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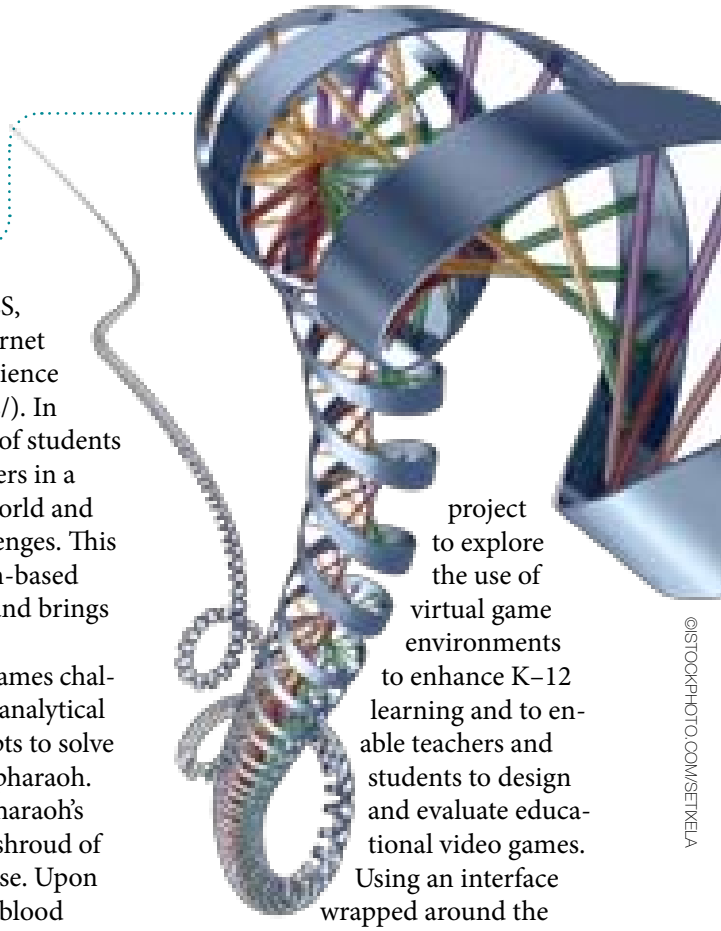
Designing and Evaluating Educational Video Games

By Len Annetta



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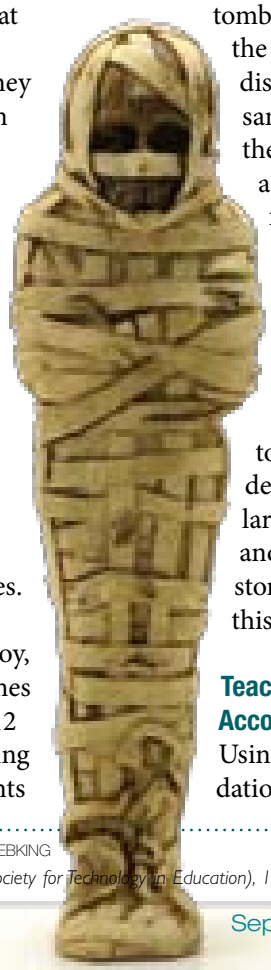
Working in the College of Education at North Carolina State University (NCSU), I have found that many practicing teachers realize that children today are different. "They are not doing the things we used to do when we were young," the teachers would say, targeting video games as mindless distractions hour after hour when their students get home from school.

With end-of-grade, "back to basics," multiple-choice testing for the masses and mechanical instruction methods, there is growing concern that children are not learning to problem solve as much as they are mastering memorization of isolated facts in order to answer questions on the tests. Yet when they get home from school, children eagerly devour new information and concepts while immersed in video games. In what has become known as a "stealth-learning" environment, children are developing skills that connect and manipulate information in the virtual worlds of these games.

Instead of trying to fight what children obviously enjoy, the enticement of video games can be used to enhance K–12 education. We are introducing virtual learning environments to schools through HIFIVES, Highly Interactive Fun Internet Virtual Environments in Science (http://ced.ncsu.edu/hifives/). In these environments, teams of students assume the roles of characters in a game, exploring a virtual world and collaborating to solve challenges. This approach takes the problem-based learning teaching strategy and brings it to life.

For example, one of the games challenges students to combine analytical skills with biological concepts to solve the murder of an Egyptian pharaoh. The players must find the pharaoh's tomb and analyze the shroud of the mummified corpse. Upon discovering ancient blood samples, students can analyze the DNA and test the results against possible suspects to find the pharaoh's murderer.



