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# Using Digital Storytelling to Advance Scientific Comprehension and Retention in a Middle School Science Course

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***Abstract*: As computers, digital cameras, and video editing software tools become ubiquitous in schools across the United States, teachers expand their roles from educators to producers as they take on digital storytelling projects. Unfortunately, current teacher education and experience does little to prepare teachers for this new role. The job of a producer is not only to understand the subject matter of the video project, but to also know the technologies necessary to execute the vision and the pitfalls likely to be encountered along the way. In short, teachers are asked to teach not only their subject matter (e.g. science, math, history, and language arts), but to also help students navigate a technically complicated environment of digital movie making, as well as help them translate their story ideas into an audio-visual-temporal format. Inadequate preparation creates situations where some students who are able to get outside technical support create far superior movies then their classmates without such resources. And teachers and students often have unreasonable expectations as to the necessary time and effort these projects require, as well as the quality of the output. This paper explores the difficulties teachers face when they become producers of digital stories and why it's still worth it.**

***Keywords*: digital storytelling, science documentaries, digital movies, science education, problem solving, technological scaffolding**.

## I. Introduction

Digital tools are now ubiquitous in the United States, both at home and at school. Digital images and videos are cheaper to generate then the old tape and film-based systems. Most current classroom computers come with digital photo and video manipulation tools. In such environment, it is difficult to resist the temptation of integrating digital storytelling projects into the curriculum. And why not? On the first look, students are excited by the prospect of making movies—it seems much more fun then writing term papers. But closer inspection brings up problems. This paper focuses on the pitfalls teachers, students, and parents face when the digital storytelling enters the classroom. As its inspiration, this paper draws on the student work of a San Francisco Public Middle School science class led by an excellent teacher, Mr. Kevin Gortney.

The role of a teacher supervising digital storytelling changes from tha a mot of a pedagogue to a movie producer. The job of a movie producer is very different from the job of a teacher. Expertise in a subject matter like physics and biology don't readily translate into the technical know-how of managingvie making project. Thus teachers come into such projects unprepared and often unassisted. Similarly with students, school children start out excited by the prospect of making a movie and often ended up frustrated by the technical and logistical challenges. In many cases it comes down to what's "doable"—given the limited resources of time, budget, and technology, what are the right expectations? What is reasonable? What can be accomplished? How can the teacher properly manage the inequalities between students' resources and background knowledge in digital storytelling projects? In order for students and teachers to be successful, what support structures are necessary?

## II. Science Teachers as Digital Movie Producers

To understand the role of a teacher leading the class through a digital storytelling project, it makes sense to examine the skills necessary to be an effective science documentary producer. By comparing the job of the teacher with that of a professional producer, the difficulties that teachers face when taking on digital storytelling in their classrooms can clearly be seen.

### A. *What Does a Science Documentary Producer Do*

When working on a project, a producer typically starts by investigating the idea for a science documentary (or a movie, or a television show). The producer needs to have deep knowledge about the subject matter of the documentary. Translating this understanding into a visual storytelling format is not an easy task.

The producer supervises the progress of the project from production to post production. There are three main stages of creating a science documentary: pre-production, production, and post-production. Pre-production involves idea development and the logistics of the project. Production work focuses on the capturing of video footage for the project. And post-production includes editing, graphics creation, and audio design, resulting in a finished science documentary [1].

Here is a list of the steps the producer needs to take at the beginning of each project:

1. Find the sources of information that can be consulted to

understand, research, and collect data on the subject of the documentary. Sift through the found material to select that which is relevant to the story. **Which materials are useful?**

2. Not all topics make good subjects for a science documentary: some topics are just too difficult to explain, some would take too long, some don't work for the intended audience. A good producer can pick just the right subset of information to include in the documentary. **Given the topic and research, what works?**
3. Determine the length of the documentary given the resources and the topic. **What is practical?**
4. Create an outline for the script. **What's the story?**
5. List all of the props and tools that will be necessary to shoot the documentary as it is conceived in the script outline. **What is needed?**
6. Check the feasibility of the project against the available resources. If the topic doesn't work for the time, materials, and people allocated to the project, start over (or narrow down the scope of the project). A good producer is continuously checking the "doability" of the project and adjusting it accordingly. **What is doable?**
7. Approve the final script for the documentary. **What will be made?**
8. Set up a shooting schedule based on a completed script. **What's the time line?**
9. Procure the equipment necessary for each day of the shoot. **What is needed when?**
10. Assign people to the various tasks need to be accomplished on each day. **Who is doing what?**
11. Create a master schedule, breaking down the overall job into the tasks to be accomplished on each day of the shoot. **What is done each day?**
12. Meet regularly with all members of the team and insure that everyone understands the goals of the project and their individual jobs. **What are the problems?**

Once the producer finishes the preliminary work outlined above, there's still the job of supervising the creation of the actual documentary footage. A good producer works hard to allow the rest of the team to do the jobs they need to do. The producer monitors progress, makes sure there's access to the necessary equipment, resolves conflicts on the set, monitors the safety of the crew, and generally does what it takes to make the project go smoothly. Once the shooting starts, the producer is constantly engaged in troubleshooting, resolving the day-to-day problems of filming and coordinating all of the activities [2]. In this respect, the job of a teacher is very similar to that of a producer.

