2006

Project: Epiphany-Fluid Motion, A Floatation Video Exploration

Jason Williams Hughs

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FLUID MOTION
A FLOATATION VIDEO EXPLORATION

Jason William Hughes, B.S. Ed.

An Abstract Presented to the Faculty of the Graduate School of Lindenwood University in Partial Fulfillment of the Requirements for the Degree of Master of Communications with emphasis in digital media production

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ABSTRACT

Educational videos have the tendency to be sterile, uninteresting productions that fail in their attempts to stimulate knowledge in young minds because they themselves are not stimulating. The focus of this culminating project is the production of an effective educational video for middle and high school science students. This work will also provide a process analysis text discussing the production process and providing statistical evidence supporting the effectiveness of the video production.

Discussing the topic of Archimedes' principle of floatation, this educational science video gives an energetic look at why some things float while other things sink. This topic can be deceivingly difficult and complex to beginning physics students and therefore was worthy of a thorough investigation with emphasis on building a good foundation of required concepts.

This video project and the process analysis developed here are divided into the stages of pre-production, production, post-production

and analysis. Creating outlines, scripts and cartoon characters are among the many things that go into the preproduction stage. Also included in this planning would be creating a shot-list of images to record or generate in the computer. Pre-production includes setting up and preparing for interviews that will enhance the topic and not be redundant. Many hours spent in the planning stages will allow for a smooth production.

Production refers to the recording of audio and video for use in the project. Setting up special effects shots and generating graphics in the computer are among the many tasks of production. This stage also conducts the planned interviews and experiences the decision making that must occur when all does not go as planned.

Post-production includes the art of editing all of the hours of recorded footage into a cohesive project that fulfills the intended purpose. Deciding what stays and what goes is a key component of this stage.

Analysis of the project requires personal reflection of the director as well as information gathering from the intended audience.

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Professor Michael Castro, Chairperson and Advisor

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Purpose:

As an educator of scientific principles I often use videos to help students visualize the concepts I am teaching. The vast majority of the movies in our school library leave the class (myself included) wanting to take a nap. The information conveyed is usually fine but boring narration, "elevator" style music and an overall lack of enthusiasm are the main problems I see in passing knowledge on to the viewer. After watching a typical video I asked my students to give me two columns of notes. One column was to share what they thought was good about the presentation and the other would tell me what needed work. This informal survey taught me that students want humor and energetic, current music with information from people and places they have not seen before. A narrator without feeling was noted as the most annoying aspect of movie watching.

Educational videos are not viewed for entertainment purposes, but learning does not need to be sterile process. Humor and upbeat music intertwined with accurate science will help students remember the information presented. I am therefore taking it upon myself to make an instructional video that is student-friendly while containing information worthy of learning. Kids need fun, understandable information for the video to have any lasting impact on their knowledge.

Introduction and Overview :

"**Fluid motion**" is an energetic look at what happens when the displaced of fluids cause objects to be put in motion. This exploration looks into Archimedes' principle of displacement and discovers why objects will float or sink. It is impossible to truly understand, let alone critically think about a complex principle like that of Archimedes' without fully comprehending the foundational concepts that make it true. Only by first exploring the key concepts of weight, fluid, displacement, density, and buoyant forces can one hope to understand the physics of floatation without "dumbing it down".

Reading and understanding science can often be difficult because of the hidden traps of require prior knowledge. In a sentence like "the weight of the fluid displaced by an object equals the buoyant force on the object," there are at least four words/phrases that require comprehension before the principle can be understood. A lack of understanding of any of the four main terms can seriously inhibit higher level learning. To combat this, the main structure of Project: Epiphany resembles a ladder in that foundational concepts are explained before more in-depth concepts are introduced. In order to reach the top of a ladder a person must step on each rung. Higher level learning is very similar. Only after the basics are learned (rungs) can students truly understand a more in depth principle (top of the ladder) like that of Archimedes.

"Weight" was chosen as the first chapter because it is the first complex term in Archimedes' principle. Understanding the relationship between mass, weight, and gravity is essential to

comprehension of the entire principle. Many might consider this knowledge unnecessary to understanding Archimedes' principle, however this attitude is usually based on inadequacies in their own knowledge base and does not facilitate real learning. It is impossible to fully understand a complex situation without comprehending the simple things that it consists of.

The concepts of fluid, displacement and buoyant force are all terms that require prior knowledge and in turn build into Archimedes principle. Project: Epiphany is designed to make complex things palatable to the average student by building a strong foundation in scientific concepts. By giving short mini-lessons on each of the essential terms in an order that makes logical sense, the project can be used as a review as well as a supplement during many different lessons.

The video has a mix of four techniques to grab attention and teach concepts. Classic demonstrations performed in science classrooms will provide exposure to lab equipment and procedures that are commonplace to scientific experimentation. Video field trips to places that reinforce the concepts include a drag boat race, hot-air balloon race, the St. Louis Zoo, and the decommissioned battleship U.S.S North Carolina. Video field trips allow concepts of science to fit within the real world without leaving the classroom. Using examples that students can relate to like the zoo will help them to attach the new information in the video to prior knowledge. Going to North Carolina to visit a battleship is an ideal field trip as well because it is likely a new place to the majority of viewers. Common places to visit are good for familiarity. Everyone has likely been to a

zoo and it is more likely that they could then relate to the ideas presented from there. It is also important, however, to include sites that are not common for variety and introducing students to rare and interesting things they would likely never travel to.

Interviews with scientists help to illustrate the main points while adding variety to the primary speaking voice. Dr. Eric Haupfear and Jim Lovins of the St. Louis zoo were able to illustrate points within expertise much better than I could have on my own. Having more than one authority adds validity to the knowledge and strengthens the production as a whole.

As a very visual learner, I tend to "see" graphics that show the big picture. One of the major goals of this production was to generate computer graphics that accurately reflect the way I see the information. Much like a diagram in a science textbook, graphics can often explain a concept much more accurately than words. Arrows, imported pictures, and computer effects are all tools I often used to show the way I think.

The fourth, and most important, aspect to this production is the inclusion of review sessions after each mini-lesson. It has been said in the teaching community that only 10% of what a person hears is actually remembered. To combat this, a short review of the essentials needed to progress was placed as a segue between concepts. The ladder structure of the program needs these reviews to make sure a student is ready to progress to the next rung of knowledge. The beauty of a video presentation is that a push of a button allows for a review of the entire concept.

Production Analysis:

Pre-production

One of the first things to accomplish in pre-production is an outline of the major components of the video. The first outline of the production is significantly different from the finished product. It represents the beginning stages of thought and is much more ambitious and less focused. The most notable change is the biographical section on Archimedes. Originally, the program was to include be more about the man than just his science. It is also interesting for me to see the structure of the program change from a logical textbook style approach to the ladder method. .

Preliminary Outline (May 2005)

I. Teaser (what do boats and balloons have in common)
    A. Show quick clips of floating and sinking objects
    B. "Up next on Project Epiphany"
II. Main Theme ending with Fluid Motion logo
III. Fluid Properties
    A. Go over teaser question "they are both floating in or on a fluid
    B. Discuss what a fluid is
        1. Liquid or a gas with no definite shape
        2. Gases fill their containers while liquids have a definite volume
        3. Molecules are moving faster than those in the solid form
IV. Introduction to Archimedes

A. Biography of Archimedes academic life in Alexandria and Syracuse

B. Introduction of the concepts he brought greater understanding to
   1. Displacement
   2. Density
   3. Buoyancy

C. Archimedes story of King Hiero's crown part I
   1. cartoon or live action showing King Hiero concerned he has been ripped off by a crafty goldsmith that did not use all of the gold given to him when making a crown. Hiero believes it to not be heavy enough to be a solid gold crown of that size. Show a scale balanced with a crown and bar of gold to show Archimedes thinking, staring at crown. "How can I show this is solid gold and not a mixture of gold and silver" (the answer is displacement)He determined the answer while getting into a bath that was too filled with water. The overflow was what he displaced.