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As today's games align closely with customary entertainment (i.e., movies and television), we find the genre of entertainment marketed at teens needs to be the plot of K–12 game design. For example, the popularity of CSI, science fiction, and psychological thrillers are storylines that tend to engage this population.

Teachers Design Games According to Curriculum

Using a National Science Foundation grant, we have a four-year project to explore the use of virtual game environments to enhance K–12 learning and to enable teachers and students to design and evaluate educational video games. Using an interface wrapped around the source code for the popular game *Half-Life 2*, we've created a platform where teachers and students can choose from about 15 different game maps (such as the desert, the tundra, the moon, and so on) and then can use "drag and drop" tools to develop their own games without actually having to write computer code. After all, who better to design a game that precisely fits the lesson plan than the teacher? These games align with the state science and mathematics curriculum objectives set forth by the N.C. Department of Public Instruction.

Thirteen North Carolina teachers of grades 5–9 have completed training at NCSU, created games for their students, and brought their students in to give their input to make the games

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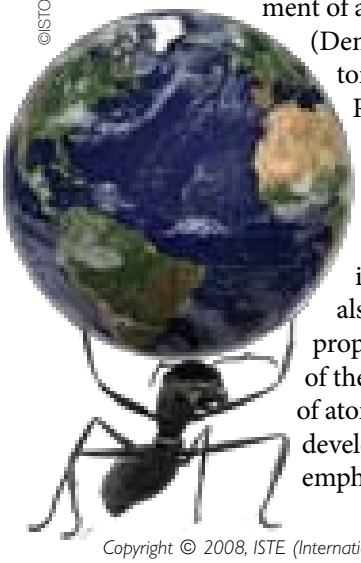
more engaging and fun. Further, 50 new teachers have joined HIFIVES to begin learning the game design process through a cascading leadership model where the original 13 teachers mentor the next 50. Many of those teachers and students will come from North Carolina's Lee County, a rural, impoverished, under-performing area according to the No Child Left Behind Act.

Going one step further, the teachers can use the same technology to have their students develop games. Our goal is to put these games into the hands of the students so that instead of assigning, for example, a research paper, a teacher will have students create games to teach other students. Sometimes the best way to learn content is to teach it. By creating games, students are immersed in an environment they are accustomed to, and this establishes a potentially new form of performance assessment.

Teacher-Designed Game Example

One teacher designed a game titled *Modeling in Chemistry: The Development of Atomic Theory*. This interactive quiz format allows a student to navigate the gaming environment and prevent the evil "Dr. Atomic" from forever scrambling time and destroying the underlying atomic structure of everything in the world. Successful navigation of the game requires knowledge of key figures in the historical development of atomic theory (Democritus, Dalton, Thomson, Rutherford, Bohr, Schrodinger).



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Contributions of the individuals as well as proper ordering of the sequence of atomic theory development are emphasized within the "time travel" aspect of the game. Successful navigation of the game also requires the application of fundamental concepts serving as the underlying foundation of current atomic theory (atomic number, mass number, atomic mass, chemical symbols, isotopes). Facility with the language of atomic theory—essential in the study of the physical sciences—is the key to defeating evil Dr. Atomic in his quest to destroy the fundamental structure and stability of matter.

In the *Mystery of the Dying Coral*, student scientists investigate the mysterious deaths of corals around the world. Using interactive gaming the scientists gather and analyze the evidence to find the culprit in this global phenomenon. The scientists use data collected from organisms within the ocean environment as well as interactive Web sites and authoritative databases. Will the scientists be able to solve the mystery or will the world's coral reefs go the way of the dodo bird?

Shrunk to the size of mere insects, a group of entomologists find themselves lost in a maze-like desert ravine in the ecological game *The Great Entomologist Escape*. With the newfound ability to communicate to the now monstrously sized insects, can the team unlock the clues necessary to maneuver through the trap of this food web adventure? Navigate through multiple stages of a food chain using multi-player online capabilities. Who will be first to escape the ravine?

Partnering with SAS, a developer of business intelligence and analytical software and services, I am adding a unique feature to my games—a behind-the-scenes exploratory study to evaluate how students learn in these gaming environments. Through another NSF-funded grant project, SAS is providing their data mining software (Enterprise Miner) for assessing students who play the games. Businesses use the software to forecast sales and make business decisions. The software enables Amazon to suggest books to purchase based on customer preferences. Educators tap into the same powerful technology to make more effective and efficient teaching and learning practices.

