ASTROPHYSICS FOR ALL

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Background:

Astronomy and Astrophysics are fascinating science subjects but why are they not included in the curriculum of Elementary or Middle Schools? A recent reading of *Scientific American* provided me with some inspiration to research more about the theories that relate to the Universe that we live in. How can these abstract concepts be explained through fun and easy-to-learn experiments to sparkle students' interest in these fascinating science subjects? I would like to share this experience with other teachers and students in grade schools and hope that school boards will consider introducing these fascinating subjects in the curriculum.

Purpose:

The purpose of this project is to understand the theories of gravity and their applications to the universe that we live in, and to figure out how they can be integrated into the grade school curriculum.

Hypothesis:

My hypothesis is that it is possible for teachers to develop methods and experiments related to Astronomy and Astrophysics that are easy to understand for students in grade school. This project focused on one specific topic – gravity. The three equations that were tested and explained in this project are:

1. The Newton equation: $\underline{a = 2\Delta d / (\Delta t)^2}$ where a is the acceleration of an object towards earth ($-9.8 m/s^2$), Δd is the change in distance between the object and the ground, Δt is the change in time.

2. The Schwarzchild equation: $\underline{R_{sch}=2Gm/c^2}$ where R_{sch} is the radius of the black hole, G is the universal gravitational constant (6.67×10^{11} N m^2/kg^2), m is the mass of the black hole in kilograms, c is the speed of light in metres per second (3.0×10^8 m/s).
3. Einstein's General Theory of Relativity: Einstein's general theory of relativity states that gravity must affect the shape of space and the flow of time.

After learning about the different theories of gravity, I developed easy-to-understand experiments and lessons for teachers to use in the classroom. From a detailed analysis afterwards, I determined how easy it would be for middle school students to understand the concepts of gravity from a variety of experiments and lessons.

Procedure:

Three simple and fun experiments were created for middle school students to learn and do.

Experiment 1: Newtonian Gravity Water Balloon Experiment

- Find a location on the ground around the school where there is a second-story classroom window right above it.
- Take the paint to create a circle of radius 10 inches below the window, and use a measuring tape to measure the distance from the second-story window to the ground.
- Then create 20 water balloons. Each student would take four (4) water balloons and take turns going to the second-story window. From this window, take turns dropping the water balloons one at a time trying to hit the painted target below.
- As each water balloon is released, the students below would use a stop watch to record how long it took for each water balloon to travel from the second-story window to the ground. At the same time, students would take note of how many times the student at the window was able to hit the painted target on the ground.

- After each water balloon dropping, record the time required for the balloon to hit the ground on a piece of paper until all 20 balloons are dropped. The student who hit the target the most out of the five-person group would be rewarded a prize.
- Use this information to calculate the acceleration rate based on the Newton equation.

Experiment 2: Einstein's General Theory of Relativity Table Cloth Experiment

Students would be split up into groups of five students. Each group would be given a table cloth and four students would be required to stand at each end of the table cloth holding his or her end of the table cloth off the ground. The fifth student would then take one of the objects and drop it lightly onto the table cloth. The student would continuously drop objects slowly and lightly onto random parts of the table cloth.