The task of the producer doesn't end with the capturing of the video footage for the science documentary. Supervision of post production is a critical part of the producer's job. Individual bits of video are nothing in themselves without the editing that creates the final story. Today, the video composing work is done on the computer. The producer has to be at least familiar with technology (computers and applications) that his team will need to use to get the job done. For teachers, it is not enough to just know what can be used. Teachers are the local resident experts. They have to educate their students not only on the available options, but they also have to teach students how to use the computer system to do the necessary tasks to finish the digital storytelling projects.

Here is a partial list of tasks the producer has to oversee during the post production:

1. Supervise the creation of the master list of video footage shots. Without such a list, editing is very difficult. On most commercial projects, all of the footage gathered for the documentary also gets transcribed.
2. Finalize the list of special effects or computer effects that will need to be created. Make sure they get done on time for editing.
3. Check the transcription against the needs of the story and the script. Is everything covered? What additional narration have to be recorded? Get the voice talent, set up the recording facility, get the audio.
4. Find the music and secure the rights.
5. Find out what sound effects are needed for the project. Find them ready-made or get them recorded. Send them off to the sound editors.
6. Arrange the editing facilities and get all of the footage, music, sound tracks, and effects for the editing team. Meet with the editing team and make sure that everyone in one the same page.
7. Procure the equipment necessary for each day of post production.
8. Create a master schedule, breaking down the overall job into the tasks to be accomplished on each day of post-production.
9. Assign people to the various tasks need to be accomplished on each day.
10. Meet regularly with all members of the team and ensure that everyone understands the goals of the project and the individual jobs.

The producer deals with all the practical and political aspects of keeping a project running. Clearly, there are similarities between the jobs of a producer and that of a teacher. But while producers hire and work with professionals who know their jobs, teachers work with students who require instruction at each step of the way. Not only is a teacher required to teach the subject matter, she has to support the students in transforming that newly-learned information into a stand-alone video product. The job of a teachers is levels of magnitude harder than that of a producer.

There's one more important difference between professional producers of science documentaries and those of professional teachers supervising science documentary creation in their classrooms. A professional producer typically works on one documentary at a time. A teacher doesn't have it so easy. A typical California public middle school class has 30 students, many have more. To work on a digital documentary project, a class of this size is divided into a dozen or so groups, each working on its own, unique topic and documentary. Thus a teacher producer has to manage a dozen or so projects at the same time, allocating often scarce resources fairly, and providing one-on-one assistance when needed. That is a lot to ask. Students lacking advanced computer skills or outside help are put at a disadvantage at the start.

### B. *Technical Expertise vs. Subject Matter Expertise*

As is the case in many professions, there are several expertise necessary to achieve success with digital storytelling in a classroom. Teachers, we can assume, have deep knowledge of the subject matter they teach. Their students are in the process of acquiring subject matter knowledge. The degree of understanding and proficiency with a particular subject matter varies greatly from student to student. But it is not enough to know the subject matter [3]. There is a difference between subject matter expertise and technical expertise. Digital storytelling requires both. Understanding algebra or physical science doesn't translate into computer expertise or movie making skills automatically, just like knowledge of the subject matter doesn't automatically qualify an individual to teach it. It takes years of training to become a teacher, just as it takes years of training to be an effective movie maker and even more training to acquire the technical computer skills necessary for this job. Students engaged in digital storytelling not only have to know the subject matter well enough to make a movie about it, but they also need to have the digital skills necessary to create their projects.

The clear differences between teacher producers and movie producers have to do with the level of expertise of technical and logistical movie making know-how (and of course the film's budget). Teachers have to be instructed in the technical aspect of digital storytelling in order to be able to help their students maneuver through this very technical process. Most teachers don't have the necessary technical expertise to solve the problems that arise with software and hardware during the process of digital movie making. Additionally, different students in one class might use different equipment (as available), adding a level of complexity to the process.

In-class technical support might help overcome the above-mentioned problems. But technical support won't help teachers solve the logistical problems presented by the digital storytelling. Teachers have to be taught how to judge the "doability" of the project proposed by their students. Knowing what would fail and what would work and steering the student on the right path is critical to digital storytelling success in the classroom.