The education games generate an extensive amount of data from chat text logs, recorded events in-game, and pop-up boxes in which students explain their actions. Reading through all the "raw" data is laborious and time consuming. The SAS technology automatically analyzes the data quickly to help teachers assess student performance and adjust the next day's lesson plan to address students' needs. The analysis also enables teachers to improve the design of the games based on the real-world feedback from students and what they are actually doing in the virtual game environment. This analytical software may be the next generation of assessment for both educational and commercial video games.

Gaming Transforms Education

Today's video games have rich storylines involving seeking out and using information, and the HIFIVES game platform allows teachers to create games that tell a story, keeping children interested in the classroom and teaching them valuable career and life skills.

Acknowledgements

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Len Annetta, PhD, is an assistant professor of science education at North Carolina State University and the lead principal investigator of the HIFIVES program in partnership with the Friday Institute (http://www.fridayinstitute.com).

Science

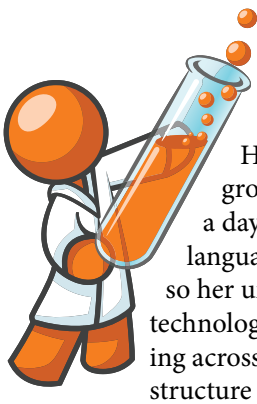
Making Meaning Across the Curriculum

Using iPods, multimedia, and video streaming technology to teach bioethics

Jeanne Halderson is an award-winning seventh grade teacher at Long Fellow Middle School in La Crosse, Wisconsin, who has gained national notoriety because of her inventive use of technology in the classroom. She used video iPods combined with Discovery Education's unitedstreaming digital library to help teach a science and language arts unit to her students.

Halderson's broad idea was that students would have access to unitedstreaming video material loaded onto a video iPod. Thus, students would have research material at their fingertips and be in a position to take greater responsibility for their own learning. Her students researched a biotechnology topic using the Internet and video material loaded onto iPods and developed a personal position on a bioethics issue. Students produced a two- to three-minute digital video using iMovie to post on the Internet or present as a podcast using Quicktime.

The Unit: Ethics and Biotechnology



Part 1: Research and Building an Ethical Stance on Biotechnology

Halderson teaches two groups of students twice a day. She teaches both language arts and science, so her unit on Ethics and Biotechnology was ideal for teaching across the curriculum. This structure gives the students the instructional continuity necessary for them to learn difficult material.

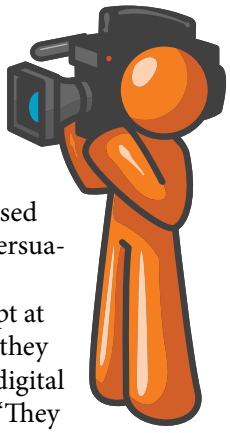
At the beginning of Part 1, Halderson loaded onto each video iPod a presentation explaining the lesson to students, teacher notes, and unitedstreaming digital video material. Carefully selected video topics included information on transgenics, gene mapping, cloning, and nature versus nurture—the subjects that students were required to research.

Halderson also modeled a reading, watching, and note-taking strategy for her students using a simple note-taking guide—a T-chart that was divided into two columns. As students watched unitedstreaming video on the iPods, they were able to place their notes into either the pro or con side of the T-chart.

During Part 1 of the unit, Halderson's students concentrated on getting the science and the facts correct. Students used their time to write and demonstrate what they knew. Halderson also had her students read *The Giver* by Lois Lowry, a science fiction story that dramatizes the moral issues associated with cloning and bioethics. Halderson focused on the basic science of genetics and covered some probability and statistics ground as well. She spent significant time poring over students' work and conducted guided practices and discussions about filling out the note-taking T-chart.

"In science class, we wrote persuasive essays. The old fashioned kind with an introduction, body, and conclusion," Halderson said. "This is where students displayed their knowledge of the nitty-gritty science facts, and in language arts class, we did the digital videos, which were a more story-based and emotional approach to persuasion."

By Day 3, students were already researching their topics. By Day 5, both the video iPod and Internet students had taken sufficient notes to determine which specific controversy associated with bioethics they were most interested in taking a position on. On Day 5, Halderson facilitated a class discussion and students shared their ideas and feelings about biotechnology. The discussion helped students clarify their positions.



