe Photoshop, etc.
c) Video editing software—e.g., iMovie, Windows Live Movie Maker, etc.
d) Screen capture software—e.g., Camtasia Studio, etc.
e) Audio creation and editing software—e.g., Audacity, Windows Sound Recorder, youtube-mp3.org, etc.
f) Animation software—e.g., GIF Animator, Adobe Flash, etc.
g) Planetarium software—e.g., Starry Night, Stellarium, etc.
h) Planetarium media playback sequencing software—e.g., Spitz ATM-4 automation software

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Completed Planetarium Program: In Search of Voyageur 2

- The following video—intended for playback in a planetarium—was designed and developed by the researcher, as part of the requirements for the graduate course *'GES 590—Planetarium Seminar'*.

>>> video display here <<<

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3. Feedback from Students (K-12 Teachers)

- "The planetarium is a novel environment for most students…[and] is likely to interest and engage students."
- "The planetarium allows visitors to explore the night sky in ways that may not be possible in real life. For example, we were able to:
  - view the night sky from any latitude point in the Northern hemisphere;
  - view a simulation of what the stars and their paths of motion would look like from different points on Earth;
  - speed up astronomical processes so that they can be observed more easily;"
  - travel to other planets—e.g., "view Jupiter and its moons revolving in fast motion."

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Feedback from Students (cont'd.)

- "Students get excited when they get to go on a field trip…It allows [them] to leave the walls of a classroom.
- You can learn about the stars and everything in our universe from a text book or a video off the internet, but getting to go somewhere where you actually feel like you're a part of it is awesome."
- "The planetarium is a realistic, immersive experience." You can show how the stars appear in the sky at different times of the year and different times in history. You can zoom in and out. You can overlay [the night sky] with images to show the constellations. You really could not do justice to these topics using photos or videos."
- "I really enjoyed the 3-D explanations of how various types of telescopes work."

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Feedback from Students (cont'd.)

- "Any time you do something unique with children it is bound to get their attention."
- It was really cool how the planetarium [software] could show visible stars in the Buffalo [night] sky for any given day."
- "Most planetariums are not portable, but this one was. Instead of having a class go on a field trip to visit a planetarium, [this] planetarium [could go] to schools and [be] set up for student use."
- "A planetarium is…a highly visual learning tool. Teachers know that students learn best when instruction is not just lecture based. A planetarium allows both auditory and visual learners to receive a highly engaging, and most likely effective, lesson."

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4. Ideas on Curriculum Uses of Planetariums

- The following uses were proposed by students and planetarium staff:
- Science: Solar system (sun, planets, stars, moons, galaxy), seasons
- Social Studies: NASA and space exploration, telling stories of Galileo, Nicolaus Copernicus, Isaac Newton, inventions, etc.
- Math: Angles (measuring angles, acute angles, 360 degree circle), calendar, time, looking for various geometric shapes (for lower level math), drawing lines between stars to create shapes, applying scientific calculations (for advanced math)
- Art: Using the Northern Lights for an art project, inventing new constellations by having students look at the stars and use their imaginations
- Creating writing: Getting the creative juices flowing to write an intergalactic story
- Language Arts: Telling Shakespearean stories assisted by night skies at various times and place

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DIY Planetariums?

- **DIY** = Design-It-Yourself, Do-It-Yourself
- There are a variety of sources, designs, and resources on the Web for designing and building your own planetarium (e.g., International Planetarium Society, www.ips-planetarium.org).

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DIY Planetarium Designs

Makershed.com, $6.49

Popular Mechanics, October 1937

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DIY Planetarium Designs

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Conclusions

- Planetariums can be engaging for students.
- Planetariums have a variety of possible curriculum uses.
- Planetariums can be built for relatively low costs.
- Planetarium multimedia programs can be designed and developed for relatively low costs, using a variety of free, open source software tools.

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Next Steps…

Artist's conception of new Whitworth-Ferguson Planetarium at SUNY Buffalo State, expected to be complete in 2017.

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Thank you!