V. Displacement

A. The definition of matter is that it has mass and takes up space

B. Two objects cannot occupy the same space at the same time
   1. show the same objects displacing the same water in different containers
   2. show different objects in the same container
   3. displacement of a fish by being in the water
   4. displacement of air when a balloon is blown up

C. True of Definitely not true
   1. Do the oceans rise if a boy throws a pebble from the beach?

D. Turkey fryer gone bad

E. King Hiero's crown part II to go into density. Archimedes took the original gold and submerged it, measuring the overflow. He did the same with the crown and found that the crown took up more space than it should have. Archimedes knew that silver weighs less then gold. If a scale had equal masses of gold and silver the silver must take up more space. The amount of mass in a space is called density.

VI. Density (specific gravity)

A. Density is a measure of mass per unit volume. Objects that have more mass per space have a greater gravitational attraction with the Earth.

B. Water has a density of 1g/ml

C. Objects greater than 1 will sink and those less than 1 will float

D. An estimate of density can be made by observing how much is below the water:
density column, egg in water and sugar water,
ice in alcohol and vegetable oil, density column,
diet and regular soda, water toys,
swimming on Salt Lake,
Mercury and pinball, Density balloons, Density kits,
show that gases have mass and space,
What happens to density when heated

a. kinetic theory
b. Galileo's thermometer
c. life preserver (word from your conscience)
a. bowling ball gag

B. Which float and which sinks (pumice and ironwood)
Ironwood sinks leads into Archimedes Cartoon of ironwood canoe to ask if it is possible to make a boat out of ironwood. (compare to aircraft carrier made of iron and concrete.

VI. Archimedes' Principle states that the weight of the displaced fluid will be the same as the buoyant force on the object

A. Demos

1. Anything can float if it displaces enough fluid
2. aircraft carrier can float
3. Archimedes proof
4. canoe sits deeper in water with more weight (cartoon?) until it runs out of boat and sinks
5. really just Newton's 3rd law in action
6. swim bladder on a fish (ability to alter buoyancy)
7. submarine (ditto)
8. He balloon
9. Hot air balloon

B. True or Definitely not true (teaser and post break lead in)
Does buoyancy occur during freefall

VII. Review
   A. Fluids in general
      1. what is and is not a fluid
      2. What does matter do when heated
   B. Displacement
      B. definition
   C. Density
      1. definition
      2. density column
   D. Archimedes' Principle
      1. definition
      2. why something sinks in fluid

VIII. Thanks for watching/ End Credits

Script and storyboarding

The following is the final script for Fluid Motion. The script started in outline form in May of 2005 and has been rewritten numerous times up until February, 2006.

Concept teaser (floating bowling ball skit)

Ext. docks Twilight

Mugsy and Doc are seen walking down the stairs towards the docks. Mugsy is carrying a bowling ball that is tied to Doc's leg.

Mugsy: OK Doc you know what happens when people double-cross the boss.

Doc: They go bowling?

Mugsy: Nah, they usually get a pair of cement shoes to go sleep with the fishes. But seeing as though we is out of cement, I think this kiddy bowling ball here will do just nicely.

Doc: I don't think that a bowling ball…uh…never mind.

Mugsy: See ya Doc. (throws bowling ball into the lake, ball floats)

Doc: I've been spared!

Project Epiphany teaser (shots of lava lamp, barges, eggs, Archimedes)

Narrator V/O : Why do some things float while other things sink? How is it that a steel barge full of cargo can float but a piece of steel by itself would sink to the bottom of the river? Archimedes asked questions like these centuries ago in ancient Greece and his discoveries hold true even today. Plan to understand how Archimedes' principle allows us to move above, below, and within the Earth's fluids on this edition of Project Epiphany!

Project Epiphany main title sequence with theme music (45 sec)

Archimedes' Principle introduction

Narrator V/O : Archimedes' Principle states that "the weight of the fluid displaced by an object equals the buoyant force on the object" As usual in science, a principle like this one is packed with information. Each word needs to be explored in order to understand what Archimedes was trying to say. As you can see some of the words in the principle are highlighted. Each of them is vitally important in learning why something will sink or float…So let's get started.

Chapter 1: "Weight"

Narrator V/O : The universe is mostly empty space called a vacuum. All the stuff in the universe that isn't space is made of matter. Stars, planets, people, ferrets, beach balls, even that plastic "nubby" thing on the end of your shoelaces… its all

matter. The amount of matter in each of these objects is called its mass and we use a balance to measure it. The balance measures in grams. A gram of mass is about that of a thumbtack. Here is an empty party balloon. The balance reads "11.7 grams". Now let's put some air inside the balloon and take another measurement. "14.8 grams. That's a difference of 4.1 grams" As you can see, the air inside has mass. Everything … even the air we breath has mass.

Sir Isaac Newton tells us that there is a force of attraction between all matter. He called it gravity. Gravity is the force that can be found between any two objects.

This means everything is being pulled on by everything else in the universe. This sounds like a science fiction movie where you could cause objects to fly to you on command, but in reality things attracted to us are more attracted to the Earth. Newton says you are attracted to the Sun , but when you jump into the air you fall back to Earth. This is because even though the Sun is much more massive than Earth, it is too far away to pull you away from Earth's gravity. It's a good thing too.
We can calculate the amount of gravity if we know the size of the two masses and distance between them. For example, the mass of the Earth would go here in the equation and the mass of the sun…here. The distance between the sun and earth is goes on the bottom of the equation. Let's look at what happens if we change things around. If the mass of one of the objects goes

up…so will the gravity between them. But if the objects get further apart the gravity between the objects gets weaker. Sometimes it gets so weak that we say you are in "Zero Gravity" but if someone says, "there is no gravity in space", it simply isn't true.

Newton's equation means that everything, not just planets and stars, has gravity with everything else. Usually we talk about the gravity between you and the Earth. You have mass and the Earth has mass so therefore there is gravity between you. We call this force of gravity your "weight". A simple bathroom scale placed between you and the Earth will measure of the force gravity between you. So when you eat a big meal, you gain more mass. With more mass there is more gravity. With more gravity, there is more force pushing you onto the scale making it read a higher weight.

Review: Weight (cue concept review graphic and music)

Narrator V/O: When we talk about "the weight of " something we are describing a force and not its mass. All matter is made of mass and all masses are attracted to each other. This force of attraction is called gravity. The force of gravity between two masses is called the object's weight. Usually one of these masses is the Earth. The other could be you, a boat, or even a hot air balloon. All of these things have weight because they are attracted to the center of the Earth, but sometimes, forces go against gravity and cause things to float.

Chapter 2: "Fluid"

Narrator V/O: OK so now we know what weight is, but in order to understand Archimedes' principle we still need to go over three other terms.

Objects float in fluids… so if we want to understand floating, we need to first understand what a fluid is. Fluids along with all matter are made of particles and they are always moving. Particles dart around, bumping into each other and their container. They move faster and spread out when heat is added to them. Faster particles mean higher temperatures while slower particles are lower temperatures.

Typically matter on Earth is found in one of three states…solids liquids, or gases. The particles of a solid are usually moving very slowly and are very close together. A solid has a definite shape to it and takes up a definite amount of space.

If enough heat is added to a solid, the particles will be moving fast enough and far enough apart to melt and now be called a fluid. Liquids are a type of fluid. They are called fluid because they have the ability to change their shape to their container. Liquids, like solids, take up a definite amount of space. One Liter of soda is still one Liter of soda no matter what container it's in.

Heating up a liquid will cause the molecules to move even faster and spread further apart. With enough heat added, a liquid will boil into a gas. Gases are another type of fluid because they too will change their shape to fit the container they are in.

(Dr. Haupfear quote) " Gases tend to expand greatly. They can do a couple of things. If they're in a volume like a balloon and you heated a balloon the balloon would begin to expand. If you had a bottle like this that was sealed up and you heated it and it was filled with gas and you heated it, what's known as the pressure would increase… if you took the cap off all of a sudden the gas would just blow out… the hot gas would just blow out.

We say that both liquids and gases are fluids because they have the ability to change their shape. Fluids move around objects when they come into contact with them. Water flows around a paddle. Air flows over a car. If fluids didn't flow we wouldn't be able to move at all. Drinking fluids would be quite a challenge …let alone breathing. And don't forget that humans are mostly made of liquid water. If fluids didn't flow, we couldn't exist.