### *C. Parent Support*

It is worth analyzing the type of support parents can give their children working on the digital storytelling projects. Using the description of a producer's job as a foundation (just as was done for the teacher), we can see that parents can provide:

1. *material support:* provide money, computer and photo equipment, digital tapes and flashcards, software, props and costumes, a place to shoot and work;
2. *scheduling support:* guide students in the day-by-day and hour-by-hour breakdown of the tasks that they need to accomplish;
3. *brainstorming:* help children make decisions about their choice of movie topics given the available resources (time and materials) and discuss the "doabilty" of the project;
4. *subject matter help:* explain difficult to understand subject matter details;
5. *political support and conflict resolution:* guide and supervise as student groups work out their differences and negotiate solutions peacefully and fairly;
6. *technical assistance:* help with equipment and software;
7. *man-power support:* give an extra pair hands for holding microphones, setting up lights, clean-up assistance, etc.;
8. *transportation:* drive students and their equipment to and from events;
9. *security:* provide adult supervision, keep the equipment safe, and protect the children;
10. *emotional support:* tell the kids everything will work out all right in the end.

While many parents are actively engaged in their children's academic life, not everyone has the time and resources to do all the tasks listed above. For example, students coming from socioeconomically disadvantaged homes are less likely to get material support from their parents for their digital storytelling projects. They might not have access to digital cameras or computers at home or have antiquated hardware and software, making it incompatible with the school systems.

Unlike teachers, parents might not be very familiar with the topics covered in an $8^{th}$ grade science class (physical science). And thus they might not be able to support their children with picking the best topics for their science documentaries or help their children understand those topics better. Not many parents are subject matter experts on the topics of their children's digital stories.

Additionally, there can be a language barrier problem. English language learners are less likely to get brainstorming help and subject matter assistance at home. And parents of these students might find it difficult to provide conflict resolution help for groups of children coming from diverse cultural backgrounds. A language barrier makes such support very difficult.

There's also the technical assistance issue. Some students get lucky—their parents work in the high tech industry and are willing and able to provide the necessary technical support to their children. But those students are clearly in a minority.

And finally, there is parents' availability. Time is a scarce resource that a lot of families simply don't have. Most kids come from households where both parents work (sometimes, multiple jobs). There are other siblings that require attention. To be an effective support for their children, parents have to have a clear understanding of the amount of time and resource commitment asked of them.

### *D. Digital Storytelling: Variables of Success*

Taking a science topic, as an example, and turning it into a digital story is not an easy process. What does it take to create a successful student project? There are several variables to consider: **subject matter**; **technology**; **time** and available **resources**; and student **group** size and composition. A problem with any one of these variables could lead to a disappointing experience or simply to a wasted instructional time.

The choice of **subject matter** is critical to digital storytelling. Some subjects are just too difficult to translate into a movie, especially for students with limited subject matter knowledge. For example, black holes are fascinating and exciting to a middle school student, but what aspect of the black hole physics is "doable"? Sexuality is another subject of interest to this age group, but what's appropriate? A careful guidance by a teacher, steering the movie making group of students in an appropriate direction, can make all the difference. The educational scaffoldings to support the subject matter variable are: help with the choice of topic; assistance with narrowing the scope of work and topic; and script writing supervision and help.

As we all know, cutting edge **technology** is not found in an average public middle school science classroom. Teachers embarking on digital storytelling projects just have to do with what they have. The biggest problem is access to modern tools, which in many cases are more user-friendly then older technology. The other problem with technology is the disparate collection of hardware and software. Some students have access to expensive cameras and some don't—the difference will be apparent in the final movie produced by the students. Some students have computers and software at home that are not compatible with those in the classroom. The teacher serves as technical support for the entire class. This is a very difficult job. Technical problems can destroy student enthusiasm for digital storytelling or even stop the project from ever reaching the final completion. Thus technical support is critical to digital storytelling success.

The teacher always has to consider **time** and available **resources** for any student project. Digital storytelling is very time consuming. A typical project of a few minutes in duration usually takes months to create. A student can ended up spending as much as 40 hours of full-time work. Such dedication is great, but it does require planning. And planning and organization are not the strong suites of middle school children [4]. And, as mentioned above, students have very different resources and support available to them at home. Teachers have to try to level the access to resources in their classroom and to support those students that do not have the necessary tools or help at home.

The final variable discussed in this paper is the student **group** size and composition. Digital storytelling is a cooperative venture—different students take on different aspects of the job while sharing the group's overall goals [5]. Different students in the class have different expertise and different passions. It is important to put together groups that don't only share friendships but have the necessary expertise to finish a movie project between them. Writers, artists, camera operators, project managers, computer experts are all necessary and valued members of the team [6, 7]. But as class time is too short to work on a movie project, student groups have to continue their labors at home. Organizing a large group of students to be at one place and one time (other then the school) is very difficult. Thus the size of the group is as important as the members' expertise. And as these projects move from schools and into homes, parents take on the roles of producers as well. Different parents have different abilities and availabilities when it comes to helping their children and their friends through the digital storytelling projects. Student and parent support is necessary for success. In particular, it is critical to set parents' expectations as to the scope of work and the needed time and resources for digital storytelling projects [8].