Part 2: Student Digital Video Productions

In Part 2 of the unit, students had to write a script for their video based on their research and persuasive essay.

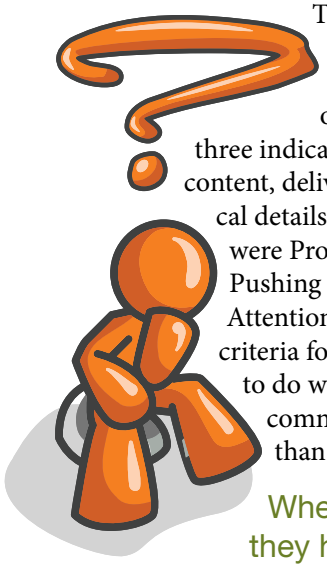
"I looked at each script at least 5–20 times before they were able to start their digital story," Halderson said. "They would never be allowed to start the digital process if they had incorrect information in any form. If I let kids start editing with errors in science concepts, they will be reinforced. I help students to clear up any misconceptions right there on the spot before they have spent hours working with an incorrect concept."

Using iMovie, students produced a short video that reflected their ethical position on one of several bioethics issues, such as human cloning. Much of the video material was cut from the unitedstreaming videos that Halderson had supplied them. Halderson was keen that students should follow a coherent narrative structure. Generally, students placed themselves in the first-person fictional narrative and read a script they composed individually that told a story of how genetic engineering either could have benefited or did benefit their family (e.g., saved the life of a sibling) or had dire consequences (e.g., the death of a family member). The

By Gordon Patrick Karim

result, with voiceover, was a story that represented their stance on genetic engineering (bioethics).

Evaluating the Student Produced Videos



To evaluate the digital video, Halderson developed a rubric with three indicators for successful content, delivery, and technical details. The assessments were Proud to Broadcast, Pushing Perfect, and Needs Attention. The primary criteria for success had more to do with production and communication skills than hard content (accurate representation of the facts) because Halderson had worked with her students during Part 1 of the lesson plan in getting the facts straight.

As is often the case, some students who struggle in traditional language arts classes found working with another medium a more effective way of communicating. But producing a digital narrative doesn't mean students are getting an easy way out.

"From listening to the student comments, I feel it is because when we write an essay, we are at a lower level of Bloom's Taxonomy," Halderson explained. "In fact, at the seventh grade level, writing an essay is just deciding your viewpoint and rewording things that other people have said. You don't have to be as creative; you have to state the facts in a 'formatted' approach—Intro, Body, Conclusion. When students create digital videos, not only did they have to make a decision, but also they have to apply it to their own life in a creative manner. They have to use the highest level of evaluation on Bloom's to do the following: appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, select, support, value, evaluate."

In the end the student-produced videos reflected an understanding of the core content as well as the skills, both technical and cognitive, necessary to do the work.

When students create digital videos, not only did they have to make a decision, but also they have to apply it to their own life in a creative manner.

Gordon Patrick Karim is an education consultant in the Washington, D.C. metro area. He specializes in program evaluation and qualitative research methods exploring the use of multimedia technology in K–12 classrooms.

Multidisciplinary

Enhanced Podcasts: A New Twist on an Old Tool

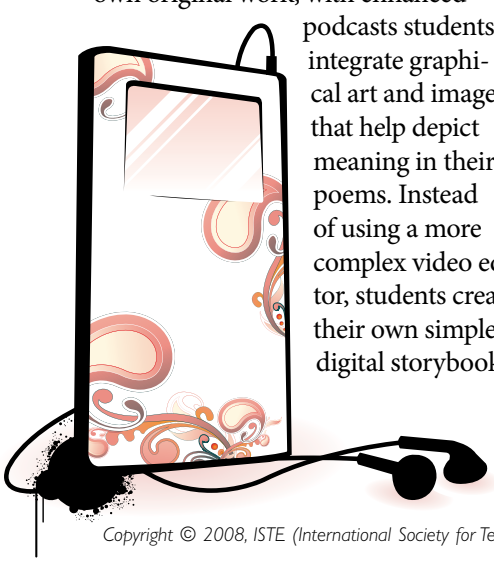
Podcasts with images and text—*enhanced* podcasts—are effective and fun projects for the classroom. By using a simple tool such as PowerPoint, students of all ages can develop their own enhanced podcasts or videos of images and text for cell phone viewing. One of the benefits is that it allows students to use visual and verbal cues to demonstrate their understanding of the knowledge they are learning.

