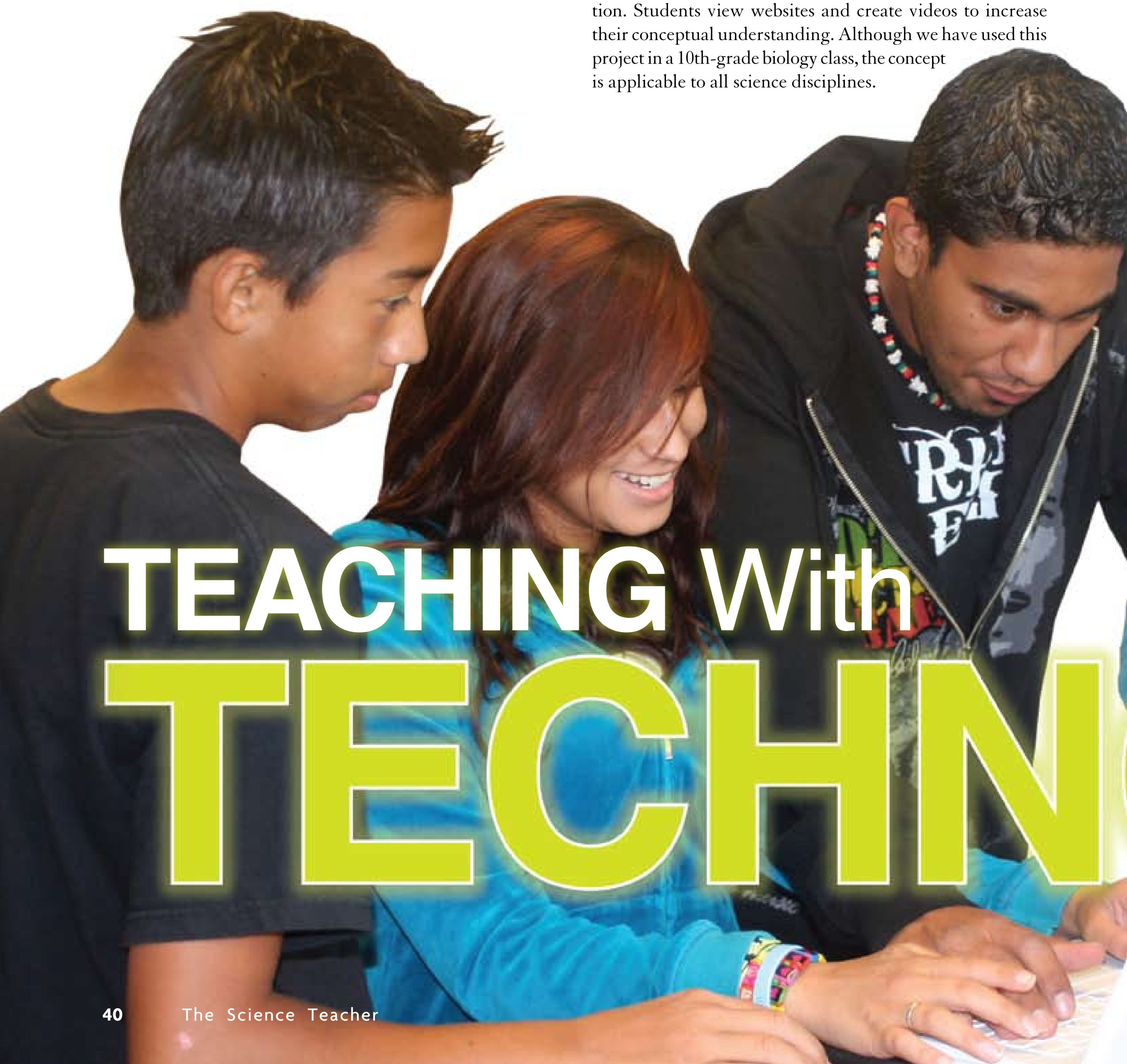
# TEACHING With TECHN

*Using websites and videos to increase understanding of bacterial transformation*

Stephanie McCormack and Donna L. Ross

Technology is ubiquitous among young people today. Outside of school, students use multiple forms of technology to surf social networking sites, listen to MP3 players, play video games, and text friends. What were once considered luxuries are now indispensable to most teenagers. Yet, integrating technology into the traditional school curriculum has been a slow process.