### *E. Detail Analysis of Digital Storytelling Workflow*

Using the framework of pre-production, production, and post-production, a detailed analysis of student workflow for digital storytelling can be constructed. By superimposing the requirements placed on the teacher and parents of these students, we can see where educational scaffolding would yield the greatest benefit.

The chart below makes it easy to see where parents and teachers have the most influence on the quality of the student work. For example, pre-production work on the digital storytelling project is divided between classwork and homework—only some aspects of the work can be completed within the available classroom time and space. If parents are notified as to the goals of the digital storytelling project, they would be in a better position to help their children work through the problems they will encounter. With enough advanced warning, parents can also pull their resources together to help their children get (or buy) the necessary supplies and plan times for students to work together outside of school time. With many students involved in after-school activities, just setting up times when everyone can meet can be a challenge.

Most of the actual video capturing tends to be done outside of the classroom time. This makes sense: having twelve or so teams run around in a tight room, acting and trying to get audio, is just not practical. Thus parents become digital producers as their children bring their projects home. For each student group, one set of parents ends-up being the host family for digital storytelling project. The better informed are the parents, the easier is the whole process. Teachers have to set expectations for both students and parents as to the amount of work involved.

Students continue doing research for their projects at home, even as they shoot the video. For example, many students use bits of video they grab from YouTube to create "mash-ups"—editing together student-created video with that shot by other people. "Mash-ups" are reasonable solutions to many digital storytelling problems. Most students are not able to do special effects, or go to far away places, or capture rare events on video. So they use video footage from movies and other science documentaries to augment their work. Clearly such video research is easier done at home. And if parents know the parameters of their children's projects, then they can better supervise such research (and keep their children from viewing questionable and undesired content, freely available on the Internet). Capturing video from YouTube and converting it into a format that students can use is also technically challenging. Some students can do it, some can't. Some parents can help, some can't. Setting up student groups with equal access to technical support at home is critical to the success of many student digital storytelling projects.

Post-production is different. Having acquired all of the different elements for their projects, students now have to put it together into a coherent story. Once this work starts, it is difficult to relocate—computer systems and applications tend to be incompatible between schools and homes. It is just too difficult to move back and forth. So once a group of students starts their post-production work, they are committed to a location. This of course can cause some logistical problems. Those students that want to use their home computers will end up with nothing to do during the times set aside for post-production at school. This could be disruptive for the rest of the class.

The students who choose to do post-production at home also don't get the help of the teacher during this portion of the project. Post-production requires students to do a lot of synthesis of their ideas. That is hard, especially for students who are just learning the material they are making their movies about. And even the most competent science documentary script gets altered based on the actual footage the team manages to get. So the story goes through a reconceptualization process during the post-production work.

Students who chose to work from home also face technical challenges. Who provides technical support while they work at home? Who knows the equipment and software well-enough to deal with frequent problems these students stumble on during post-production? There's also the need to bring the final, finished project to school in a format that can be viewed by the teacher. This could also be hard. Digital movies end-up being huge and require compression to fit onto DVDs or flash-memory sticks. Students and their parents need detailed instructions on how to overcome such difficulties.

And as with pre-production, post-production requires group work. If students work from home, then they have to find times that work of each member of the group and the parents who supervise the project at home. Again, middle school children are cognitively ill equipped to deal with scheduling, especially complex scheduling required for movie making [4]. So again, parents have step in to smooth the way.

Much of the above discussion focused on the challenges of running digital storytelling projects as part of a science curriculum. Most of these challenges can be addressed with planning, preparation, and appropriate support for teachers, parents, and students. The next section proposes a few scaffoldings.

### *F. Proposed Scaffolding for Digital Storytelling Projects*

Based on the problems discussed above, here's a proposed set of educational scaffolds that can help teachers, students, and their parents during the digital storytelling projects.

