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Using Multiple Modes of Learning in a High School Genetic Engineering Lesson

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USING MULTIPLE MODES OF LEARNING IN A HIGH SCHOOL GENETIC ENGINEERING LESSON

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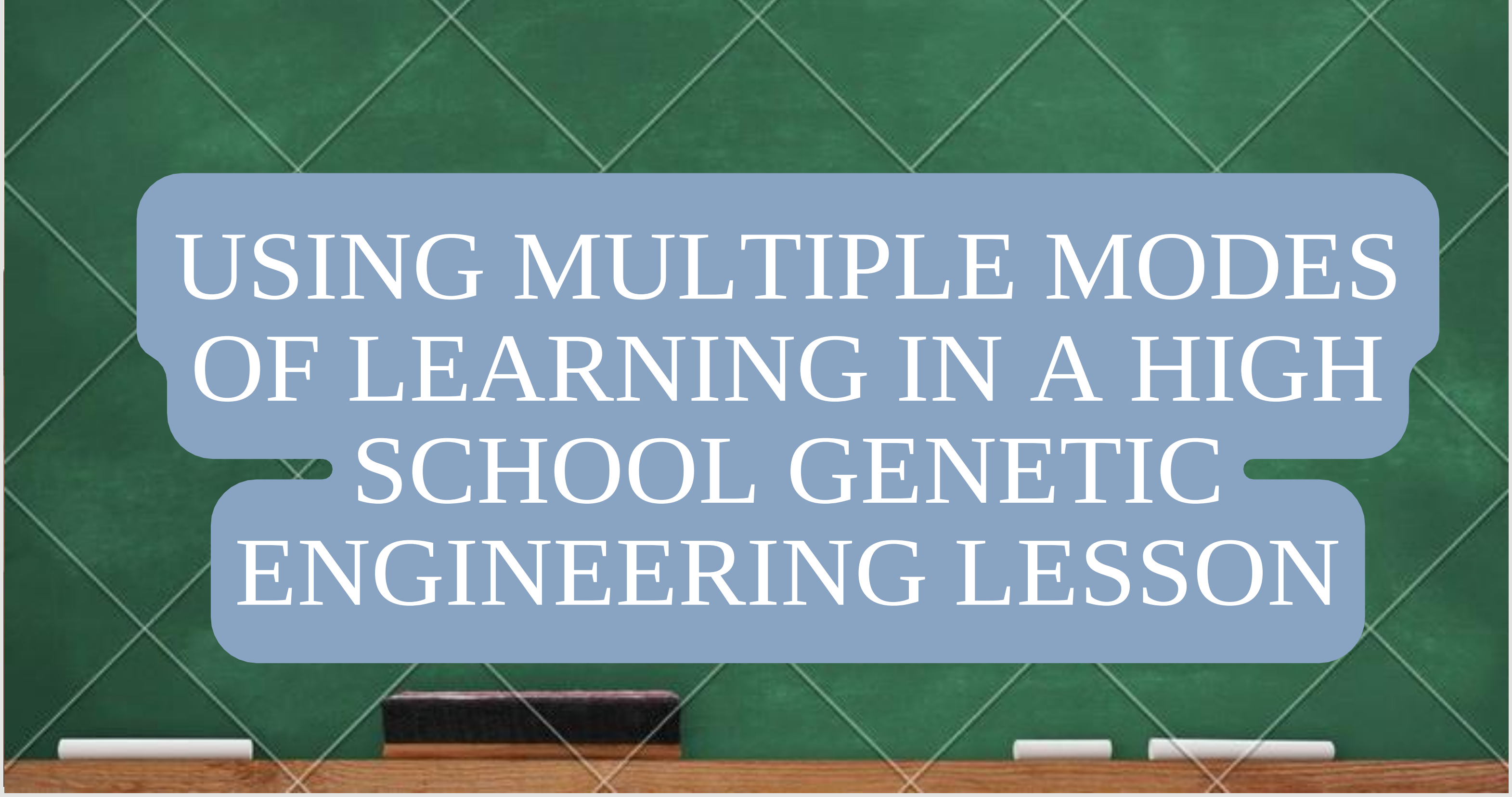
Abstract

