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### Evaluating the Efficacy of Gravitational Wave Games in Arousing Interest and Promoting Understanding of Gravitational wave Research

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# Evaluating the efficacy of gravitational wave games in arousing interest and promoting understanding of gravitational wave research

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## ABSTRACT

The LIGO Scientific Collaboration's Education and Public Outreach Group seeks to ameliorate the lack of public understanding of gravitational wave physics. I present the results of a set of pre-tests and post-tests from a public high school which measures Black Hole Pong's effectiveness in teaching the concepts and benefits of gravitational wave astronomy. Results of this test can be used in the development of other outreach games, such as Black Hole Master and Chickens in Space.

## INTRODUCTION

The LIGO project (Laser Interferometer Gravitational-wave Observatory) is one of the most promising endeavors for studying General Relativity experimentally, and is to date the largest and most ambitious project to be funded by the NSF with 800 members at 90 different institutions. In Fall of 2015, LIGO detected its first gravitational wave event, which was created by two inspiraling black holes. The LIGO Education and Public Outreach (EPO) Group seeks to communicate these findings and their significance to the public through several channels, including games.

## BLACK HOLE GAMES

### BLACK HOLE PONG

In 2010, researchers at the University of Birmingham, UK developed a game called Black Hole Pong (BHP), a novel remake of the classic 1972 arcade game. In BHP, a player can move a black hole to slingshot a star onto his opponents side.

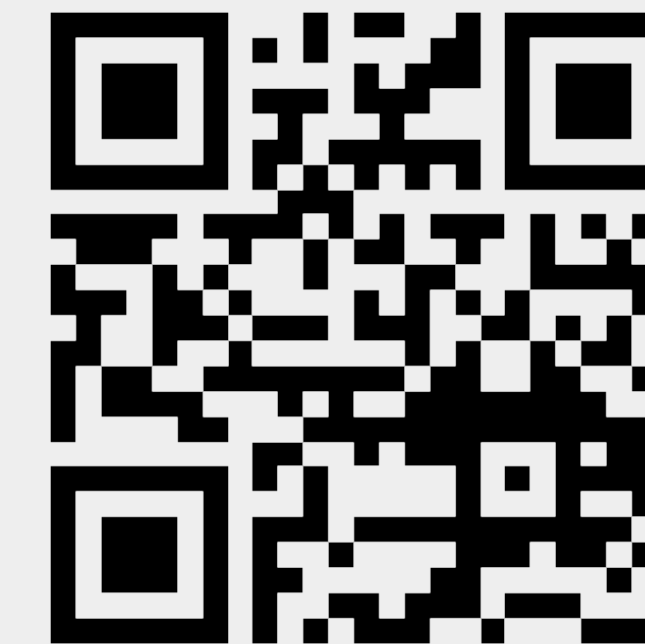


### BLACK HOLE MASTER

Successors to BHP, under the collective name Black Hole Master, are seeking to improve upon the game by improving graphics, expanding content, and increasing engagement. Black Hole Master may allow users to play multiple arcade-style games with supermassive objects.

## CHICKENS IN SPACE

In addition to Black Hole Master, I began developing a game called Chickens in Space in the fall of 2015. Players to experiment with the violation of conservation of mass. If mass can be created, but not destroyed, then excess mass eventually leads to black hole formation, and a fun narrative to explore gravitational wave physics.



Suppose you have a space craft that can produce chickens *ex nihilo*. Your craft could then eject the birds for propulsion. The play area quickly becomes filled with fowl which coalesce with each other, and whose gravity causes supernovae and black holes, presenting challenges for players.



## METHODOLOGY

In January, physics students at Sheboygan North High school had the opportunity to voluntarily participate in a pre- and post-game survey to measure how their interest and understanding of gravitational wave research changed from playing Black Hole Pong. Students received extra credit for their participation.