**Table 1. Framework for Producing Digital Movies**

| Pre-Production | Production | Post-Production |
|---|---|---|
| • analyze the assignment<br>• come up with ideas for a digital story<br>• choose one idea that would work<br>• research<br>• write a script and have it approved<br>• create a master work schedule<br>• create the necessary props, costumes, sets, etc.<br>• find existing video clips to reuse in their digital stories (e.g.: students can use some video clips from YouTube or other sources) | • filming<br>• acting<br>• capturing voice-over audio<br>• special effects work | • importing all video and audio into a movie-making application<br>• editing<br>• audio work<br>• computer-generated special effects<br>• titling<br>• DVD creation (this includes exporting the final video and compression)<br>• uploading the final video to a public location (e.g.: YouTube, school site, etc.) |
| Clearly, some of this work has to be done at school. But a large portion of the workload requires time outside of the classroom. Students labor during their lunch hours, after school, and at home to complete the pre-production work. | Most of the work capturing the video tends to be done at home or on location (e.g.: museum, park, etc.). | Depending on the amount of support students can count on at home, most of the post-production work has to get done at school. Shuttling the work back and forth simply doesn't work—the computer systems and software are rarely compatible between home and school. |

*1) Set expectations.*

Start the project with showing sample student projects. Students have to understand what they are expected to create as a finished product. Some students suffer from aiming too high—they base their ideas on high-budget movies with many special effects and great acting. Some students are just the opposite and experience a paucity of ideation. Both ends of the spectrum, and everyone in between, benefit from watching how well other students measured up to the challenges of their digital storytelling projects.

*2) Create timelines and schedules.*

Time management and the scheduling of group work times are notoriously hard for students [4, 3]. But these skills are essential to smooth production flow in the digital storytelling projects. Creating handouts that can serve as backbones of organization can solve a lot of problems early on in the project. Such tools can also help with setting expectations: how much time do we need to get this done?

*3) Organize small student groups according to abilities.*

As mentioned above, not all students have the necessary skills and resources to engage in the digital storytelling projects. A teacher can organize the work groups by pairing students with previous experience with novices, and by insuring that each group has help at home [5 , 9].

*4) Provide technical specifications and instructions.*

Each student group needs access to a clear set of instructions on which it can rely while using complex technological tools (e.g.: cameras, lights, microphones, computer software and hardware). While this scaffolding seems obvious, it is by no means readily available in the classroom. Students don't have access to technical support incase their hardware malfunctions. Most applications have a very broad set of functions—great for experts, but less useful for novices. A simplified set of numbered steps can save a lot of time for both teachers and students [3]. For example, a simple "how to import your video" handout allows the whole class to work, and leaves the teacher to deal with difficult technical cases.

*5) Give out script page stylesheets.*

Script writing is not a simple task and film schools typically devote semester-length courses to this topic. That is clearly not the goal of a science class. Again, a simple handout that shows how to format ideas into a script can help students avoid the most obvious pitfalls of movie making. A short lecture can explain how the script is used during the digital storytelling project. The teacher can approve the students' scripts prior to allowing them to move into the production phase of the project.

*6) Help breakdown the project into a set of small tasks.*

Once a group of students has an approved script, it has to convert it into movie. Movie making is all about doing thousands of small things that somehow come together into a coherent whole. We call this "movie magic." An expert producer is very good at this task. To an untrained novice, it seems overwhelming. Students need help breaking the project down into doable chunks they can reasonably accomplish during class time or as home assignments. A presentation of a sample digital storytelling project dissected into such mini tasks can illustrate to the class how they can approach the breakdowns of their own projects. Even then, most groups need one-on-one assistance with this part of the project. Once the digital storytelling project is disassembled into doable tasks, students need to assign those tasks to a particular individual and create a time frame for completion. Since some aspects of digital storytelling are on a critical path of others, students have to understand what they have to accomplish first and work accordingly. On a real movie set, this is a job of a producer.

*7) Setup regular "Producer" meetings.*

Digital storytelling projects take a long time and tend to evolve significantly as students work through problems that arise during pre-production, filming, and post-production. Regular progress meetings (with and without the teacher) help keep these projects on track.

*8) Manage time.*

And finally, the most valuable scaffolding for digital storytelling projects is time. Movie making takes a lot of time. There are always things that go wrong. Students have to have enough time to complete their projects. This doesn't mean that they should be left to their own devices for months at a time. On the contrary, students need regular meetings with a teacher to discuss problems, progress, and work distribution issues. These are not the kinds of projects that get done the night before they are due.

### G. Assessment of Digital Storytelling Projects

Digital storytelling projects provide lots of opportunities for assessment. Each part of the framework—pre-production, production, and post-production—is a milestone with a distinct assessment opportunity. Within each of these, there are stages (described above) that allow for a more fine-grain evaluation:

- How well did the students translate the assigned topic into a idea for a movie?
- How good was their research?
- What was the quality of the script?
- How well did the students work together in a group?

At each point, a teacher can take a quick measure of the overall progress as well as assign a grade to a particular task. Students that ordinarily don't shine in a science class might become indispensable in their roles of group leaders, or artists, or camera persons [7]. Digital storytelling projects are rich with opportunities for assessment [10].

Aside from the typical group grades, summative assessments, and progress reports, digital storytelling allows for student evaluations of each other's work. This type of assessment is rare in a science classroom. Digital storytelling projects allow for an audience review, making them feel authentic to their makers [11, 12, 3, 8].