The goal of this article is to discuss a genetic engineering lesson presented to high school biology students to obtain mastery of the Biology Standard of Learning (BIO.5e) associated with genetic engineering products and practices. The lesson described in this article follows the 5E lesson plan model. Therefore, the article will describe the 5Es used in the creation and implementation of this lesson: engage, explore, explain, elaborate, and evaluate. This article focuses on the use of resources and activities that appeal to students with varying learning styles and looks at the effectiveness of individualized teacher-student attention during individual practice time. These pedagogical strategies were purposefully selected and implemented based on previous research and classroom observations.



USING MULTIPLE MODES OF LEARNING IN A HIGH SCHOOL GENETIC ENGINEERING LESSON

Content Area:
High School Biology

Grade Level: 10th grade

Big Idea/Unit:
Genetic Engineering

Essential Pre-existing Knowledge:
How DNA base pairs to a complementary strand.

Time Required: Two 90-minute classes

Basic Safety Requirements:
No horseplaying with scissors

The lesson described in this article is part of a genetic engineering unit and focuses on the uses of genetically modified organisms (GMOs), how they are made, and the ethical considerations associated with them. This lesson is designed for high school biology students (10th grade) to meet the BIO.5e standards of learning for biology, which requires students to understand that “synthetic biology has biological and ethical implications” as outlined in the Virginia Standards of Learning (Virginia Department of Education, 2018). Some of the main focuses of this lesson is for students to understand that genetic engineering is used in a plethora of industries, such as agriculture, medicine, and research. Students also learn the benefits of genetic engineering processes, such as its use to produce human growth hormone, insulin, and pest and disease resistant crops. Many science disciplines are combined to build new synthetic biological products through genetic engineering, and students must have a knowledge of the ethical considerations that are associated with these practices. This information is important for students in today’s society to know because increasing technological advances allow for advances in the fields of biology and genetics and has yielded a wide array of genetically modified organisms and uses of genetic engineering. This is something students will likely experience during their everyday lives, even just by picking up a tomato at the grocery store.

This lesson has a focus on using multiple modes of resources to appeal to various learning styles, especially kinesthetic (hands on) learning based on observations performed in the classroom prior to the lesson being developed and taught. There is also a focus on individualized attention during practice time and completion of independent work. This pedagogical approach was also based on experiences observed in this classroom prior to the creation of the lesson. The strategies used support diverse learners because they give students several opportunities to share their own experiences and ideas with regards to the topic of GMOs and genetic engineering. This lesson didn’t come with many safety concerns. The proper use and handling of scissors was modeled and emphasized prior to student use. Safety considerations with regard to genetic engineering were also discussed throughout the lesson.

Materials Needed:

- Chromebooks (1 per student)
- Internet access (whole class)
- Projector (1 for whole class)
- White board (1 for whole class)
- Amoeba Sisters: Genetic Engineering Video -
- Youtube (1 copy for whole class)
    - Amoeba Sisters Genetic Engineering Video
- Slideshare PowerPoint (1 for whole class)
- Scissors (1 per student)
- Plasmid Activity Cutouts (1 per student)
- Bacterial Transformation Worksheet (1 per student)
- Bacterial Transformation Student Answer Key (1 for teacher)
- Design Your Own GMO Guidelines (1 per student or 1 per group)
- Design Your Own GMO rubric (1 per student or 1 per group)
- Canva (or other infographic creation tool) (1 per gifted student)
- PowerPoint (1 per group or 1 per student)
- Group Member Grading Rubric (1 per student)
- Quizlet/Quizizz or another online assessment tool

Figure 1: *Supplies needed for bacterial transformation demonstration.*

The approximate time required for the lesson is two 90 minute classes. The lesson is flexible and can be adjusted to fit the time restraints and level of detail needed.