Technology can be a powerful tool to increase motivation, engagement, and achievement (Park, Khan, and Petrina 2009). In this article, we describe our collaborative approach to integrating technology with a lab on bacterial transformation. Students view websites and create videos to increase their conceptual understanding. Although we have used this project in a 10th-grade biology class, the concept is applicable to all science disciplines.



## Bacterial transformation lab

Bacterial transformation involving recombinant DNA is taught in most biology and biotechnology courses and may be introduced as early as ninth grade (see "Addressing the Standards"). But transformation is not an easily accessible topic. In fact, we have observed many students struggling to understand it, even after they have passed advanced biology classes.

However, bacterial transformation is an important concept for understanding the basics of genetic engineering—or the manipulation of an organism's DNA to produce a change in phenotype. In agriculture, genetically engineered plants can be made more drought-resistant or less prone to bruising than their nonmodified counterparts. In medicine, insulin is just one of many proteins synthesized through this process.

SCiLINKS THE WORLD'S A CLICK AWAY
Keywords: Bacteria
at *www.scilinks.org*
Enter code: TST101001

Bacterial transformation is the process that occurs when a host organism takes in foreign DNA and expresses the foreign gene. For several years, each of us has had our students complete a bacterial transformation lab to better understand this concept. Until recently, our lessons included lecture, readings, and a physical lab, in which *E. coli* bacteria are transformed to express a protein for fluorescence.

In this lab, students insert a plasmid vector containing a gene for a specific fluorescent protein and a gene for ampicillin-resistance into the *E. coli* bacteria (see "More on the transformation lab," p. 45). They then observe as the bacteria fluoresce on either Lysogeny broth (LB) agar plates or plates containing both LB and ampicillin (the LB and ampicillin plates are the most dramatic, where the nontransformed *E. coli* do not grow). This proof-of-concept lab models the insertion of DNA into a novel organism to produce a protein of interest. It also provides a concrete example of the dramatic effect produced by genetic engineering.

In the past, students wrote reports to explain the process of bacterial transformation after they completed the physical lab. Although they enjoyed viewing the fluorescence and successfully followed the steps to complete

### Addressing the Standards (NRC 1996).

- Life Science Content Standard C: Molecular basis of heredity (p. 185)
- Science in Personal and Social Perspectives Content Standard F: Science and technology in local, national, and global challenges (p. 199)


**Students at Health Science High edit their group video.**

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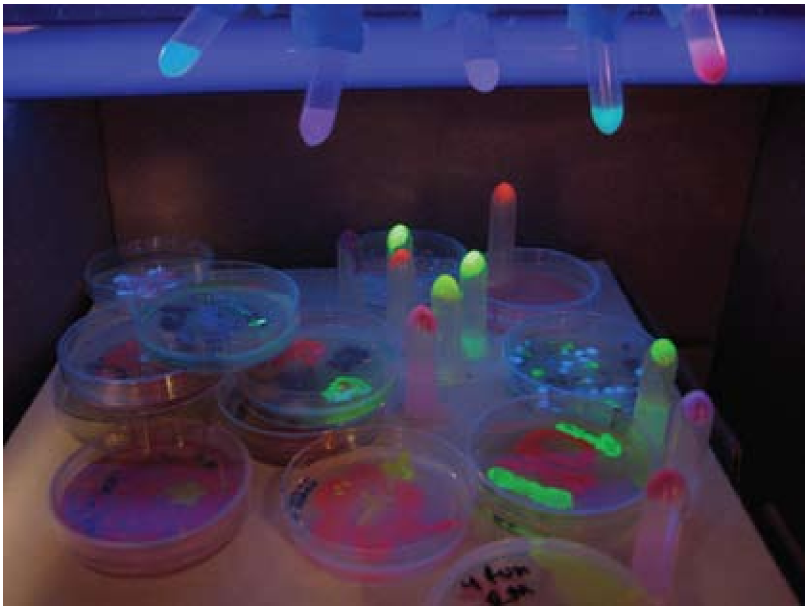