Experiment 3: Black Hole Experiment

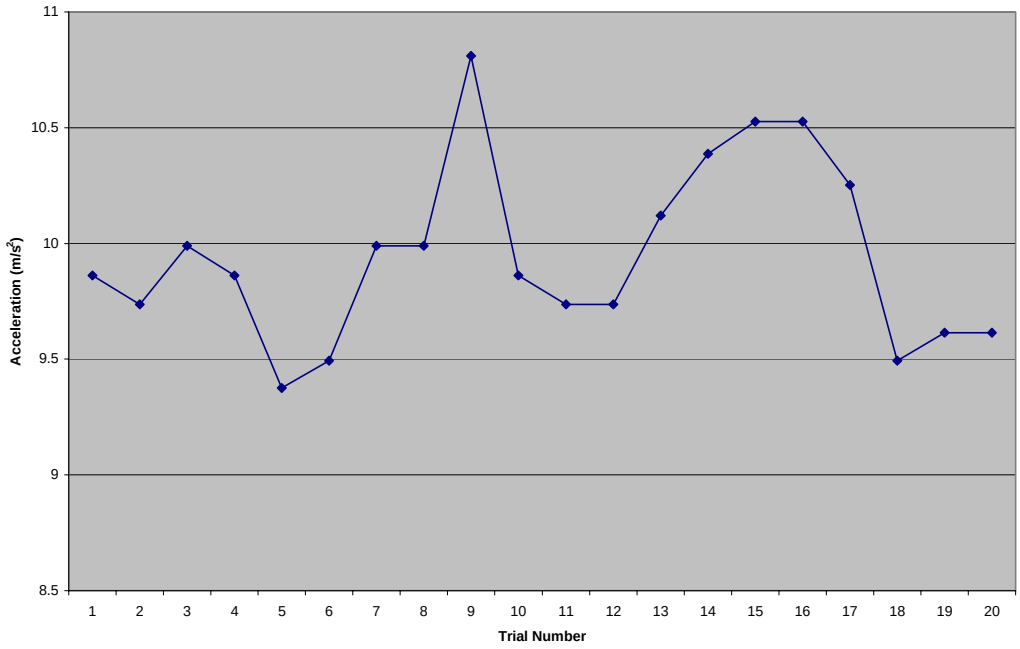
Students would take turns using a scale to determine the mass of their objects. They would also estimate the radius of their object. Using the Schwarzchild equation, they would calculate the radius of their object if it were as dense as a black hole using the object's measured mass. Students would also be required to determine the mass of their object if it were a black hole using the radius that they estimated.

Observations/Results:

Experiment 1: Newtonian Gravity Water Balloon Experiment

When I dropped 20 water balloons out of that second-story window, I realized that the time was very consistent. Using this information, I calculated the acceleration rate using the formula $a = 2\Delta d/(\Delta t)^2$. Sir Isaac Newton said that acceleration should equal $9.8 m/s^2$. The average of the 20 calculated acceleration rates was $9.949 m/s^2$ which is very close to what Newton said it should equal. The average time was 1.554 seconds.

Graph 2: Calculated Acceleration of Water Balloons from Freefall



Experiment 2: Einstein's General Theory of Relativity Table Cloth Experiment

The observers could see that gravity pulls the objects towards the ground curving the cloth (space) around it. Einstein's General Theory of Relativity states that Gravity curves the shape of space and the flow of time. Thus, this experiment illustrates Einstein's General Theory of Relativity on a scale that is practical to demonstrate in class.

Experiment 3: Black Hole Experiment

When I did this experiment, I was astonished that in such a small object, when I calculated its mass and radius as if it were a black hole, it can have so much mass and matter in it. This experiment shows that many black holes (which are large), have infinite density.

Conclusions:

Teaching and learning the theories of gravity could be very simple. Many students along with teachers can learn these basic and easy-to-learn concepts. The theories of gravity affect the universe in many different ways: it affects the flow of time, the shape of space, and how things act on earth or in space. The water balloon, table cloth, and black hole experiments are ways to

creatively teach middle school students in a fun way. As a result, all students will be exposed to the exciting world of astronomy and astrophysics so that they may begin their learning and understanding of these exciting subjects at a young age.

Applications:

The Ontario School Boards are currently not teaching these subjects in Elementary or Middle schools. However many students are curious about astronomy and the universe that they live in. They walk down the streets at night, looking up into the sky and wondering why the stars are where they are. Using the simple, fun, and easy-to-learn experiments presented in this project, students will learn that gravity holds the Universe together. Teachers along with students also need to learn these fascinating subjects. When I told teachers about my project they became interested in these subjects. I think that students will do the same.

Acknowledgements:

I would like to thank my brother Dan Le, who assisted me in putting my display board together and proofreading my written work. My brother has been one of my most valued advisors while I was creating this science fair project. My father also helped me with buying the materials for me.

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Proof of Requirements:

The necessary certifications/approvals were obtained and will be part of the display.

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