Social Studies Projects

Probably the most popular use of a podcast is having students develop radio broadcasts in which they "go back in time" and cover many different topics of a time period (arts/entertainment, politics, culture, innovation, top news stories, and so on). An enhanced podcast turns the radio broadcast into a simple and quick television show, with images, charts/graphs, and text included. With an enhanced podcast, students add images and graphs of data from interviews of people who have lived through certain events in history.

Literacy Projects

Instead of a simple audio poetry slam, where students read and record their own original work, with enhanced podcasts students integrate graphical art and images that help depict meaning in their poems. Instead of using a more complex video editor, students create their own simple digital storybooks by inserting their pictures into different PowerPoint slides, narrating the story, and adding music or sound effects.



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Science Projects

In an enhanced podcast for biology class, students create graphical images of scientific cycles (such as the nutrient cycle or metamorphosis) in a slideshow program and then narrate their understanding of how the cycle works. Similarly, in a chemistry class students create slides graphically depicting a chemical reaction while describing it. In an elementary classroom, students participating in a science fair take images of their science project and give a brief audio description of its significance.

Mathematics Projects

Imagine asking students in a math class to describe what is happening in a mathematical equation and being able to represent that description visually. In an enhanced math podcast for an elementary classroom, students insert or create their graphs and charts while narrating their analysis of the meaning of the graph.

Foreign Language Projects

Imagine being able to create a digital "travel" postcard podcast with audio and images of a foreign country, thus enhancing the text with speaking about the country in the foreign language. Another project is to create "flashcard" podcasts. Younger students create counting or alphabet flashcards with narration and images or text of what is being narrated, while older students create flashcards based on vocabulary lists for different units.

Creating Enhanced Podcasts with PowerPoint

The "make movie" option in PowerPoint is currently only available on Macintosh versions of the software. Schools with Windows versions of Microsoft Office can put together slides in PowerPoint, but cannot do an export as a QuickTime movie. One solution is to use a free online video editing resource such as Voicethread (http://www.voicethread.com). Voicethread allows anyone to edit and store images, record narration online, and then immediately publish to a Web site or blog.

The steps below will help you develop your own enhanced podcast with PowerPoint.

1. Open PowerPoint and select new presentation.
2. Create your presentation.
3. Using your computer's microphone (Macintosh computers have built-in microphones, and some PCs do as well), record your narrative for each slide by going to Slide Show—Record Narration. When you are done, make sure you save.
4. The sound icons should appear on each slide in your presentation. The sound should be set to automatically play when you preview the slide show.
5. Now make a movie with your PowerPoint. Go to File—Make Movie (Mac-only option).
6. When the save menu appears, save the movie to your desktop.
7. The podcast is done. It is now a QuickTime movie file, which you can convert to an iPod format or the 3pg format for cell phones. Go to Zamzar (http://www.zamzar.com), a free conversion

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site. Or if you have QuickTime Pro on your computer, you can convert it to an iPod format through Quicktime.

8. At Zamzar, upload your movie file. Then select Convert to iPod or 3pg format. Enter your e-mail address. Click on Convert. The converted file will be sent directly to you.
9. Open your e-mail and download your podcast.
10. You can upload your podcast (mp4 file) to a variety of free podcasting sites, including Gcast (http://gcast.com) or Podomatic (http://www.podomatic.com). You could also upload to your school Web site, blog, or server. To upload your movie (3pg file) to your cell phone, you can use a variety of Web sites. One free site is Cellfish (http://cellfish.com), which uploads to most cell phones. You receive the video in a text message to your cell phone and save it by selecting "store" or "save."

Enhanced Photo Albums

Using an enhanced podcast, your students can create a narrated video photo album of a school field trip, yearbook, and other special activities throughout the year. Use them for weekly "week in reviews" that can be e-mailed home to parents. Include pictures of the students' activities throughout the week, narrated by different students who participated in the activities.