Imagine you were the size of a molecule at the very top of the atmosphere where the air is extremely thin and there is nothing above it but the vacuum of space. As you drop towards the

Earth there would be more air above you. This air is pushing down on you because it is attracted to the Earth and you are between them. This means the air pressure is increasing. Lower altitudes get higher and higher air pressures because there is more air above you to press down. Now let's go under the water a bit. To determine the pressure here you need to think about what is above you. Not only do you have an entire atmosphere of air on top of you, but now there is water forcing on you as well. The deeper underwater you travel, the more water is on top of you pressing down. In fact, the bottom of the ocean has more than 1000 times the pressure than at the surface!

Concept Review: Fluid

Narrator V/O: So what do we need to know about fluids? Matter is most often found in one of three states…Solids, liquids and gases. Liquids and gases are called fluid because they can flow and change shape to fit their container. An important aspect of fluids is that the pressures within them are identical at the same altitude or depth. The more matter above you will increase the pressure on top of you. It is also good to know that the forces in a fluid are in all directions and not just pressing down.

Chapter 2-2: "the weight of the fluid"

Narrator V/O: So far Archimedes' principle says, "the weight of the fluid". Because fluids have mass, they are attracted to

the Earth and must have weight. A waterfall is a beautiful example of fluids having weight. If water had no weight, it wouldn't fall. A gust of wind can do a lot of damage. If air was weightless, it couldn't force anything anywhere. Now we know about the concepts of weight and fluid. Two down…and two to go.

Chapter 3: "Displacement"

Narrator V/O: From the day we are born we start exploring. We find out that water takes the shape of a bathtub. Water moves when we're in it and when we splash it around with our toys. Whether the toys float or sink, it doesn't matter. Everything that goes in the bathtub makes the water level rise. But the same is true of any fluid and not just in a bathtub. As these drag boats speed towards the finish line, they are actually raising the water level in the lake. Fluids change shape when something pushes on it. We say that it is being displaced.

Everything takes up space, but not the same space. If the hippo wasn't swimming, water would be in its place. If this balloon wasn't here, cool air would fill in the space. But as it is, both the hippo and the balloon are displacing fluid. The question we need to ask now is "How MUCH fluid is being displaced by these objects?" This will become very important in learning why something floats.

Scientists call the space an object takes up its volume. For example, the volume of this is container is 1 Liter. It is simply a cube measuring 10 cm on all sides. By multiplying the length, width and height, we can find out the cube's volume. 10 cm X 10 cm X10 cm equals 1000 cm3 also called 1 Liter. Inside the cube right now is 1 Liter of air but if I pour a Liter of water into the container the air will be pushed out or displaced.

This happens because two things can't be in the same space at the same time.

Measuring the volume of a cube is pretty easy, but most things are oddly shaped. Think about all of the curves that make up a hot air balloon…the bottom of a canoe… the body of a fish, or a person. The volume of these things would be nearly impossible to find with just a ruler. In ancient Greece, Archimedes was able to figure out a way to measure the volume of just about anything regardless of it's shape!

Archimedes story of King Hiero's crown

Scene 1: Introduction

Ext.- Greece

Narrator: It is the 3rd Century B.C. and Hiero II, King of Syracuse, has called for the royal goldsmith to take on a very special assignment.

Scene 2: Hiring the Goldsmith

Int – Throne room

King Hiero: I would like you to make a gold crown worthy of the King…namely Me.

Goldsmith: Yes sire, It would be my honor.

King Hiero: Here is the amount of gold I will give you for the crown. See to it to that all of the gold is used.

Goldsmith: Yes sire, I can't wait to take this gold into town.

King Hiero: What did you say?

Goldsmith: I said 'I can't wait to make this gold into your crown.'

Scene 3: Archimedes' workshop

Int –workshop

Narrator: When the new crown arrived, King Hiero felt that something was wrong and went to find Archimedes He was a man who could solve many problems but most of all could be trusted by the King.

King Hiero: Archimedes, I have a job for you. I need to know if I've been cheated in the making of this crown.

Archimedes: Yes sire, I won't do anything until I find the answers you need.

Scene 4: Royal vaults

Int – front desk of the vaults

Narrator: Archimedes went to the vaults and obtained another chunk of gold the same size as the one the goldsmith was given

Scene 5: Archimedes' workshop

Int –workshop table

Archimedes: First, Let's see if they weigh the same

Narrator: Sure enough, the crown and the chunk of gold were the same weight. But something didn't feel right about the crown.

Archimedes: A crown this size should be heavier than this, but how do I prove it?

Narrator: Archimedes thought… and thought….and thought some more. The days went by in his workshop. Day after day after day…and soon he began to stink.

Scene 6: Bathhouse

Int – Greek bathhouse

His servants drug him off to the bath house. As he got into the water he noticed that the water… level… rose.

Archimedes: Eureka!

Scene 7: Eureka Streaka

Ext – Streets of Syracuse

Narrator: Forgetting his robe, Archimedes ran down the streets of Syracuse back to his workshop.

Scene 8: Archimedes' workshop

Int –workshop table

Narrator: He took the chunk of gold, submerged it in a tank and measured the displaced water level. He did the same for the crown. The crown displaced more water than it should have if it were solid gold. Remember they had the same mass but they ended up with different volumes. They could not both be solid gold. The goldsmith had replaced some gold for less expensive silver. The king had been cheated.

Graphic: "The End"

Narrator V/O: We use this same technique to determine the volume of objects. The water level will rise by the same volume as the object. When this toy is submerged, it raises the water level. A little subtraction tells us that the toy has a volume of almost 30 ml!

Displacement sounds like it should be easy concept to master but every Thanksgiving many people lose their possessions because they don't think about Archimedes' principle.

Insert Underwriter Laboratories turkey fryer segment

Displacement Review

Narrator V/O: So what do we need to know about displacement? It boils down to the fact that no two things can be in the same place at the same time. The amount of fluid pushed aside will equal the volume of the object. It is also good to know that Archimedes discovered the relationship between mass and volume.

Chapter 4 : Density (cue principle review graphic and music)

Narrator V/O: Ok, three of the four terms are finished, but before we move on, Archimedes' experiment with the mass and volume of gold have led to us another very significant concept…density.

Density is a measurement of the mass of an object divided by its volume. This easy calculation is a way of identifying and separating substances. Every substance has its own density and this number can tell us which things will sink and which will float. Pure water has a density of 1 g/ml because 1 ml of water has a mass of 1 gram. It is the most common substance on the planet and it is no coincidence that it has a simple, easy to remember density. The metric system was designed with water in mind. Densities greater than 1 will sink in water while those densities that are less than 1 will float.

Ice sinks while in alcohol but floats when placed in vegetable oil. Notice that when the ice melts into liquid water it sinks below the oil. Fluids order themselves according to their densities.

Not all things sink at the same rate. Watch as these substance fall through water. The objects on the right are more dense than the objects on the left.

How much of these objects are floating below the surface of the water? If we estimate the percent of the object under the water it will tell us the object's density. This wood floats so that half of it below the water. That's 50% so it should have a density of 0.5 g/ml. Styrofoam floats much higher on the water than wood typically does. How much do you see below the surface of the water? What would its density be?

What would you expect from a piece of wood and a rock? (Ironwood sinks and pumice floats) Surprising? This exotic ironwood is one of the few trees in the world that produce wood more dense than water. Pumice is an igneous rock, which means it is produced from volcanic activity. As the rock cooled, air was trapped in pores similar to a sponge. As a result the density is less than 1and floats. Keep that in mind if you ever shipwreck near a volcano!

Insert Jim Lovins interview about fish swim bladders

Narrator V/O: A submarine is man's improvement on the swim bladder. Instead of filling up with air, a submarine has chambers that can be filled with water. As the heavy liquid rushes in, the boat becomes denser than the water and sinks. When the captain wishes to surface, submarine can force the water back out into the ocean making the sub light enough to rise.