**Transformed bacteria and some purified proteins.**

the lab activity, we found that their reports typically contained weak explanations and did not demonstrate mastery of the concepts. To more fully immerse our students in the content and deepen their conceptual understanding, we decided to integrate technology into this annual lab activity beginning in 2008.

## Incorporating technology

There are many animations, videos, and podcasts available to educators on virtually any topic. Beginning in 2008, we had our students browse the University of Utah Genetic Science Learning Center (see "On the web") to reinforce their understanding of DNA transcription and translation before they began the physical lab. A website associated with the textbook (see "On the web") was also posted on the class website for individual or group review of concepts learned in class.

Students were then tasked with evaluating two websites: BioAlive and the DNA Learning Center (see "On the web"). Initially, they did not know they would be doing a bacterial transformation lab in class—they were simply told that they would be producing a multimedia presentation about a scientific topic, and that to prepare, they needed to analyze the educational value of certain DNA websites.

In small groups, students evaluated and commented on the background information, lab procedures, ease of navigation, and level of engagement found at each site. Although the science content and language were challenging, students were not intimidated because they viewed the assignment as a review of a media product's effectiveness.

For their first task, students selected a DNA animation from the BioAlive website to review. The second assignment, the Harlem DNA Lab on Bacterial Transformation from the DNA Learning Center site, became one of the most important resources for this unit. As students thought about what qualities made this site an effective multimedia tool, they bridged the roles of media consumer and producer, while also learning the necessary lab procedures.

For students to become producers of multimedia technology themselves, they must first analyze artifacts and develop production skills. The website evaluations thus served two purposes: As students focused on how multimedia professionals create an effective presentation, they jumpstarted their own planning process and the science content was reinforced. Later, as students completed the physical lab, it was evident that the website reviews had given them a better understanding of bacterial transformation. Compared to prior classes, students made fewer mistakes in the procedures because they understood the reasons behind the steps and were better able to anticipate the results and discuss the real-world applications of genetic engineering.

## How-to videos

Teaming with the multimedia teacher added another technology component to this lab. Initially, students learned about video-production concepts, such as creating a script and capturing quality audio. Additionally, the math teacher helped them understand the equation relating concentration (C) and volume (V) in dilutions ($C_1V_1 = C_2V_2$), and taught them how to explain this equation to an audience.

In small groups, students then produced a how-to video about making dilutions—a basic concept students need throughout the year, but one they often struggle with due to the equation-solving and physical steps involved. Students wrote the scripts and acted in their own productions, using camcorders and editing software. The how-to videos served as an effective assessment tool—it was readily apparent when students did not fully understand the concepts. The skills training and practice with the video prepared the class for a more complex integration of technology and science.

## Live-action and animated videos

In 2009, as part of a professional development project with two local universities, we again expanded the technology component. After completing the bacterial transformation lab and how-to video, students were then challenged to create a video using characters or symbols to represent key aspects of the bacterial transformation process. This allowed students to demonstrate an even deeper understanding—

they were forced to think critically and create analogies and representations that translate the transformation process into a story for nonscience audiences.

Before creating their characters, students viewed several web-based DNA animations to help them brainstorm ideas; in one of these animations, a pair of scissors represented restriction enzymes and glue represented ligase (see "On the web").

In their planning documents, student groups were asked to provide written explanations for their analogies. They easily chose a trip to the desert, a visit to the Sun, or a minute in the microwave to represent heat shock, but some of the more complex representations were difficult to illustrate.