Making Podcasts Public

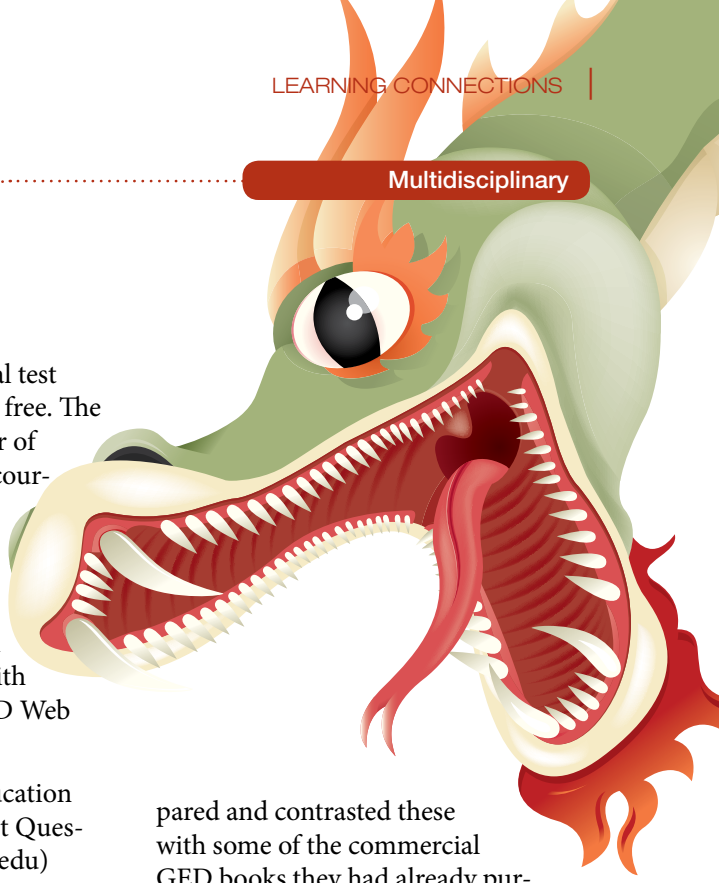
In many cases you may want to upload the enhanced podcasts to your Web site to share with parents or to make them available to other students to help with review and practice.

If so, you need to be careful about the information you are publishing, such as student's names, school identification, student pictures, or student work with their names attached. You also need to make sure the images published are free of any copyright infringement. One easy solution is to publish enhanced podcasts to a school intranet or protected Web site. This a wonderful opportunity to talk with your students about issues of copyright and the World Wide Web as well as issues of online privacy. Or you may want to view your slide presentation on any mobile phone that plays video.

—Liz Kolb taught high school and middle school social studies and was a technology coordinator/integration specialist in Ohio. She is currently an adjunct assistant professor at Madonna University in Michigan as well as a doctoral student in learning technologies at the University of Michigan.

Multidisciplinary

Using Free Test Prep Sites To Slay the GED Dragon



Students can save money and personalize their studying for the GED by using the many free and meaningful test preparation sites that are already available on the Web. I used the following approach to help students pass their GED examination in a Bronx Social Services center. All had either failed the test once or failed to complete the seven-hour, multiple session exam.

I had the students begin by reflecting on their prior standardized test-taking experiences. To help conquer the stress they had previously experienced with this or other testing and to motivate the participants to work together as a team, I introduced the concept of the class as a group of dragon slayers who would work together over the course to "slay" the GED—giant educational dragon—one claw (subject area) at a time.

First, each cohort searched the Web for inspiring dragon slayer illustrations. During the process, I discovered that the participants had no idea of the distinctions and options for image, theme, and topic searches using Google or other search engines. They were truly fascinated by the possibilities of visual searches—getting a mix of sculptural, painted, lithograph, illuminated medieval text, and other graphic dragon images.

Next, they searched for the best, most credible and valuable GED individual test prep available for absolutely free. The immediacy and vast number of matches dazzled them. I encouraged them to evaluate the various hits for "edu," "org," and "com" designations. Together they compiled a set of resources from which they selected three with my coaching. The three GED Web sites were:

- American Council of Education (ACE)—GED Sample Test Questions (http://www.acenet.edu)
- Test Prep Review (http://www.testprepreview.com), and
- Steck Vaughn (http://GEDpractice.com)