Time to review the main points. Density is a term we give to describe how much stuff is in a given amount of space. Higher density objects are found below low density objects. A hot air balloon must be less dense than air in order to float. Water is denser than air which is why we find the ocean below the atmosphere. A fish has a density very close to water so it doesn't float or sink but hovers where it wants to. A chunk of concrete or steel has a density much greater than water so it sinks to the bottom.

Chapter 4-2: "The weight of the fluid displaced by an object"

Narrator V/O: "The weight of the fluid displaced by an object." Fluids have weight. Archimedes determined that the weight of the water displaced by an object is the key to floating. We can measure this by first weighing an empty container for catching water. We will need this for later. Now gently drop an object, like this child's bowling ball into the fluid and be careful not to spill any. As you know, the water level rises

because it is being displaced. Using this fancy piece of equipment called an overflow container (Archimedes "you mean a bucket with a hole in it") … um well, yes…we can catch all of the fluid that is pushed out of the spout…down to the last drop. Finding the displaced fluid now just a matter of reading the scale. One problem though, the scale is reading the water, but it is also measuring the bucket. This is why we measured it by itself first. We only want to know the weight of the fluid displaced so we subtract off the weight of the bucket. The weight of the water pushed aside by the bowling ball will help us understand why it floats.

We know about weight, fluid, and displacement and density too. Now on to the final hurdle in understanding Archimedes' principle.

Chapter 5: "buoyant force"

Narrator V/O: A force is a push or a pull. As you sit and watch this program, there are forces acting on you? Gravity pulls us down towards the center of Earth and the chair supports us with an upward force. Without this upward force you would fall to the floor. Notice that the forces are the same size. We say that the forces are balanced when you aren't moving. It's like a constant a game of tug-o-war. If the forces are balanced, than the rope will not move in either direction. When one team pulls harder than the other, the forces become unbalanced. Only then will the rope move.

In fluids, there is a battle between forces as well. Gravity forces downward, but without another force to balance it, everything would sink. We need an upward force to work against gravity and keep things afloat. This is called a *buoyant force.* Buoyant forces make things lighter when they come in contact with a fluid.

Let's prove it by weighing a brick. This is a metric spring scale so its measuring in Newtons. Most bricks this size aren't 14 pounds. Bowling balls maybe but not bricks. Anyway, as any object is lowered into water it gets lighter. The water is forcing up on the brick and cancels out some of its weight. This is the buoyant force in action. But even though it is lighter it is not light enough to overcome gravity.

Where is the buoyant force coming from? Just like your chair holding you up, fluids have the ability to force back on the matter that is "sitting" on top of it. Consider some water along this line near the surface. Water an air force down on this point just like when you sit in the chair. The water at this level must push back with the same force. As we go deeper, there is greater weight sitting on the water, so the water at this level has to push back with equally greater forces. See how the forces get larger the deeper we travel.

The U.S.S. North Carolina. Built in 1941, it was the first of many modern battleships. Longer than 2 ½ football fields from

aft to stern and over 100 feet wide, this seasoned battleship was a key player in the war against Japan. Primarily built from concrete, steel and wood; the North Carolina housed over 57 guns, a seaplane and more than 2000 sailors. Fully loaded with fuel and water for its boilers, the North Carolina weighed in at a staggering 46,000 tons! The massive weight of this battleship would be a significant force downward on the water and the forces near the surface of the water would not be enough to hold up a ship of this size. This is why we never see battleship floating like Styrofoam on top of the water. The boat will sink until an equal force can hold it up. Notice that the boat displaces more water as it sits deeper in the water. The North Carolina displaces 46,000 tons worth of water in order to float. A lighter object, like this 4000 pound seaplane, will only have to push aside 4000 pounds of water in order to float. Make sure you see the relationship…as an object displaces more water it has a greater buoyant force acting on it.

Chapter 4-2: " the weight of the fluid displaced equals the buoyant force"

Narrator V/O: Archimedes principle states that the weight of the fluid displaced will equal the buoyant force on an object. The following demonstration is used to prove this principle to be true.

Remember the brick from before? It had a buoyant force of 7 N. We calculated it by looking at the difference in its weight

above and below the water. Now let's do the same experiment, but this time, catch all of the displaced water. Look the brick pushed out 7 N of water! Archimedes principle is correct. The weight of the water displaced equals the buoyant force on the brick.

Archimedes principle says that in order to float, an object must displace an amount of fluid equal its own weight. A ball of clay doesn't displace enough water to float, but watch as these students transform the clay into a shape that can sit deep in the water. Oops, not enough water was displaced that time. Ah… Much better. These boats are deep enough in the water to float. Shape is everything. As we have seen, even concrete and steel can be shaped into a floating battleship.

Think of it this way. When the hippo pushes water aside, which is heavier the hippo or the water? The force of the hippo down is greater than the water pushing up so the hippo sinks. A fish should displace water equal to its weight in order to hover within the water where it chooses. The USS North Carolina is obviously not completely underwater but the water that is displaced MUST weigh the same as the ship.

Which of these barges on the Mississippi river has more cargo on board? We can tell just by looking at them. The heavier barge is the one deeper in the water. Heavier objects must displace more fluid to get a bigger buoyant force.

When a boat takes on more weight it lowers into the water. Eventually the ship runs out of hull and starts to take on water. This water adds more weight. In order to stay afloat the ship must sink deeper in the water which lets in more water, which adds more weight, so the ship lowers in the water and takes on more water weight. The physics of sinking are hard to overcome once the cycle has begun.

It is hard to sink some canoes because of Styrofoam in the tips. These boats can still float even when filled with water and people. "Swamping" a canoe can be a lot of fun but it isn't very easy to paddle.

Here's a thought. You have a buoyant force right now. You take up space and must displace air which is a fluid. So just by being here you have a buoyant force equal to the weight of the air you push aside. Obviously no human has a buoyant force large enough to fight off gravity. A hot air balloon, however, does.

A balloon must displace cold air to rise. It must move aside more cold air than the basket, people, fuel, material, and hot air combined. The pilots warm the air in the balloon with fire. As the hot air spreads out and becomes less dense, some air is pushed outside the balloon. Less air means less weight. So much so that when the balloon, basket, people, and fuel are added, the total is still less than the cold air that was displaced.

And away they go…buoyant forces winning out over the force of gravity…gently gliding where the winds take them on a beautiful summer afternoon. Its too bad Archimedes never had the opportunity to witness his principle take to the skies. "Eureka!"

End credits

Written, produced, and edited	by Jason Hughes
Science advisors	Dr. Eric Haupfear Dr. Scott Pinkham
Music	Backtraxx Jason Hughes
Project advisors	Peter Carlos Dr. Michael Castro
Special thanks to my family for patiently waiting for me to emerge from the editing room.	

Project: Epiphany Shot List

Description of shot	recorded		
INTERVIEWS			
Haupfear interview			
Lovins interview			
St. Louis Zoo / Downtown			
Hippo at large window			
Various fish hovering (at least 3)			
Various fish swimming(at least 3)			
Zoo sign and monument			
Riverboats by the bridges			
St. Louis Arch			
Joel observing fish and/or penguins			
Find barges at different displacing different amounts of water (at least 3)			
Great Forest Park Balloon Glow (Friday)			
Wide shot during balloon glow			
Close up on one balloon glow			
XCU on burner			
XCU on burner looking up balloon			
Interview handlers or pilots			
Great Forest Park Balloon Race (Saturday)			
Take out balloon envelope			
Burners heating air			
Time delay of balloon inflating			
Balloons inflating			
Handlers pulling on balloon to show weight			
Various beauty shots of balloon in sun			
Multiple balloons taking off			
Interview handlers or pilots			
Interview kids on why balloons float			
Aquarium shots			
Ironwood sinking			
Pumice floating			
Ironwood and pumice simultaneous			
Rubber duck floating			
Sinking plastic pool sticks together			