There are many specific frameworks by which to assess digital storytelling projects. Helen C. Barrett provides a nice set of rubrics and a good collection of references [13]. Her focus is mainly on student assessment. My interest is in finding variables that lead to the overall success of using digital storytelling as one of the many instructional tools available to modern teachers.

## III. Digital Storytelling is Meaningful Learning

As stated above, digital storytelling is difficult. Since digital storytelling is so much work, is it worth it? Is digital storytelling meaningful? Meaningful learning is defined as active, intentional, cooperative, authentic, and constructive [10].

**Active** meaning that students do more then press "return to continue" on a computer screen—students are actively involved in the learning activity [14]. Making a movie qualifies as an active learning activity.

**Intentional** describes students' awareness of the curriculum and its impact on their educational careers. Intention means that students know why they are learning and understand the goals of instruction. Again, digital storytelling qualifies as an intentional learning activity. The goals of the movie are stated at the start of each project: create a movie that explains or demonstrates a scientific process to the audience of student peers. And students have to continuously gauge if their digital storytelling projects align with those goals.

**Cooperative** requirement seems self-obvious, but it is more nuanced than the initial definitional take. There's a difference between cooperative and collaborative learning [5]. Collaborative activities require all members of a group to participate in the same way and contribute the same amount to a project. But in a classroom, different students bring different skill sets to the project of movie making. Some are great artists, some are fine writers, and others excel at the technical aspects required by these projects. So collaboration is not an appropriate group dynamic for digital storytelling projects. Cooperation, on the other hand, allows students to participate in different capacities according to their talents, interests, and availability. Some students take on the jobs of editors, others that of scriptwriters, some become camera operators, etc. Thus cooperation is really well aligned with how movies are made.

Authenticity specifies that schoolwork is not just done for the sake of busy work alone. There is a real audience for these projects and not only the eyes of a teacher [11, 12]. Movies made by students to illustrate scientific concepts are shared with the whole school and are upload on YouTube for an even wider possible viewership. This makes digital storytelling an **authentic** learning experience.

And finally, to satisfy the parameters of meaningful learning as defined above, an activity has to be **constructive**—students need to build upon the skills and background knowledge that they bring to these projects. To reconceptualize textbook-style explanation of a physical phenomenon into an audio-visual presentation is clearly an example of constructivist learning activity. Not only is it necessary for students to really understand the subject matter, but to also find a way of teaching others using a new medium of information delivery.

Digital storytelling projects qualify as meaningful learning. They allow a wide range of students to participate and really engage with subject matter. They should have a place in a modern science curriculum.

## IV. Case Study: Presidio Middle School 8th Grade Science Class

Presidio Middle School, a public school in San Francisco, has been working to incorporate digital storytelling into its science curriculum for the past several years. Kevin Gortney has been leading his 8th grade science students through the process of writing and making science movies. His students' digital storytelling projects can be found at: http://kgortney.pbworks.com/

### A. Presidio Middle School: Basic Statistics

Here are some statistics on Presidio Middle School, a San Francisco public school. In 2007-2008 academic year, Presidio Middle School had 1219 students, with 394 in 6th grade, 418 in 7th, and 407 in 8th. These numbers are from School Accountability Report Card and are published by the San Francisco Unified School District on the Web [15]. The average size of a science class for this academic year was 31.6 students. As a popular teacher, Mr. Gortney tends to have more students. The school serves a large population of children from an Asian community—60.05% of the total. The numbers are: African American is 5.82% of total, American Indian or Alaska Native is 0.49% of total, Filipino is 2.87% of total, Hispanic or Latino is 6.23% of total, White (Not Hispanic) is 16.24% of total, and multi-racial (or No Response) is 8.29% of total. Of these, 46% are from socioeconomically disadvantaged homes; 10% are English language learners; and 9% are students with disabilities. San Francisco Unified School District spends $4,020 per pupil. Seventy one percent of Presidio Middle School students scored Proficient or Advanced on the California Standards Test in science at the end of 8th grade.

### B. Mr. Gortney's 8th Grade Science Class

Mr. Gortney teaches two GATE 8th grade science classes, in addition to a regular 8th grade science class (in California, GATE stands for "gifted and talented education"). All of his students participate in the digital storytelling projects, creating as many as three science documentaries per school year. Below is his Web page that details the digital storytelling assignment.