A whole-class discussion focused on the science content represented through this technology. For example, one student group used a sequence in which the main character traveled from a snowstorm to a desert and then back to the snowstorm, but then realized that the character needed a reason to travel to these destinations. After the class discussion, the group included a storyline in which the character was forced to go to a warmer location because he needed an object from the back of a trailer in which the locks were frozen shut. This represents the importance of the heat shock (cold-hot-cold) required in transformation—which allows the plasmid to pass into the *E. coli* cells. Another group created a story about a fairy princess who ate a marshmallow (the plasmid) and then developed the trait of wakefulness during magical spells (fluorescence).

For the filming of this project, students were allowed to choose different types of video formats. Approximately half of the groups chose live-action videos, and half chose animation.

## Formative assessment

In selecting appropriate analogies, students became aware of holes in their own understanding. Initially, some groups chose characters that were symbolically incorrect or could not be adequately explained. For example, in the lab, positive charges of calcium are attracted to negative charges of phosphates in DNA—this allows the plasmid DNA to move more easily through the cell membrane. In the video project, many students could not develop an analogy for this: Although they knew they had added calcium chloride, they did not fully understand the purpose. For each character, step, or symbol, students were assessed on the accuracy of their analogy and their overall storyline. During planning, the discussions served as a formative assessment; after the video was finished, it was scored using a rubric (Figure 1, p. 44) as a summative assessment.

## Conclusion

Overall, this project created a positive learning experience for students. Many remarked that they had fun as they learned about bacterial transformation. Another benefit was that the English language learners (ELLs) in our classrooms had an opportunity to practice the vocabulary multiple times with their group members and engage with the content through a variety of learning styles.

Although our experiences integrating science and technology were positive, there were some challenges. Even with the collaboration between teachers, the time commitment was greater for the version of the lab with the video production. There was also an initial time commitment for the science teacher to develop a familiarity with the technology and for the multimedia teacher to learn the basics of biotechnology. We also had to discuss

### Using Google Docs.

One of the unique aspects of this project is that students and teachers can use Google Docs as a tool to plan, develop, and grade. Google Docs is a free, online word processor, spreadsheet, drawing, and presentation service that allows users to collaborate in real time to create and edit documents (see "On the web"). We use Google Docs as a means to collaborate with other teachers and create project timelines and overviews. Using Google Docs is incredibly simple and allows editing in near real time. You can keep track of just one document, instead of sending multiple attachments back and forth.

Once the project goals and expectations are refined, student groups are sent worksheets via Google Docs. These include a summary of important facts regarding genetic transformation, a template sheet to record the characters and symbols they choose for their video, and a storyboarding outline guide. It is easy for students to reference the summary during the video-planning process since all of the information is available online.

Google Docs is especially convenient if students are working on the project for multiple classes because comments are immediately available to any invited viewer. We posted rubrics on Google Docs so students could reference the project expectations (Figure 1, p. 44). This encourages paper conservation, improves the timeliness of feedback, and makes collaboration easier. It also decreases students' excuses for missing work; if one group member is absent, the assignment is still available.

We also used Google Forms throughout the project to collect quick information from students about their progress, schedule group meetings, and rate self-evaluations.