Pool stick by itself	
Plastic ball with holes (stay on it until it sinks)	
Hold plastic ball under until filled, then let go	
Toy submarine sinking	
Toy submarine wound up and let go	
Toy fish swimming across camera	
Toy turtle swimming across camera	
Wood stick floating	
Styrofoam floating	
Foam discs floating	
Drop density cubes with grid background (order the cubes by increasing density)	
On the pool table with various backgrounds	
Displacement of water toy in a grad. cylinder	
Mass empty party balloon	
Mass of party balloon with air	
CU of "gram" on the balance	
1 liter of water from graduate into liter cube	
Liter cube with small cubes (length)	
Liter cube with small cubes (width)	
Liter cube with small cubes (height)	
Liter cube with small cubes (1 ml cubes)	
Baby blocks spelling "solid" in glass tube	
Displacement of clay gold ball	
Displacement of clay crown	
Time delay of blue ice cubes in alcohol	
Time delay of blue ice cubes in vegetable oil	
Time delay of Galileo's thermometer	
1 ml of water tared on scale	
CU on "1 gram" with 1 ml of water	
Creve Couer park drag boat race	
Drag boats crossing camera	
Boats accelerating from start	
Boats waiting for race	
Revving engines	
Joel shots	

Joel turning on faucet to bathtub	
Joel playing with bath toys	
Joel standing on bathroom scale	
U.S.S North Carolina	
Wide shots of entire ship	
Close up of guns	
Close up of seaplane	
Pan up from water line	
Show concrete, steel, wood	
Graphics to create	
Project: Epiphany logo	
Fluid motion logo	
Archimedes movable character (head and torso)	
Archimedes movable character (lower jaw)	
Archimedes movable character (eyes)	
Archimedes movable character (eyebrows)	
Archimedes movable character (arms)	
Archimedes movable character (standing legs)	
Archimedes movable character (walking legs)	
King Hiero (head and body)	
King Hiero (lower jaw)	
Goldsmith (head and body)	
Goldsmith (lower jaw)	
Goldsmith close up (head)	
Goldsmith close up (eyes)	
Goldsmith close up (lower jaw)	
Archimedes servants	
Bathing Archimedes	
Bathing Archimedes with strategic towel for running down streets of Syracuse	
Graphic of crown	
Graphic of gold chunk	
Throne room background	
Archimedes' workshop background	
Gold vault background	
Bathhouse background	

Streets of Syracuse background	
Greek introduction background	
Volcano island background	
Raft with floating goldsmith	
Pumice with Archimedes	
Archimedes uses the "force" background	
Three rocks to rotate	
Seaplane	
USS North Carolina side	
USS North Carolina front view	
Venice Archimedes in gondola	
Goldsmith in gondola	
Venice background	
Chair graphic	
Hippo mask cutout	
Balloon mask cutout	
USS North Carolina waterline mask	
Fish cutout mask	
Joel "inflated" to segue into hot air balloons	

Releases /Letters

Along with planning scripts and graphics, it is essential to clear the rights to use the voice or images of experts or other talent. The following is the release form used for all participants of Project: Epiphany and are held on file for archive purposes.

Request for Release

I allow my image and voice to be used in the production for the Masters Degree of Jason Hughes entitled *Fluid Motion*. This is to certify that the recorded audio and images will only be used in the projects of Jason Hughes for the purposes of producing educational videos.

_____

_____

Jason W. Hughes – producer talent

I wrote another release specifically for the use of my 6th grade students. Due to the fact that they are minors they require parental permission as well.

Dear Parents,

I am currently working on my masters in media production at Lindenwood University. My goal is to produce a professional-quality educational video on the topic of buoyancy. Entitled *Fluid Motion*, my project will show why an object will sink or float due to the laws of physics. I have chosen this practical but challenging thesis project in order to hone my producing and teaching skills while providing my students with a fun opportunity to learn something new.

In order to make this project a reality I am wanting to videotape students in class doing activities and labs that apply to the topic. I ask your permission to videotape your student during the 2005-2006 school year and to use the sound and images in my masters project.

Thank you for your help.

Jason Hughes – science faculty FHMS
Jason_hughes@fhsd.k12.mo.us

Request for Release

I allow my child's image and voice to be used in the production for the Masters Degree of Jason Hughes entitled *Fluid Motion*. I understand that the recorded audio and images will only be used in the projects of Jason Hughes for the purposes of producing educational videos.

_____

_____

Jason W. Hughes – producer student

_____

parent or guardian

It is also required to get permissions for any work not my own that will be used in Project: Epiphany. The following letters are my attempts to gain release for several video and graphic clips.

In my discussion of hot air balloons I had intended to use the rectangular "US flag balloon", owned and operated by Teri and Barry DiLibero. After several phone and email contacts I believed they would be willing to allow the use of images for their balloon. The rectangular shape would have been very easy to calculate the volume of and work graphics with.

Dear Teri and Barry DiLibero,

Thank you for the use of your pictures. At present I am making the video solely for my masters in media production and for use in my classroom when I get to Archimedes' Principle of buoyancy. I am looking for pictures and video of America One taking off, in flight, landing, and during a balloon glow.

Eventually, I would like to try selling my project to other schools as a way to help pay off my education and video equipment. As this is my first project, I have never asked for any material outside

of what I had shot. If there is a fee that you would require to release some video and pictures to me please let me know. I completely understand and respect your material and would not any of it without your permission.

Below is a list of pictures from your site that I would love to use.

On Page 2002archive/LewistonAuburnfrisat.htm

The 2nd and 4th pictures on the left column under the heading "Saturday Morning-Beautiful photos courtesy of Maine State Senate Candidate Bob Stone "

On Page 2002archive/SpiedieFestFridayNight.htm

The balloon glow right above the caption "Photos of this balloon while glowing just don't work. So, if you want to see this one glow, you have to come out and see it in person."

On Page 2002archive/SpiedieFestSaturdayMorning.htm

You have shot a few pictures of a landing sequence that would be great to use if video is not available.

Thank you for any help you can provide.

Jason Hughes

Jason_hughes@fhsd.k12.mo.us

Unfortunately they became too busy and did not send the images requested. I was forced to choose another more generic looking balloon.

During the discussion of displacement I wanted video field trip that would be energetic and memorable. I had seen in recent years a company that tested the safety of turkey fryers. During a web search I found the company to be Underwriter Laboratories outside of Chicago. They had recorded several demonstrations of turkey fryer accidents and reported them on national morning news. The

following is a summary of the project at the request to Underwriter Laboratories for the release to use the footage. If they denied, I was prepared to have the local fire department help me to reenact the same demonstration.

fluid motion

A floatation exploration

Purpose:

As an educator of scientific principles I often use videos to help students visualize the concepts I am teaching. The vast majority of the movies in our school library leave the class (myself included) wanting to take a nap. The information conveyed is usually fine but boring narration, elevator music and an overall lack of enthusiasm are the main problems I see in passing the knowledge on to the viewer. After watching a typical video I asked my students to give me two columns of notes. One column was to share what they thought was good about the presentation and the other would tell me what needed work. The results were not surprising. My students commented on the lack of enthusiasm in the voice of the narrator and the need for well placed music and humor.

Though educational videos are not to be played in schools for entertainment purposes alone, that does not mean that learning has to be sterile and monotone. Humor and upbeat music intertwined with accurate science I believe will help students remember the information presented. I am therefore taking it upon myself to make an instructional video that is worthy of watching. Kids need understandable information in a fun format. It must be memorable for the video to have any lasting impact on their knowledge.

"**Fluid motion**" will be an energetic look at what happens when fluids (gases and liquids) are put in motion. This exploration will look into Archimedes' principles of displacement, density(specific gravity) and buoyancy. I plan to use demonstrations, field trips, interviews with experts and graphics as the meat of the production along with side quizzes that help with critical thinking. I will also incorporate short segments entitled "**Listen to your con-*Science*™**" that will promote

general safety using scientific principles. A turkey fryer becomes very dangerous when someone does not understand Archimedes' principle of displacement. A life jacket put on improperly will make Archimedes' principle of buoyancy work against you instead of help to keep your head above water.

Specifically to Underwriters Laboratories Inc.

I am a science teacher working on my Masters degree in media production at Lindenwood University in St. Charles, MO. I have finished my coursework and am now producing a half hour educational video for my thesis project.