This lesson uses multiple modes of resources and activities to appeal to the various learning styles of students (visual, auditory, kinesthetic). Visual images support learning and aid in comprehension of content material (Afhasafari, Bivins, & Nordgren, 2021). Zhang, Carter, Basham, and Yang (2022) affirm that multiple means of learning helps ensure that all students have meaningful access to the learning material. This is accomplished during this lesson by giving students access to a PowerPoint (visual learners), lecture and discussion (auditory learners), videos (auditory and visual learners), and hands-on activities and demonstrations (kinesthetic learners). Culturally sustaining pedagogy involves providing students with a positive environment where they feel open to express their thoughts, experiences, and viewpoints (Afhasafari, Bivins, & Nordgren, 2021). This includes being given the opportunity to make connections between the world they live in and the content material, like genetic engineering and GMOs in this case.

Building on students' prior knowledge, as demonstrated by Zhang, Carter, Basham, and Yang (2022), helps students build a bridge across the gap in their knowledge from what they already know to new information. Students are given the chance to make these connections at various points throughout the lesson, especially during discussions throughout the lecture. In the following sections, I will detail the 5Es of this lesson plan, the pedagogical strategies that were implemented, and the activities used in this genetic engineering lesson.

Engage

To engage students at the beginning of the lesson, I always ask students to raise their hands if they have a cat. The majority of students will raise their hands. Then, I asked students to raise their hands if they have a cat that could glow in the dark. Students generally respond with confused looks. Then, I will show them a picture of glow in the dark cats, which can be found with a quick Google search. Students are absolutely blown away by the pictures.

Next, I ask students if they have ever seen Glo Fish in pet stores. Again, most of the students will raise their hands. Then, I show pictures of GloFish, as well. Students are then posed with the questions, “What makes these organisms glow? How is this possible?” In one of the classes this lesson was taught in, a student guessed the correct answer of genetic engineering. I pushed further and asked if anyone could give me a definition for genetic engineering. In the first class I ever taught this lesson, I asked students if genetic engineering was just when several generations in a family decided to drive trains for a living, which was met with mostly blank stares. That joke was retired quickly.

Figure 2: *Student Example Paper Plasmid*

Explore

After the initial discussion and introduction of these topics, students will form groups and research three GMOs that were modified to glow in the dark. These include a tobacco plant, Glo fish, and glow in the dark cats. Students can either complete their own research on one of the given topics, or specific articles can be selected by the teacher. The latter would be beneficial in a class with students of varying reading abilities because students can be grouped based on reading level and read differentiated articles on each topic. Students can make their own discoveries based on the article or can be given guided questions used to point students to certain information. In the past, I have asked students to find out what causes these organisms to glow, what genetics are involved, and how this is accomplished. After each group shares their discoveries, a brief discussion will be held that connects the topics of the glowing GMOs students have researched. Other types of GMOs can be researched as well.

Explain

Next, the PowerPoint slides will be pulled up and taught while asking probing questions that foster discussion. The PowerPoint describes what GMOs are, the process by which they are formed (bacterial transformation), and gives examples of GMOs. The discussion about the glow in the dark animals can lead into talking about how GMOs can also be used for things students can relate to: diabetes, livestock, fruits and vegetables. One key question I like to ask is what GMOs students encountered in their daily lives. A common response from students involves fruits and vegetables in the grocery store. When I taught this lesson previously, I brought up the use of genetic engineering to produce human insulin for people with diabetes. One student volunteered that she had diabetes and her father made insulin for her as a little girl because the genetically modified insulin was too strong for her. Students will also need to come up with uses of genetic engineering in the agricultural and healthcare fields. While moving through the PowerPoint slides, it will be beneficial to discuss the pros and cons of a few GMO scenarios. For example, while looking at the example of pine trees modified to grow bigger and faster, students can discuss how genetically modified organisms could become invasive to native species. Students can discuss if they think the pros outweigh the cons.