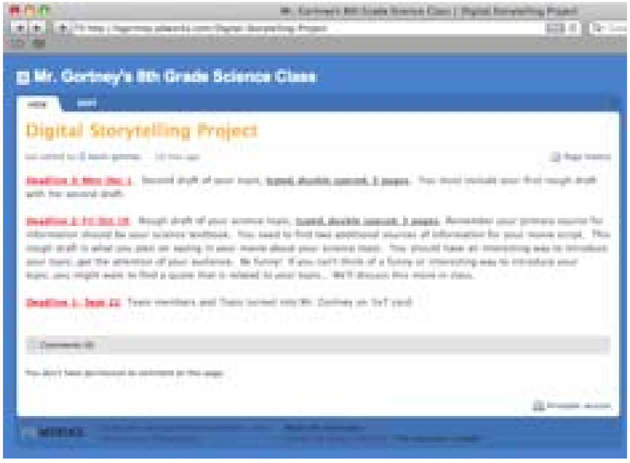


**Figure 1.** Screen Shot of Mr. Gortney's 8th Grade Science Class Web-based Instruction Page

Mr. Gortney's students are encouraged to use iMovie to edit their digital story projects. He provides his students with an "iMovie: Quick Cheat Sheet & How to get Started" by Lex Milton via a link from his Web page (http://etmadeez.com/ET%20made%20EZ_files/imovie%20and%20iphoto.pdf). Mr. Gortney's site also has links to student work from previous years. He uses movies created by his previous students as both an inspiration and as a way of setting expectations for his current class. He also provides a link to his own stop-action movie, explaining Carbon 14 decay, on YouTube (http://www.youtube.com/watch?v=cdtXAa8H7Vs).

I have a very privileged view on Mr. Gortney's classroom: both of my sons had him as a teacher and, since I taught science in a local elementary school for years, I knew many of his other students and their families since kindergarten. As the result, I had intimate knowledge of how these digital storytelling projects played out at home and experienced first-hand the demands placed on the parents when children are engaged in such projects.

As another disclosure, my husband and I run a digital production business and so our children have the access to all of the latest computer tools, camera equipment, and expert advice they could ever want. Other students clearly had a very different experience. But I spoke with many parents who went out of their way to help their children do well, some resorted to spending several hundred dollars in the process. Clearly, not all of the children experienced such privileged situations (as can be deduced from the statistics above). And it is these differences in support that partly account for the vast differences in quality of the resulting videos.

From the statistics above, 46% of the students in the Presidio Middle School come from socioeconomically disadvantaged homes. Those students didn't have access to the latest and greatest equipment or software at home and had to complete their projects at school or partner-up with students that had these resources.

**Figure 2.** Screen Shots of Mr. Gortney's Students YouTube Videos

There is a large immigrant population at the Presidio Middle School: 10% of Presidio students are English language learners and an even high percentage comes from homes where languages other than English are spoken routinely. As discussed above, these students are less likely to get help with subject matter, ideation, or conflict resolution from their parents.

San Francisco is a city of experts—we have a high density of computer professionals. But not all of the parents work in the high tech industry. Some students get lucky and have lots of support at home (e.g.: my sons and the students that were in their groups), some don't.

### *C. Sample Digital Storytelling Assignments and Projects*

At this point, it is useful to describe an actual project example. I have quite a few to choose from: "Fire," "Evolution," "Exploratorium: Cow's Eye Dissection," "Exploratorium: Water-repellent Property of the Micro-coating of Lotus Leaves," and "Time Travel." I have first-hand knowledge on how these digital stories were made. I was the "producer mom" for all of these projects: I drove the kids to the museums and parks to gather video footage; I hosted and fed groups of students while they worked on their projects at our home; I found old doctor's frocks to serve as lab coats; I supervised fire experiments; I assisted with the setup of tripods and microphones; I helped negotiate schedule conflicts with other students and their parents; my husband provided endless technical support and helped transfer the resulting movies onto DVDs and memory sticks. I often wondered how other children coped when their computers crashed, wiping out days-worth of work and setting the projects back many, many hours? Could other parents help by restoring old footage from backups? Could other parents be there weekend after weekend, providing supervision, food, equipment, props, and advice? Clearly, some other parents could, as evidenced by many wonderful projects featured on Mr. Gortney's Web site. But it is not a level playing field for kids without such support at home.

I will focus on "Evolution," a stop-action animation digital film made by my youngest son and another boy in his class, because it is the latest digital storytelling project created in our living room. The students had about two months to create their movie, but because of after school sports commitments, my son's partner couldn't start the project until the last week before it was due. This scheduling conflict was not an exception. In every single digital storytelling project I was involved with, it was very difficult to get a chunk of time when everyone could focus on the project. Getting kids in the same place at the same time to actually do the work (outside of classroom time, of course) was very difficult. For the "Evolution" project, the boys had to finish all of their stop action and voice-over work in one long day. The acts of composing of hundreds of individual shots into a video, editing, sound effects, music, and final mastering was done by my son without his partner's support, during the following week, after school. My son's comment on the experience was: "You have to choose your partners carefully."