I had seen the demonstration of a turkey fryer engulfed in flame a year or so ago on the news and planned to incorporate it in my discussion of Archimedes' principles. My original goal was to contact our local fire department to help me in the reenactment of the turkey fryer demonstration. As I was researching on the internet for recipes and equipment, I found your company site and the demonstration already produced. Before I went to the effort of producing it myself, I wanted to ask you for an official release of the turkey fryer demonstration for use in the video described above. I believe it will show students that seemingly harmless things can turn disastrous when basic scientific principles are not applied to real life.

I was going to try to sell "Fluid Motion" to schools when it was completed as a way of paying back my Masters and producing other similar videos. I would be very grateful to Underwriters Laboratories if I could use the footage already produced. If not, I would appreciate any insight you might have into helping our fire department perform the feat safely.

Thank you,

Jason Hughes
Project: Epiphany
636-978-2479 home
314-581-9638 cell

Underwriter Laboratories not only granted permission to use their footage, they also sent me a DVD of the raw footage for me to edit as I wished. This was a very pleasant surprise.

Preparing for interviews was essential as well. Knowing the direction of the conversation before it takes place allows it to flow with a more natural progression of questioning. It also keeps the hectic nature of a production setup from making chaos out of the interview itself.

The following is an email correspondence with my good friend Dr. Eric Haupfear on the discussions we were preparing to record.

Good Morning Eric,

Let me give you some background into my project. My video, called Fluid Motion, investigates how and why objects will float or sink. Archimedes principles of buoyancy and displacement will be the focus but in order to discuss how matter behaves, we will need to establish just what matter is. I will be looking at the density of objects as the heat energy increases and decreases. This project has a target age of middle to early high school and will likely be the first time most viewers will be exposed to particle ideas. I would like to use the billiard ball metaphor and the idea that particles have a wobble to them. I plan to get a shot of a giant bulls eye with kids in the very center representing a liquid. Finally the kids will become "gases" and spread out into the entire circle. I would love to have an explanation of expanding and contracting matter from you to place over the top of that. I also have shots of the expansion joints on the Page extension bridge in winter and again on the hottest day of summer so far. These ideas will aid in understanding matter and density and how it directly relates to the air in a hot air balloon taking up more space than the cooler air that has been displaced. These are some questions that would sound much better coming from Dr. Haupfear than little ol' me. I will be narration most of the production myself so having another voice to use will be helpful as well.

1) what is matter?
2) If we could look at matter under a very powerful microscope what do we think we would see particles doing?

3) If we added heat energy to some matter like water or air, what can we predict would happen?
4) What would occur if energy was removed from these fluids?
5) Archimedes was the first to identify the concept of density. What is density and why do different elements have unique densities?
6) Why do substances of lower densities float on top of substances that have larger densities?
7) Archimedes talked about the idea of displacement. What happens to particles of water when an object is placed in it?
8) There are so many different shapes to hot air balloons. How do bunny, flag, and space shuttle balloons inflate and take their shapes?

Thank you Eric for helping me out. I know you love the ideas of science and appreciate your willingness to help me share it with students. Would you be available after church to do some shooting?

Jason

The following is a list of questions created for use with Jim Lovins at the St. Louis Zoo concerning the nature of fish and swim bladders.

Questions for Jim Lovins- Aquatic Director at the St. Louis Zoo

This is for middle school and early high school

1. For the record, what is your name and title?

2. How long have you been working with fish?

3. What is it about fish that fascinate you most?

4. Do you have a favorite species of fish?...Why?

5. We've been learning how things less dense than water float and

those more dense than water will sink. How do fish swim up and down in the water so easily?

6. How does having a swim bladder help the fish?

7. Do fish have the ability to change the amount of air in their swim bladders?

8. What kind of things can go wrong with a swim bladder?

9. Are there fish that don't have swim bladders?

10. How do these fish stay buoyant?

11. The turtles in the tank seem to be working harder at swimming deeper, what is the reason.

12. Brackish fish swim in both salt an fresh water. How does this effect the fish's ability to swim?

During one of the many cartoons in the production, I had planned a sequence where the goldsmith floats on a raft near an island. Instead of designing the raft graphic I went in search of one already made. Naturally I asked permission for the use of the graphic.

Dear Mr. Ellison,

I am a masters student at Lindenwood University in St. Louis Missouri. I am currently working on my thesis project in video production. I have chosen an educational video on the topic of why things float. I was searching the web for pieces that I could use in a short cartoon segment I had planned and "Googled" your raft. I found it to be exactly what I was needing for about 20 seconds of cartoon. I have nothing to offer except mention in the end credits but If you would agree to letting me remove the water so I could place your raft in video of the ocean I would be very grateful.

Please let me know soon so I can make a much more inferior raft if you decline.

Thank you.

Jason Hughes
Jason_hughes@fhsd.k12.mo.us

The request was granted as the raft was placed in the short cartoon. The vast majority of images found in the cartoons were found on the web but manipulated beyond recognition in Macromedia Fireworks.

Production Budget

Project: Epiphany
Budget

Items purchased	Qty	Cost each	Subtotal		Total
16" balloons	4	$1.06	$4.24		**$958.33**
Poster board	5	$0.59	$2.95		
measuring glass	1	$1.06	$1.06		
pumice	2	$5.00	$10.00		
Narra wood piece	1	$8.95	$8.95		
Narra wood piece	1	$5.50	$5.50		
ironwood pieces	1	$5.50	$5.50		
ironwood stump	1	$11.24	$11.24		
Mini Dv tapes (set of 3)	2	$14.99	$29.98		
microphone	1	$49.99	$49.99		
microphone stand	1	$19.99	$19.99		
U.S.S. North Carolina passes	2	$12.00	$24.00		
plane ticket to Raleigh, NC	1	$250.00	$250.00	*	
Hotel near battleship	1	$80.00	$80.00	*	
toy sub	1	$9.99	$9.99		
toy surfer	1	$4.99	$4.99		
rain stick	1	$9.99	$9.99		
toy fish	1	$6.99	$6.99		
toy turtle	1	$6.99	$6.99		
glass containers	2	$7.99	$15.98		
used digital video camera	1	$400.00	$400.00		
Diet Pepsi for Dr. Haupfear ☺	1	$0.50	$0.50		

Much of the production cost is equipment. Interesting trips would be expensive and likely not possible unless I was already intending to travel. Therefore research of the places I do travel to in the future will allow side trips for video work.

Production

With a completed script and budget in place, the correct equipment would need to be assembled for the project. First and foremost a high quality camera would need to be acquired. Through connections a Calvary Church in St. Charles, I was able to borrow a Panasonic AG-DVX100 digital video camera. The footage shot on this digital equipment has the look of being recorded on film. This is due ot the difference in frames per second captured by the lens. A video camera classicly shoots at 30 frames per second whereas a film camera records 24 frames per second. Along with a high quality lens, this camera was a priviledge to use as it added a professional look to my low budget project.

Knowing that I would have many underwater shots to complete, a large aquarium was filled and the water was dyed blue for effect. Knowing that the aquarium glass would act like a mirror and see the reflection of the camera more than the objects in the water, the aquarium was set up outside for night shoots. In this way, I was able to shine several lights on top of the water lighting up the inside. With the only light coming from inside the aquarium I was able to avoid the mirror effect of the glass.

Several summer nights were spent setting up a shot in the viewfinder, hitting record, and dropping toys into the water. Toy fish, submarines, bobbers, rubber ducks and many types of wood, boats and pool toys were dropped over and over until the toys did what I was looking for. Special care was taken to dry off the sides of the aquarium as well as the toys between takes to make the set look brand

new each time. It was also very important to be completely dry before touching the camera or other electronics for obvious electrocution hazards as well as equipment damage.

An interview with Dr. Eric Haupfear, a chemical engineer, proved an invaluable resource in helping to flesh out the physics. It was important that this take place very soon in the shooting process due to the fact that much of the script would be interwoven with sound bytes from the discussion. It would be a waste of time to produce a section of video only to have an expert explain the same thing only better and in less time. I have had numerous scientific discussions with Dr. Haupfear and found his perspective to be informative, but sometimes well above the target audience of middle to high school students.