**FIGURE 1**

## Rubric for the transformation video project.

Student names:____________________________

| | Exemplary | Proficient | Partially proficient | Incomplete |
|---|---|---|---|---|
| **Content**<br>Key components of transformation are included:<br>◆ bacteria<br>◆ plasmid/DNA<br>◆ calcium chloride<br>◆ heat shock<br>◆ ampicillin<br>◆ fluorescence (trait) | All key components of transformation are modeled or represented, shown in the video, and clearly labeled or referenced to the actual components of the lab.<br>(40 points) | All key components of transformation are modeled or represented and shown in the video.<br>(30 points) | Some key components of transformation are modeled or shown in the video.<br>(20 points) | Several key components of transformation are not shown in the video.<br>(10 points) |
| **Audience**<br>The audience is younger students; the goal is to teach about and model transformation using analogy. | Deliberate effort is made to appeal to audience; students would likely understand all major aspects of bacterial transformation through this analogy.<br>(40 points) | Effort is made to appeal to audience; students would probably understand some aspects of transformation through this analogy.<br>(30 points) | Although it does contain age-appropriate content, not much effort is made to appeal to audience; students might not understand transformation through this analogy.<br>(20 points) | Contains age-inappropriate content for younger viewers or school project.<br>(10 points) |
| **Scientific accuracy**<br>Analogy and explanation portray transformation correctly with regard to how each component works. | Video correctly and clearly models transformation.<br>(40 points) | Video correctly models transformation.<br>(30 points) | Video models transformation with a few errors.<br>(20 points) | Video contains many errors.<br>(10 points) |

**Total: _____/ 120**

our plans with our IT specialists to obtain prior approval for internet access during class time.

The decision to incorporate technology seems easy, though, after seeing how motivated students were and how much more deeply they understood the content. Students volunteered to come in and work during lunch and after school, and students from other science classes asked when they would have an opportunity to make movies. The students from classes with the added technology did better on questions relating to genetic engineering on the final exam. The multimedia aspect of the lesson allowed students to tap into their creative abilities. One student, repeating the class because she failed it the first time, compared her multimedia project to the written report she had done the year before, saying, "I usually don't understand science, but this was fun, and I really get it. My group said they want me in their group every time."

Many of our students are ELLs and will be first-generation high school graduates. Our students, much like students in other urban areas, often feel disconnected from science and are unable to find its relevance to their daily lives (Barton 2007). It is time for teachers to embrace the oppor-

A Health Science High student in the lab.

tunities offered through the integration of technology and science. As Press (1995) states, "The technology gap between schools and the rest of the world is real, and it is growing. … If we plan carefully, if we bring teachers along with us and implement new technology wisely together with other needed reforms, learning could be dramatically better." With the explosion of tools, resources, and professional development for teachers, now is the perfect time to support deeper conceptual understanding of science content by integrating technology in the classroom. ■

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## More on the transformation lab.

The genes that code for the protein in the physical lab are obtained from the Pacific jelly *Aequorea victoria*, or from corals. The plasmid vectors containing these genes are available commercially, but we get them through a partnership with a local university (see Biobridge "On the web").

In the lab, calcium chloride is mixed with the untransformed *E. coli*, the plasmid containing the fluorescent protein gene, and the gene for ampicillin-resistance. The cells are heat shocked and plated. After the *E. coli* reproduce—transcribing and translating the inserted DNA—students observe a fluorescent color (green or pink depending on the original source of the DNA). This change in phenotype is due to the expressed proteins inside the bacteria. The transformed bacteria grow on Lysogeny broth (LB) agar plates, or plates containing both LB and ampicillin; however, they are most dramatic on the LB and ampicillin plates on which the nontransformed *E. coli* do not grow. (**Note:** Complete instructions for this lab can be found at the Harlem DNA website [see "On the web"].)

## On the web

BioAlive animations: *http://bio-alive.com/animations/DNA.htm*
Biobridge: *http://biobridge.us/programs/biobridge/sciencebridge-labs*
DNA animation: *www.youtube.com/watch?v=x2jUMG2E-ic*
DNA Learning Center: *www.dnalc.org/view/15916-DNA-transformation.html*
Google Docs: *http://docs.google.com*
Harlem DNA Lab on Bacterial Transformation: *www.dnalc.org/labcenter/transformation/transformation_h.html*
University of Utah Genetic Science Learning Center: *http://learn.genetics.utah.edu/content/begin/dna/transcribe*
Pearson textbook: *www.phschool.com/science/biology_place/labbench/lab6/concepts1.html*

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