ARTICLE

A New Species of Science Education: Harnessing the Power of Interactive Technology to Teach Laboratory Science

NABT BioClub RECOMMENDATION

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Abstract

Interactive television is a type of distance education that uses streaming audio and video technology for real-time student–teacher interaction. Here, I discuss the design and logistics for developing a high school laboratory-based science course taught to students at a distance using interactive technologies. The goal is to share a successful model of science implementation that has the potential to alleviate financially induced stress on science programs.

Key Words: *Interactive television; laboratory; high school science.*

Describing the First of Its Kind

BIOL 105: The Human Gene was an introductory genetics course taught at Hudson Valley Community College and was adapted for high school learners. The course is unique to high school science education because some of the students enrolled receive the course through interactive technology. While adapting the existing curriculum, laboratory activities were made more challenging and more technically demanding. BIOL 105 is a molecular genetics curriculum, and the lab activities focus on biotechnology skills. Examples of lab activities include genetic transformations, protein purifications, polymerase chain reactions, and restriction enzyme DNA analysis. At its core, the content is centered on teaching the students how to help other people. We have emerging biotechnology companies in our area and wanted to serve those companies by teaching students common lab practices found at a typical biomanufacturing facility. The course has a total of 42 meeting days; 18 of these are designated lecture (nonlab), 21 are lab days, and 3 full classes are formal assessments. The students have access to course materials through blackboard.com. This interface also allows students to submit work via e-mail. Total enrollment of students in the class (remote students + host students) is typically about 18–20, though some sections have reached 28–30.

Place yourself in the shoes of a high school senior as you enter your science classroom. Taking your seat with your classmates, you recognize the laboratory equipment placed on the tables as electrophoresis chambers used to analyze DNA. As you remove your lab notebook from your backpack, a voice begins speaking on the mobile video conferencing unit positioned in the front of your classroom.

Waving with your classmates at the screen and receiving a thumbs-up in return, you smile because you are proud of your important role in a new way of learning science. Your school has partnered with another high school to offer elective courses via distance learning. You are a participant in one such course. *BIOL 105: The Human Gene* is a laboratory-based biotechnology course taught from a distant school to your classroom through interactive technologies. With a simple wave you symbolize an exciting, innovative method of implementing lab-based science.

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The instructor on the television continues with class by describing the uses of gel electrophoresis and potential safety issues associated with the procedure. The screen is part of a mobile interactive television unit used to implement the lab component of your genetics class (Figure 1). With a high-definition camera and microphone, it allows real-time, synchronous interaction between you and the primary instructor teaching from the other high school miles away. Taking hold of the television remote that controls the unit, your classmate activates the microphone and speaks: "Mr. Reddy, before we begin the lab and just so you know, several of us have to leave early to meet with a college representative, so we'll need to connect and finish the lab after school with you." The ease of using the technology allows you the same opportunities to meet with your instructor as if he were in the same room.

The current situation facing schools is a constant source of anxiety for educators, administrators, parents, and students. Distance learning (DL) through interactive television (ITV) is a method of content delivery that breaks down the fiscal barriers currently being erected. Through this type of instruction, school districts can capitalize on community partnerships to

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Figure 1. *"Hello, I am happy to see you and excited to get us started, Maple Hill, please wave if you can see and hear me."* A mobile videoconferencing unit is used to provide lab instruction.

implement an effective, alternative way of delivering quality science education to high school students. Here, I describe how you can create a platform to develop a lab curriculum taught through interactive television.

Laboratory courses offered to students learning at a distance seem to present formidable obstacles. Lab safety, setup, and other in-class management issues immediately come to mind. Hannum et al. (2009) phrase it perfectly: "While science is a core course, it is possible some districts do not offer science by Distance Education due to the difficulty including the lab component."