Setup for the interview required changing around plants and tables in the chapel at Calvary Mid Rivers church. The only lights were those in the room as portable lighting was unavailable. A microphone held in a stand was inserted via XLR cable to the 1/8 inch jack leading to the camera. The camera was set to its slowest speed to keep from having to change tape midway through the conversation. The majority of the discussion was recorded with short pauses for breaks and additional research in textbooks.

Within the two hours of discussions that were recorded, there were many student friendly sound bytes hidden amongst the jargon of a veteran scientist. Questions would often be reworded in order to simplify the words used to explain the answers.

Overall the discussion would shape the script in many ways I would not have thought of on my own. For example, Dr. Haupfear

reiterated to me the importance of understanding that Archimedes' principle, though true, is a byproduct of the forces of water and air pressure. I had to decide at that point if the true nature of every concept I was to present would be too advanced to complete in the 30-40 minute range. It became evident that there was a tremendous amount of foundational science needed to fully comprehend floatation. Coming away from this interview, I started to develop the ladder-like structure necessary to wade through difficult concepts that build on each other.

Numerous small demonstrations were set up on the pool table in my basement. Grabbing as many halogen and reading lamps in the house, I set up a makeshift studio for vegetable oil density columns, ice and alcohol demonstrations, as well as multiple instances of massing objects on an electronic balance. This area turned into the place for hours of trial and error with toys in small aquariums and demonstrations with poster board backgrounds to hide the reality of the basement. This aspect of the production work was fairly easy after it was all set up. I was left with an impression of how easy it would be to produce the *Baby Einstein* videos put out by Disney. These are just half hour videos of close ups on baby toys under lights with classical music beneath it. The lesson to learn is that simpler is often better and therefore lucrative.

Another large portion of the production was the creation of graphics. This time consuming process requires fluency with a picture manipulation program like Fireworks or Photoshop. In these programs pictures are changed in color, shading, given 3-D effects, and often changed beyond recognition in their original state. It is also

in these programs where graphics are generated from scratch. Arrows, lines, shapes, and background scenery can be constructed from the digital tools available. One need only think of the graphic and it can be created with time and patience.

A challenge to graphic production is knowing what format digital media must be in to be accepted by each program necessary for entry into the video. For example, if a graphic is generated in Fireworks it may have multiple layers that make up the entire image. If the image were to be saved to the hard drive it must be determined if the layers should remain intact or flattened. If they are flattened down they cannot be manipulated as layers anymore. Therefore, multiple copies and an excellent, logical naming system are required for keeping track of files.

Post-Production

After all of the planning, writing, and shooting there is a video to edit together as one seamless production. This by far is where the majority of the production time lies. Hundreds of hours, sitting at a computer clicking, dragging, importing, scrubbing, key framing and rendering. As tedious as it may seem, this is where the "magic" happens. Being able to assemble tens of hours of footage in a 30-40 minute production first and foremost requires time. The footage must be overviewed and logged for sequences that need to be captured onto the hard drive. It is important to have some idea of how the images are to be used at this point simply because hard drive space is a limited commodity. Capturing too much footage only makes the editor wade through the footage twice. Set a precise "in" and "out" point whenever possible and ignore the rest.

Audio is usable as well as a separate entity. The raw footage can be captured as video and audio or as just an audio file for use in the soundtrack. If the images are meaningless because something else will be on screen it will save precious hard drive space to capture an audio file only and not the images associated with it. Narration was captured live in this way through the microphone of the digital camera. Instead of capturing the image of the wall for 40 minutes as I spoke the script, the video was turned off as only the audio was important.

A precise filing system is required here as well. Hundreds of clips captured into memory would be meaningless if they could not be found. Thankfully the Pinnacle Liquid Edition editing software

facilitates this necessary evil very well. Showing the first frame selected by each clip, the program allows the editor to choose video by sight and not by file name. Clips are dragged and dropped into precise spots, to the 1/30 of a second, layering music, narration, video, titles and effects until the computer renders the production desired.

Capturing the attention of the MTV audience means quick and frequent edits. Unfortunately that means it takes more time to move forward in the production. Aggressive editing techniques like moving pictures and titles are almost required to keep the attention of students today. Key frames are the placed whenever the editor desires a change in the appearance of the video or titles. If a title was to fly across the screen in one second, hold position in the middle for three seconds before fading away for one second, two additional key frames would need to be created. The beginning and end are automatic key frames. At the beginning, the editor would position the title off the screen in the desired starting location. One second later a new key frame would be created. There the title should be in its hold position. Three seconds from that point another key frame will tell the computer to begin fading the title at its current position. Lastly, the end point will describe the title fully faded away. After a quick rendering session, the computer should produce a title that performs just as the editor requested.

Unfortunately, computers are fallible creations of man and do not always do as they are seemingly told. Often, program glitches must be analyzed and creatively worked around in order to achieve the desired effect. Too often time seems wasted on computer issues when creativity beckons the editor to try something new. Familiarity

with the program will lessen the time it takes to predict or circumvent possible glitches. A good example for Pinnacle Liquid Edition on my machine is the number of layers that can be successfully rendered to make the desired sequence. Digitized mistakes usually occur while rendering seven to eight layers at a time. Only late in the editing process did I learn a way around this problem. In hindsight had I learned it early I would have saved hours of rendering time. More than any research paper, experience with production is the only way to improve.

Because of its length, this project was completed in small sequences and brought together as one sequence at the end. A problem with this technique is leveling the volumes across the many short sequences so the audience does not have to "ride the volume knob" up and down to find an audible and comfortable level.

Producing a final copy of the production can pose problems as well. In a long and complex sequence such as this computers may display a memory lapse during playback. This shows as a blackout or digitized glitches on the screen. To solve this issue, I had to export the video sequence via firewire cord to ensure the quickest possible connection to the recording devices.

Analysis of test audience:

Project: Epiphany was designed and created to help students learn the physics of floating. Its intended audience being middle to high school students, it should introduce or reinforce many fundamental concepts in science. Being a science video it is only appropriate that its effectiveness be analyzed as scientifically as possible. A series of ten multiple choice questions was written to judge understanding of the core concepts presented in the video. These questions were given to 6^{th} grade students at Francis Howell Middle School as a pre-test before watching the presentation. Immediately following the video the students were administered the same ten questions to check for improvement in score. The following data was analyzed from the answers sheets of these two tests.

Project: Epiphany Pre-test

Before you watch the movie, let's figure out what you know and don't know.
Use the scantron sheet to answer the following 10 questions.
Fill in the circles with a #2 pencil next to the best answer.

1) What is weight?
   a. the amount of matter in something
   b. the force of gravity on a planet
   c. the amount of gravity between two objects
   d. another word for mass

2) A fluid is...
   a. Water only
   b. a liquid or gas
   c. air
   d. solids, liquids, and gases

3) Displacement can be best described by saying...
   a. "No two things can be in the same place at the same time"
   b. "Gravity pulls everything downward"
   c. "Matter can be found in solids, liquids, and gases"
   d. "balanced forces do not move"

4) Density is a measure of which two things?
   a. Mass and volume
   b. Mass and weight
   c. Volume and weight
   d. Force and distance

5) A buoyant force is present only when something is in water?
   a. True
   b. False

6) If a boat weighs 10 pounds, what force would be required to keep it floating at the surface of the water?
   a. No force is needed, boats float by themselves
   b. Less than 10 pounds of force is needed

c. 10 pounds exactly would float the boat
d. More than 10 pounds of force is needed

7) If a turkey fryer can hold 8 Liters of oil and is filled to 7 Liters, what will happen if a 2 Liter turkey is added to the oil?

a. 2 Liters of oil will spill out
b. 1 Liter of oil will spill out
c. There will be 10 Liters of oil
d. There will still be 1 Liter of space left in the fryer

8) If a soccer ball is kicked into a lake and floats, which would be true?

a. The density of the soccer ball is greater than water
b. The density of the soccer ball is less than water
c. The density of the soccer ball is equal to water
d. Density has nothing to do with soccer balls

9) In order to float, a 4000 pound seaplane must…

a. displace water
b. displace more than 4000 pounds of water
c. displace less than 4000 pounds of water
d. displace 4000 pounds of water

10) If a dry brick weighs 10 Newtons and underwater it weighs 6 Newtons, what is the buoyant force on the brick?

a. 4 Newtons
b. 16 Newtons
c. 60 Newtons
d. There isn't a buoyant force because the brick sinks

Project: Epiphany Post-test

After you watch the movie, let's figure out what you know and don't know.
Use the scantron sheet to answer the following 10 questions.
Fill in the circles with a #2 pencil next to the best answer.