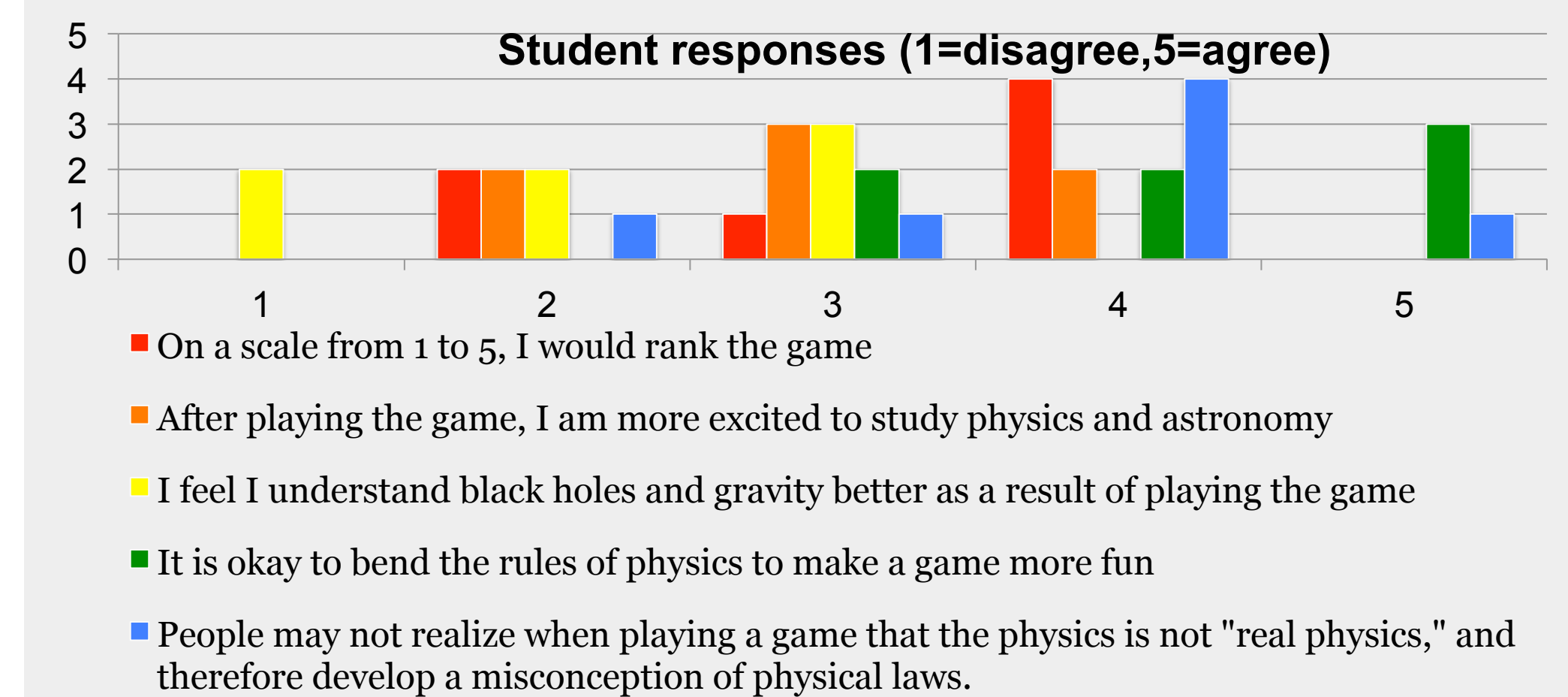
In March, students at Andrews University will have the opportunity to participate in a similar pre- and post-game survey to measure how their interest and understanding of gravitational wave physics changes from playing Chickens in Space.

## BHP RESULTS

Although 17 students participated in the pretest, only 7 students finished the post-test. The 7 students were sophomores and juniors (3 males, 4 females).



Four of the students played for less than five minutes, and likely quit as a result of frustration. When asked in the post-test what they would improve about the game, all four of these students responded that they wanted the controls to be more intuitive, or to have some directions within the game.



Between the pre-test and post-test, overall student enthusiasm for LIGO did not change as a result of playing Black Hole Pong, and interest in studying astronomy and physics on average remained the same. No student agreed to the statement that they understood the topics of gravity and black holes more deeply as a result of playing the game. Students recognized that it was possible for players to develop misconceptions when playing a game that deviates from "real physics." However, many students agreed with the statement that it is okay to bend the rules of physics in order to make a game more fun.

average score on 6-part true/false questions	Pre-test	Post-test
Gravity	5.7	5.7
Black Holes	3.9	4.3

Students did not display any changes in their average score for questions about gravity. Three students performed better in understanding black holes after playing the game, but one student performed worse. However, with N=7, changes this small are not conclusive.

## CONCLUSION

This study of BHP did not demonstrate strong evidence for increasing interest in gravitational wave astronomy and physics among high school students. This study also did not find strong evidence that playing BHP increase's students' understanding of gravity or black holes.

On average, students found the game to be neither exciting nor boring (3.3 on a 1-5 scale). Students indicated that a providing directions or instructions would improve the game. These considerations can be taken into the development of Black Hole Master and Chickens in Space.

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