Science courses that are offered to students learning at a distance use a variety of methods to implement the lab portion. Forinash and Wisman (2001) observed that there was a growing list of lab implementation techniques that attempted to solve the DL lab dilemma. They cited current techniques used to satisfy the lab component of science courses taught through distance learning, including activity kits made available for purchase by the remote student, computer simulations of lab activities, and videos showing a specific lab activity. Interactive television is a popular method of content delivery (Horvath & Mills, 2011) and has been utilized to offer content to students learning at a distance in subjects other than laboratory science. Paulsen et al. (1998), Donorfio and Healy (2008), and Kleinpeter and Potts (2003) all discuss different aspects of non-science ITV courses and are excellent examples of the potential of ITV for educating students at a distance.

First, a few terms. As used here, *distance education* is the teaching of students who are physically separated from their primary instructor. The *primary instructor* is the individual who designs, organizes, and is the current implementer of the curriculum. The *remote site* is the classroom that is physically separated from the primary instructor. The remote site has a *facilitator*, an adult responsible for the daily management of classroom procedures (described below in greater detail). The *host site* is the classroom where the primary instructor is physically present. *Interactive technology* is any device that allows the synchronous interaction of anyone physically separated.

○ Program Development, Step 1: Develop a Partnership with an Area Community College or University

The discussion of teaching a laboratory science course to students at a distance using interactive television would be irrelevant if the financial strain on schools were absent. Community partnerships help alleviate the financial challenge of teaching through a television. Most universities and colleges are financially stable and work hard to serve their surrounding area. Teaching using interactive television is an expensive endeavor and, hopefully, is a cost that can be more easily absorbed by our larger, more financially independent neighbors.

Designing an elective curriculum allows you to teach past "what the state requires" and give your students access to ultra-relevant science content. What better way to inform yourself of content that is relevant to your area than partnering with an institution whose sole purpose is to be responsive to the community? Community colleges are dynamic organizations whose course offerings, curricula, and professors directly reflect the needs and the wants of the surrounding area. Community college partnerships can inform curriculum development so that the content being taught is relevant and valuable.

Finally, the community college handles the technology involved. When connecting with your remote students, you are essentially videoconferencing. Most, if not all, community colleges support distance education initiatives, and most offer classes through interactive technologies. It is their responsibility to set up the connections and provide the technology. From a more technical perspective, the community college will provide the "bridge" and have the technological capabilities to provide streaming, synchronous audio and video from one classroom to the other. It is important that the issue of connectivity be brought up early and often in your planning conversations. Community colleges are familiar with the concepts, and their technology staffs are very capable of providing the technical support required for your initiative.

This may seem like a lopsided relationship – we get financial support, curriculum guidance, and technical expertise; how do we scratch their back? By developing a community partnership with an area community college or university, you are appealing to the business component of their institution. The college views the partnership as an investment. They invest money and content guidance and, in turn, receive highly qualified students ready to succeed in their college programs.

○ Program Development, Step 2: Make Initial Observations So That You Can Develop & Define Goals Collectively

Decreased course offerings, empty student parking lots, swelling study-hall numbers, and a lack of course options for middle-level learners led us to develop our program. What observations can you make in your school that motivates your initiative? Consider your observations and collectively define your goals. For example:

- *High school educator:* It is my goal to encourage students to explore their higher-education options by teaching relevant science and reach as many students as possible despite the financial climate.

- *Community college:* Our primary educational purpose is servicing the surrounding area by supporting secondary science programs that generate genuine interest in our academic programs.

Collective goal setting ensures that all parties involved are cognizant of the objectives; we can now work together to meet those goals. With goals identified, we can also define our thought process and identify our rationale (Figure 2). To prevent program failure, the thought process and rationales need to be interdependent. Each party identifies their rationale and includes components dependent on other members of the partnership, creating a web of support.