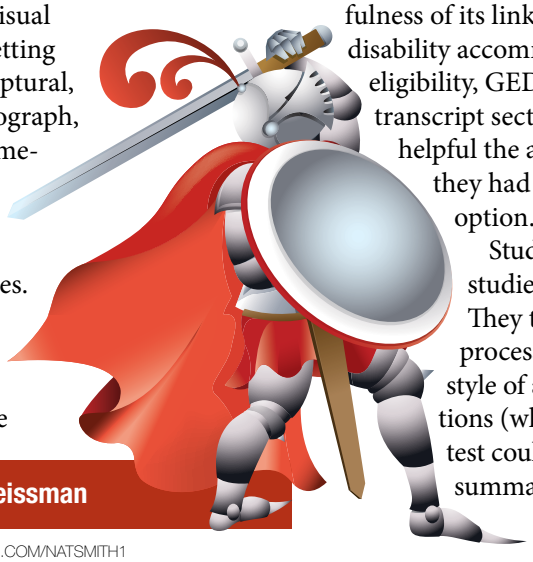
The students decided to first explore the site created by ACE. This is a practice site, with answers and key information about GED test centers, who is qualified to take the GED, and even who can be accommodated for disability on the GED.

I gave students time to talk about their experience using the site as a timed practice tool, its appropriateness for them as test takers, the usefulness of its links (particularly its disability accommodation, GED eligibility, GED test center, and transcript sections) and how helpful the answers were when they had selected the wrong option.

Students took the social studies set during class. They then discussed the process, content, and style of answers/explanations (which on the ACE test could be accessed for a summary at the end of the exam). They compared and contrasted these with some of the commercial GED books they had already purchased. Students noted that they got more practice questions and answers with the materials that cost money, but these were not as detailed as those provided on the ACE Web site. They also noted that much of the key information about test score decoding, transcripts, content, timing, and so on was actually available *free* on the Internet. The students never even conceived of the idea of accommodations for special needs such as unlimited time, access to a computer, or an actual reader, and at least three were eligible for such accommodations.

During the course, students used desktop publishing and graphics software and their dragon images and free GED Web sites they had discovered to make a test maker and dragon slayer guide or tips posters for the next group of participants in the GED course. They created documents with separate sections for their answers and scanned images or developed their own for online use. To field test each other's test practice questions, they literally switched work stations to enter what they felt were the correct options.

We also e-mailed the tests they created to another GED prep class, which



By Rose Reissman

By the end of the course, my students were as prepared and confident as they could be and ready to slay the GED dragon, which many of them did!

took the tests and gave my students feedback. It is difficult to quantify the value of the smiles and pride that my students evidenced as they read the collective e-mail to me from the other instructor with responses from peers who congratulated my students on their tips and questions as well as shared their fears, anxieties, and tensions.

As the course progressed with two hours of content study and six hours devoted to essay writing, the students shifted test prep sites to suit their individual needs, learning styles, and tasks for that session. Without my prompting, they compared and contrasted easily the number of available levels and content areas for each site:

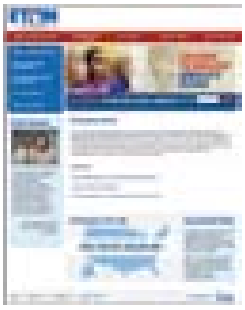
- Test Prep Review had the most with multiple Reading Practices (special ones for main idea, comprehension), Structure, Commas, Basic and Advanced Grammar
- GEDpractice.com had content sessions broken into U.S. history, world history, economics, civics and government, geography, organization, mechanics, sentence structure, and usage
- ACE had single offerings for content.

They noted that some sites, such as Test Prep Review, had no sample essay prompts and model answers. Others, such as the ACE GED Sample Test Questions, had instructions on a sample essay prompt and answers that demonstrated not only what an excellent model essay response to the prompt would be, but how one that would receive a low rubric rating would compare and contrast to a top-rated one.

As the course rounded into its final six hours, participants were given many options as befitted their increasing capacity to make meaningful individual judgments about the value of a particular site for individual practice. By the time we focused on the science and mathematics strands of the examination, the participants selected individually or in teams those sites they felt would fit their content needs best based on their previous use.

By the end of the course, my students were as prepared and confident as they could be and ready to slay the GED dragon, which many of them did!

—Dr. Rose Reissman is the director of the Museum in School Program, curriculum writer for the New York Daily News, *President of the New York City Association of Teachers of English, and the curriculum author of the Family Technology Driven Literacy Program developed by Futurekids NYC for Inwood House Social Services Community Center.*