My son and his partner didn't pick "evolution" as their topic. It was assigned to them by their teacher. The students had to find a way of illustrating evolution using stop action animation in such a way as to make it accessible to an audience of their peers ($8^{th}$ grade). They were free to use clay, or paper cutouts, or toys, as long as they clearly communicated the central concept of evolution. Unfortunately, when the boys finally got together to work on their project, they haven't figured out what they were going to do. They had a written definition of evolution, but not much else. Since we didn't have any clay at home, I suggested moving shapes around on a table. We just happened to have a collection of magnetic letters and words and a large piece of sheet metal. The boys were set to do something, but what? How could letters illustrate evolution? For the next couple of hours, they brainstormed a script: the primordial alphabet soup was born. My job in that process was to shot down ideas. The boys were coming up with many interesting ways of illustrating evolution, but most of them would have taken days to make and the support of the Industrial Light & Magic Digital Effects department. We had to find something that could be made in a day.

Stop action animation is time-consuming work. After making minute adjustments to the objects being animated, the camera (carefully secured on a tripod) takes one shot. There are typically 30 shots in one second of animation. To make a five minute movie, the various objects have to be moved about 900 times. My son and his partner choose 15 shots per second rate, but they still had to take close to 450 photographs!

While Mr. Gortney explained the process of making the stop action movie in class, both children were horrified at how long it took. And because they started working in the morning and ended late into the evening, the light in the room changed drastically. The final video had to be color-adjusted to compensate for the changes in the ambient light. My husband's technical expertise saved the day.

When they finally finished shooting the stop action animation, my son commented: "The most important thing I learned today was 'doability'."

## V. Conclusion

The use of student-made video in the classroom is becoming more prevalent. The rationale is that video and other digital tools are a gateway for some students into difficult subjects like science, math, and history. By its very nature, movie making is a group effort which requires many different talents and expertise to create. Students whose natural skills are social organization and leadership, for example, have few opportunities to shine in a standard science curriculum. But these students can take a central role during student digital storytelling projects. And while traditional classrooms still reward individual performance at the core of assessment, teachers using student-created video projects as part of their instruction have to adopt a different approach to evaluate individual as well as group work. There is a change in culture from both the student and teacher perspectives.

A teacher producer is a technical and logistical problem-solver, making practical and procedural decisions so that the students working on a movie are free to focus on the creative job of actually putting together the film. The technical problem-solving skills are obvious: knowledge of camera operation; understanding of the digital file formats used by the camera and the editing software; ability to import the video into the computer and to record and digitize the audio; and expertise in exporting the finished product out of the editing software and into the appropriate presentation format (e.g.: creating Web pages with embedded video, uploading digital storytelling projects on YouTube, projecting movies in front of an audience, etc.). Each step described above can be complicated, as software and hardware varies greatly in degree of usability.

Jonassen's definition of meaningful learning is that it has to be active, intentional, cooperative, authentic, and constructive. Digital storytelling clearly satisfies meaningful learning as defined above [10]. It is worth the trouble and difficulties of bringing it into a curriculum. But in order to be successful, digital storytelling requires a lot of technical and logistical support for the teachers, students, and parents. It is not enough to know the subject matter; it is also necessary to understand the technological pitfalls and basic movie making know-how. As digital storytelling becomes part of the every day curriculum, teachers as well as parents become movie producers and require support to do those jobs well.

## Acknowledgements

Presidio Middle School, a public school in San Francisco, has been working to incorporate digital storytelling into its

science curriculum for the past several years. Kevin Gortney has been leading his 8th grade science students through the process of writing and making science movies. His students' digital storytelling projects can be found at: http://kgortney.pbworks.com/ His site has links to student work from previous years which he uses as both an inspiration and as a way of setting expectations for his current class.

The short version of this paper, presented at IADIS conference in 2010 [16], was named after his insight. The final "Evolution" digital storytelling project can be seen on Mr. Gortney's Web site.

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## Author Biography

Olga Werby holds a doctorate in education with a focus on cognitive science and HCI and a Masters in Online Learning from the University of California at Berkeley. For the last 18 years, she was a partner and president at Pipsqueak Productions, LLC, a small company delivering business and education solutions based on careful union of cognitive science, cutting-edge technology, and art. Olga teaches product design classes at UCB Extension and AUP (American University in Paris). She and her partner, Christopher Werby, are working with UCLA and the International Criminal Court's Office of the Prosecutor (ICC-OTP) to develop and run UCLA Forum—a project aimed to engage the world with ICC Prosecutor and debate special topics in international criminal law. Olga organized a community to promote ICT as a human right and will head the panel, "ICT & Human Rights", during the IADIS conference in Rome this coming summer. Her blog can be found at www.Interfaces.com and her company at www.Pipsqueak.com.