○ Program Development, the Final Step: Designing Your Curriculum & Preparing Your Lab Experience

Organizing Your Curriculum

It is the community college's responsibility to guide development of the curriculum. If students are receiving college credit, the course must follow the college's existing curriculum. If an existing curriculum is not available, use resources in your surrounding area and the

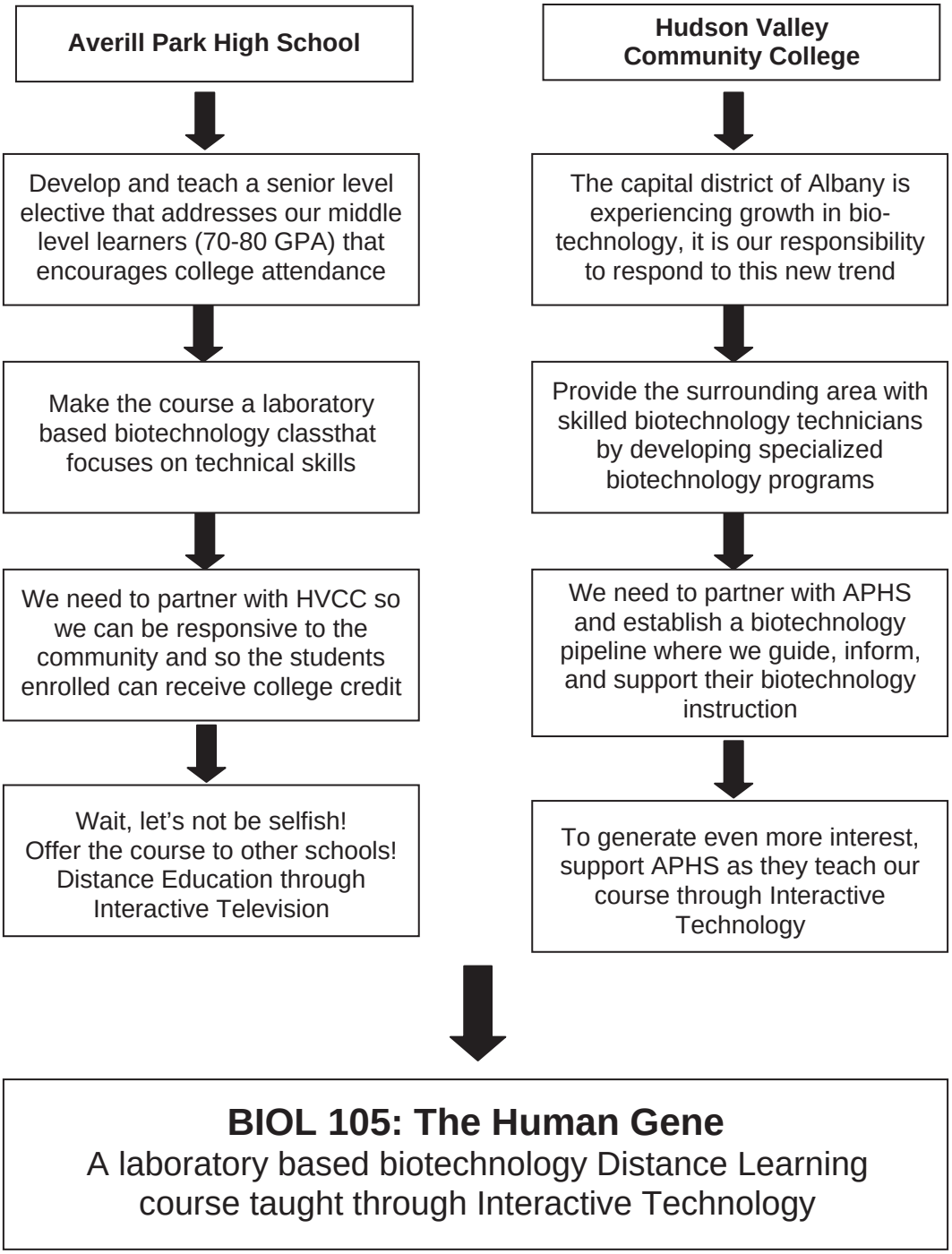

Figure 2. Thought process to develop BIOL 105, a laboratory-based science course taught through interactive technology.