11) What is weight?

a. the amount of matter in something
b. the force of gravity on a planet
c. the amount of gravity between two objects
d. another word for mass

12) A fluid is…

a. Water only
b. a liquid or gas
c. air
d. solids, liquids, and gases

13) Displacement can be best described by saying…

a. "No two things can be in the same place at the same time"
b. "Gravity pulls everything downward"
c. "Matter can be found in solids, liquids, and gases"
d. "balanced forces do not move"

14) Density is a measure of which two things?

a. Mass and volume
b. Mass and weight
c. Volume and weight
d. Force and distance

15) A buoyant force is present only when something is in water?

a. True
b. False

16) If a boat weighs 10 pounds, what force would be required to keep it floating at the surface of the water?

a. No force is needed, boats float by themselves

b. Less than 10 pounds of force is needed
c. 10 pounds exactly would float the boat
d. More than 10 pounds of force is needed

17) **If a turkey fryer can hold 8 Liters of oil and is filled to 7 Liters, what will happen if a 2 Liter turkey is added to the oil?**

a. 2 Liters of oil will spill out
b. 1 Liter of oil will spill out
c. There will be 10 Liters of oil
d. There will still be 1 Liter of space left in the fryer

18) **If a soccer ball is kicked into a lake and floats, which would be true?**

a. The density of the soccer ball is greater than water
b. The density of the soccer ball is less than water
c. The density of the soccer ball is equal to water
d. Density has nothing to do with soccer balls

19) **In order to float, a 4000 pound seaplane must...**

a. displace water
b. displace more than 4000 pounds of water
c. displace less than 4000 pounds of water
d. displace 4000 pounds of water

20) **If a dry brick weighs 10 Newtons and underwater it weighs 6 Newtons, what is the buoyant force on the brick?**

a. 4 Newtons
b. 16 Newtons
c. 60 Newtons
d. There isn't a buoyant force because the brick sinks

t #	#1 pre	#11 post	Δ	#2 pre	#12 post	Δ	#3 pre	#13 post	Δ	#4 pre	#14 post	Δ	#5 pre	#15 post	Δ	#6 pre	#16 post	Δ	#7 pre	#17 post	Δ	#8 pre	#18 post	Δ	#9 pre	#19 post	Δ	#10 pre	#20 post	Δ	% pre	%post	% Δ
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	0	0	**0**	0	0	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	0	0	**0**	40	50	10
	0	0	**0**	1	1	**1**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**1**	20	60	40
	0	1	**1**	0	1	**1**	0	1	**1**	1	1	**0**	1	1	**0**	1	0	**-1**	1	0	**0**	1	1	**0**	0	1	**1**	0	0	**1**	70	90	20
	0	1	**1**	1	1	**0**	1	1	**0**	1	1	**1**	1	1	**0**	0	0	**0**	1	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	30	60	30
	0	0	**0**	1	1	**0**	0	0	**0**	0	1	**0**	1	1	**0**	0	0	**0**	1	0	**-1**	1	1	**0**	0	0	**0**	0	0	**0**	50	60	10
	0	0	**0**	1	1	**0**	0	1	**1**	0	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	80	60	-20
	0	0	**0**	1	1	**0**	0	1	**1**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	1	**1**	0	0	**0**	50	60	10
	0	1	**1**	0	0	**0**	1	1	**1**	1	1	**0**	1	1	**1**	0	0	**0**	1	1	**0**	1	1	**0**	0	1	**1**	0	1	**1**	50	100	50
	0	1	**1**	0	1	**1**	0	1	**1**	1	1	**0**	0	1	**1**	0	0	**0**	1	1	**0**	1	0	**-1**	0	1	**1**	0	1	**1**	40	80	40
	0	0	**0**	1	1	**0**	0	1	**1**	0	1	**1**	0	0	**1**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	0	1	**1**	30	70	40
	0	1	**1**	0	0	**0**	1	0	**-1**	1	1	**0**	1	0	**-1**	0	0	**0**	1	0	**1**	1	1	**0**	0	0	**0**	0	0	**0**	40	60	20
	0	1	**1**	0	1	**1**	0	1	**1**	1	1	**0**	1	0	**-1**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	0	0	**0**	30	50	20
0	0	0	**0**	1	1	**0**	1	0	**-1**	0	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	60	70	0
1	0	0	**0**	1	1	**0**	1	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	1	**1**	0	0	**0**	50	70	20
2	0	1	**1**	0	1	**1**	0	1	**1**	0	1	**0**	0	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	40	80	40
3	0	0	**0**	1	1	**0**	0	1	**1**	1	1	**0**	0	1	**1**	0	0	**0**	1	1	**0**	1	1	**0**	0	1	**1**	1	1	**0**	40	70	30
4	0	1	**1**	0	1	**1**	0	1	**1**	0	1	**0**	1	0	**-1**	1	0	**0**	1	1	**0**	0	0	**0**	1	1	**0**	0	0	**0**	50	70	20
5	0	1	**1**	0	1	**1**	0	1	**1**	0	1	**0**	0	1	**0**	0	0	**0**	1	1	**0**	0	0	**0**	0	1	**1**	1	1	**0**	30	70	40
6	0	1	**1**	0	1	**1**	0	1	**1**	0	1	**0**	1	1	**0**	0	0	**0**	1	0	**0**	1	1	**0**	0	1	**1**	0	0	**0**	40	80	40
7	1	0	**-1**	1	1	**0**	1	0	**-1**	1	1	**0**	1	1	**0**	0	0	**0**	1	0	**1**	0	1	**1**	0	0	**0**	1	1	**0**	50	60	10
8	0	1	**1**	0	1	**1**	0	0	**0**	1	1	**0**	0	1	**1**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**0**	1	0	**-1**	40	60	20
9	0	0	**0**	1	1	**0**	0	1	**1**	0	1	**0**	0	1	**0**	0	0	**0**	1	1	**0**	1	1	**0**	0	0	**-1**	0	0	**0**	40	40	0
0	0	0	**0**	1	1	**0**	0	1	**1**	1	1	**0**	0	1	**1**	0	0	**0**	1	1	**1**	1	1	**0**	0	1	**1**	1	1	**0**	40	80	40
1	0	1	**1**	1	1	**0**	0	1	**1**	1	1	**0**	0	0	**0**	0	0	**0**	1	1	**0**	0	0	**0**	0	0	**0**	1	1	**0**	50	70	20
2	1	0	**-1**	0	1	**1**	0	1	**1**	0	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	0	0	**0**	0	0	**0**	1	1	**0**	80	50	50
3	0	0	**0**	1	1	**0**	1	0	**-1**	1	1	**0**	1	1	**0**	0	0	**0**	1	1	**0**	0	0	**0**	0	0	**0**	1	0	**-1**	50	50	0
4	0	0	**0**	0	1	**1**	0	1	**1**	1	1	**0**	0	1	**1**	0	0	**0**	1	1	**1**	0	0	**0**	0	0	**0**	1	1	**0**	50	70	20
	8	**30**		**88**	**99**		**45**	**74**		**91**	**99**		**62**	**65**		**29**	**56**		**87**	**83**		**77**	**66**		**24**	**43**		**58**	**64**				**9.82**

Analysis of the data suggests that Project: Epiphany was effective in raising the average score of 6th grade students by almost 10%. Though improvement was observed, the data also suggests that the typical 6th grade student was not fully understanding the concept. This is due to several instances of scores getting worse on the post test. Reasons for this are believed to be 1) guessing 2) the movie was shown on a Friday 3) the movie was outside of the curriculum and so there was no grade motivation behind paying attention. Overall their comments were encouraging in that my goal was to stimulate correct scientific learning and many stated they had learned something new. Several months after the viewing I have still had students quote and use the information they saw in Project: Epiphany.

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