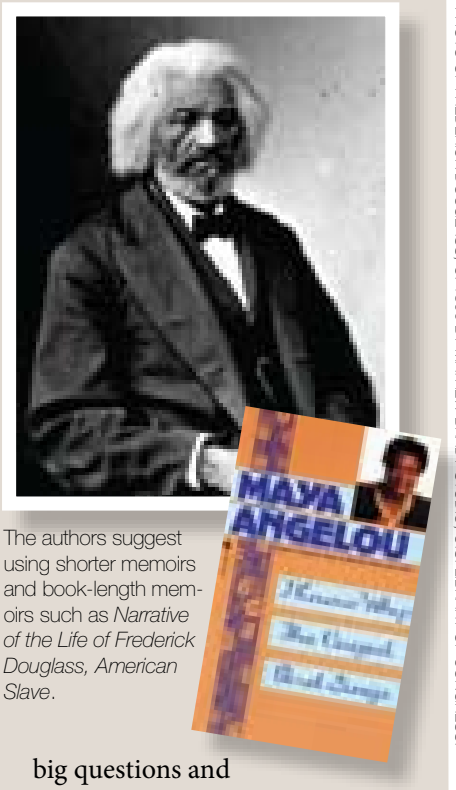


Making Memories

What does the life of a ninth grade American student in 2008 have in common with the life of Holocaust victim Anne Frank? Or with Frederick Douglass and the Civil War? With the characters yearning for freedom in Maya Angelou's *I Know Why the Caged Bird Sings*? How might the sharing of life stories among teenage peers be a meaningful activity, building skills in social awareness, communication, empathy, writing, and reading?

After reading the assigned memoirs and selected chapters from longer works, students write four or five autobiographical sketches describing meaningful, funny, or transformative events in their lives. Next, using a free online word processor such as Google Documents, Zoho Writer, or Thinkfree, pairs of students will peer-edit their memoir collections.

In the course of the unit, students learn how to cooperatively revise and edit text as they do the work. One of the strengths of the collaboration is the ability for all to review and revert to previous versions. Throughout, students are taught how to be supportive of one another and how to contribute suggestions that are useful and appropriate. They are taught to ask big questions and give big answers, and how to explain their decision-making process about the edits they have made to their peer authors.



The authors suggest using shorter memoirs and book-length memoirs such as *Narrative of the Life of Frederick Douglass, American Slave*.

PHOTO OF FREDERICK DOUGLASS, C. 1890 BY MATHEW BRADY STUDIO, U.S. LIBRARY OF CONGRESS.

The author reminds teachers that an assignment such as this can place students in a vulnerable place, and so it requires the teacher to meet with groups each day in conferences.

—*Adapted from* English Language Arts: Units for Grades 9–12, *by Christopher Shamburg, (ISTE, 2008).*

Language Arts

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Science

Enhance Science Lessons With Podcasts

Science-related podcasts such as NPR's Science Friday abound on the Web.

Classroom learning has dramatically changed over the past few years with the availability of new technologies and media that transcends platforms and delivery methods. Today's young learners have at their command a dynamic new set of tools that belongs to the 21st century in ways that simply did not exist for previous generations. Studies have shown that integrating videos into the classroom enables students to learn more effectively by appealing to their different learning styles. With the rise of portable mp3/video players and the steady growth of podcasts in education, educators are able to take advantage of the range of science resources to address students' 21st century learning styles.

Science comes alive in the classroom with video podcasts produced by experts such as NASA and PBS, and provides for the ongoing feed of rich science content and ongoing support of the transparent access to science content inside or outside the classroom. By bringing these innovative technologies to the classroom, learning and teaching can transcend the traditional domain of curriculum and provide multimodal content delivery. Curriculum is enhanced by the use of these new technologies and our students receive a richer learning experience from the plethora of new media allowing them to learn in different ways.

Science, in particular, is a very rich area for learning with media. Science podcasts are easily available and free, and enable educators to expand their curriculum by accessing information on specialized topics directly from experts in the field. Classroom instructors can enhance their lessons by projecting the podcasts for the entire class, by making them available on classroom computers through iTunes, or by putting them on iPods for portable use by students. These rich curriculum resources extend teaching and learning beyond the classroom, allowing students to easily and continually learn on their own.

There are many science-related podcasts that have classroom application from elementary through university levels. Some include teacher resources as well. Podcasts like these are a great way to get kids excited about science and motivated to learn more, all at the time and in the place that is convenient for the mobile learner.

Science Friday (NPR), Science Talk (Scientific American), Ask an Astronomer, NASA Cast, and Why? The Science Show for Kids are some of the more popular science podcasts. You can find science podcasts by using the iTunes Store (Mac or Windows), or checking out a wiki with links to exemplary science podcasting resources at http://k12podcasts.pbwiki.com/Science-Podcasts.

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