expertise of the community college to guide its development. Develop the curriculum to meet your goals. To accommodate the technology, you need to work through several steps for advanced preparation. First, divide the course into lecture topics and lab activities, designating "nonlab days" and "lab days." This will help with initial organization and lab preparation. Organize your calendar: It is absolutely imperative that the calendar of the course be organized before the beginning of implementation. You need to know what you are doing and when you are doing it. With the course sequence organized, you have a framework from which to work. This will allow you to organize and distribute necessary lab materials and ensure proper lab setup. Additionally, with the content sequence established, management of remote-site logistics is made easier. (For example, "On 1/9/13 the students are working through a gel electrophoresis and need prepoured agarose gels…. I need to make sure the facilitators at my remote sites remember where they are stored.") Make your life easy and plan the entire year. This is how you do it:

- Count the number of days your class plans on meeting (42). Count the number of lecture days your course will have (18). Count the number of lab days you plan on having (21). Count the number of days you plan on assessing the students for the full meeting time (3). This step allows you to make preliminary adjustments by adding or subtracting lectures and labs on the basis of time available.
- Make a sequence of lab classes, lecture classes, and full class assessments. With a blank school calendar, match your sequence with the days the class is scheduled to meet. At the end of this step, you at least know what you are teaching and when you are teaching it. Be sure to send this calendar to the community college so that they remain informed. With your calendar organized, you are now ready to organize lab activities.

Organizing & Preparing Lab Activities

When implementing lab activities for students learning at a distance, "morning-of" setup is out of the question. Setup needs to occur before the semester begins. The process of organizing lab materials for an entire course may seem overwhelming, and it can be, but it is the most important step in ensuring lab success. Try doing the following to begin.

(1) List the materials for each laboratory, and then develop a master list for the entire course. An Excel spreadsheet is very useful and helps with organization. Collect all the lab materials and distribute them to your remote sites. Make sure that each material is labeled with its name and what lab it will be used in. Labeled storage bins containing the necessary materials for each activity may be useful.

(2) Set up and complete the activities yourself before implementation of the course. This is done for two reasons and is a very important step for your remote facilitator. First, as you complete the lab activities, make note of any special circumstances or "sticking points." You already know how to problem-solve during a lab activity when you are physically present in the classroom. Problem-solving at the remote site is a new and unique experience. Consider each issue as a problem and preplan how you will address them when they arise at the remote site. This step allows you to be proactive about potential problems.

Next, take a picture of the lab setup as you work through each. It is strongly encouraged that you make a Laboratory Setup Manual, which will ensure that the facilitator at the remote site correctly prepares each lab and, thus, that both sections of students have equal experiences while working through the activities. This is how you create a Laboratory Setup Manual:

- Take pictures of each lab setup. Make sure you have one depicting each student station and any common area with shared materials that you may need. Label materials if necessary.
- Place the pictures in a Microsoft Word document.
- In the same document, give the title of the activity, background information, safety concerns, a list of needed materials, any procedures for preparing necessary components (e.g., mixing buffer and culturing bacteria), expected results, and most important, a step-by-step procedure to set up the activity.
- Print all the lab setup documents for each activity, bind together, and distribute.

Finally, write your student lab manual, which will contain all the activities completed throughout the course. While working through the labs on your own, make necessary adjustments to the procedures and make them as descriptive and straightforward as possible. Including labeled pictures is a great way for students to double-check their progress. It is recommended that the manual be spiral-bound so that it remains flat when open.

○ Remote Facilitator: Safety, Lab Preparation, & Daily Management

The facilitator, to this point, has simply been described as the adult present in the remote-site classroom. The facilitator may be a certified science educator, though they need not be, because they have been trained and informed on laboratory procedures. The facilitator has three important responsibilities: lab safety, lab preparation, and general classroom management.

Lab safety is the most important consideration when designing and implementing a lab activity. An immediate question often arises: How are the remotely learning students kept safe? The primary responsibility of the remote-site facilitator is student safety. They are briefed on potentially hazards laboratory materials and instructed on laboratory safety protocol.

In preparation for laboratory implementation, a Laboratory Setup Manual has been developed. The second responsibility of the remote-site facilitator is to prepare and set up activities as described in the manual. They simply need to follow instructions to position necessary equipment and prepare materials.

Finally, they attend to daily procedures. Attendance, drills, and other common classroom occurrences need to be managed by the remote facilitator. A strong working relationship is required between the primary instructor and remote facilitator to ensure laboratory safety and success. Constant communication is the most important factor in developing and maintaining this relationship.

○ Getting Started with the Development Process

Approach your curriculum coordinator, administration, or anyone in the position of deciding course offerings. Describe your initiative: to design an upper-level science elective, offer it to other area high

schools through interactive technologies, and engage the support of an area community college so that no cost is incurred by the district. With administration support, approach an area college and pitch your idea!

○ Conversation Questions: The Logistics That Matter

How do the students submit work?

Students submit work through our interactive website, http://blackboard.com. The primary instructor manages the shared website.

Doesn't the safety of the remote students worry you?

YES! The students, parents, principal, and primary instructor all sign a Distance Learning Laboratory Safety Contract. Additionally, the remote facilitator is trained in lab safety. The facilitator's primary responsibility during the lab activity is student safety. They monitor the lab situation with one goal: to prevent potential safety issues.

How do you have "personal" conversations (grades, etc.) with your remote students without including the rest of the students?

Private conversations between remote students and primary instructor are made possible with Jabber (Movi, Skype). Private conversations can be had using desktop computers in each classroom that have connected via our shared Jabber account.

How do you assign and report the students' grades at the remote site?

Remote students are entered into the primary instructor's electronic grade program. When grade submission is required, the primary instructor sends the calculated grades to the guidance offices or to the facilitating adult at the remote schools.

What happens if you have a fire drill? Or the other school has a fire drill?

It happens! All the course materials are made available to students on blackboard.com. Treat the drill as a break and simply move forward when appropriate. If you run out of time, the students are still responsible for the material as it is made available to them.

What about snow days (or other school closings and absences) for one school and not the other?

The short answer is "We deal with it." Lecture materials are provided to each student through blackboard.com, and the students are responsible for the material. The students who do not attend school that day are responsible for completing the lab. Connecting after school is always an option for completing missed laboratories or reviewing lecture material.

What happens if you cannot connect during lecture or lab?

Lab materials, lab procedures, and lecture/discussion notes and topics are made available to every student. All the materials to work through a lecture or lab activity are in place; the students need to be proactive about their own learning in this situation. As with unplanned school closing, the remote students need to complete the work without the guidance of the primary instructor. The remote facilitator will have a greater responsibility for managing and conducting the class in the situation.

How do you pace lessons if you are not in the actual classroom?

Assign one student at your remote site as your "eyes and ears." They have an added responsibility during lab activities. Every 10 minutes, it is their job to quickly check in with each lab group and report progress back to you (e.g., "group 1 is on procedure step 6, groups 3 and 4 are both on procedure step 7, and my group just finished and is beginning the analysis of questions"). Though you can observe them, this helps you stay even more involved with their progress.

Since you are working so closely with a community college and have modified their curriculum, do the students have an opportunity to earn college credit?

Yes, Hudson Valley Community College has a high school outreach program called College in the High School. Many community colleges have similar programs. The students receive three college credits upon course completion.

How do the students react to the camera?

At first, everyone is hesitant speaking on camera (primary instructor included!). Get the students speaking early and often, and within a week there will be no issues. The students will feed off your comfort level with the technology.

What should I remember when approaching a local community college or university?

Stress the formation of a partnership. You will provide highly qualified students who will "plug into their pipeline." If possible, they provide the technology (videoconferencing units), technology support (videoconferencing bridge), and curriculum guidance.

How should I approach my administration?

Your administration will be receptive if you approach them with a solution to the financial plague. Clearly outline the responsibilities when developing the program and stress the financial contribution of your area college or university. Be explicit with your descriptions of how your administration can support your initiative. You need them to help initiate the conversation with the college and other high schools, help with the logistics (scheduling), and provide you with the time you need to develop the course.

○ Acknowledgments & Correspondence

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