When discussing bacterial transformation, the process by which GMOs are formed, demonstrate the process using different colored construction paper, scissors, and tape to show how restriction enzymes (scissors) cut open a plasmid (blue paper) and ligase (tape) glues the gene of interest (green paper) together to form recombinant DNA. Upon completion of the lecture, ask students if they have any ideas for a new GMO they want to invent. Students will likely come up with a plethora of answers. When I previously taught this lesson, one student wanted to make himself taller using genetic engineering. After the lecture, students will watch an Amoeba Sisters video on genetic engineering to review the information they just learned.

Elaborate

Next, students will complete the Paper Plasmid Activity where they will cut out the human insulin gene and insert it into a plasmid. Throughout this activity, students will demonstrate the bacterial transformation process using a paper plasmid and insulin gene to create recombinant DNA that could then be taken up by bacteria to make a biosynthetic product or produce GMOS.

Scissors will represent restriction enzymes and tape will represent ligase. The first time I taught this lesson, I explained all the steps at the beginning of the activity and then turned the students loose. Chaos ensued, and I quickly realized I was going to have to explain the activity differently in the future. For the following two classes that day, I adjusted to step by step instructions with intermittent individual work time for each step. This allowed for more individualized help with each step, which proved helpful. I had to tell the last class to not work ahead in creating their plasmid because several students tried to work ahead in the second class and cut their plasmids into pieces and had to either start over or tape them back together. I highly suggest having students complete the activity in steps. Figure 3 shows the individual steps to complete the Paper Plasmid Activity. At the end of the activity, students will be left with their own piece of recombinant DNA with the ability to make human insulin.

Figure 3: *Paper Plasmid Activity Steps*

Evaluation

Both formative and summative assessments will be used during this lesson. Students will complete a Bacterial Transformation Worksheet as a formative assessment upon completion of the Paper Plasmid Activity to see if students could apply what they learned in the activity.

The purpose of this worksheet is solely to gauge student understanding of the process of bacterial transformation and the enzymes and biological molecules involved, and will not be graded. These worksheets can be collected at the end of the lesson and reviewed to see if students understand the material or if they will need additional practice. To extend this lesson you can also use the additional formative quiz that is included in the lesson plan. This lesson plan calls for the use of Quizizz and Quizlet as assessment resources but other online assessment tools can also be used.

Students will complete a summative assessment which is a performance assessment that requires students to create a poster or PowerPoint presentation designing their own GMO to solve a global or local problem (ex. hunger, pests, school lunches). Students will have to answer the following questions:

- What is the gene of interest? What organism is the normal DNA from (plasmid?)
- What organisms are involved?
- Discuss how this will improve or solve the problem.
- What are possible pros and cons of this solution?
- Are there any ethical considerations?

Students will be allowed to work in groups to develop their GMO. Each group will present their GMO to the class at the end of the lesson. Below is the rubric that comes with the Design Your Own GMO activity.

Concluding Thoughts

After the first time I taught this lesson, I realized that I would have to make some changes. To begin with, I gave students the full set of instructions on the Paper Plasmid Activity and turned them loose. However, there was a lot of confusion and chaos. Even the special education teacher who was trying to help students was confused. It was clear to me that I was going to have to figure out what adjustments to make before the next class. For the next two classes, I instructed students step by step. I explained how to do step one, gave them time to work on it, and then showed them what their plasmids should look like at the end of that step. This seemed to work much better and allowed me to walk around and assist students. Based on my experiences with this lesson, I highly recommend breaking the Paper Plasmid Activity into steps and providing guidance and a demonstration of creating your own plasmid at each step.

By teaching this lesson, I have learned a great deal about adapting my teaching style to the needs and interests of my students. The first conclusion I have made based on my observations is that hands-on learning increases engagement and student learning. A student who rarely participates in class is more likely to participate during a hands-on learning experience. In general, students will become more excited about hands-on learning than they will about passive learning. This engagement in turn creates greater student learning and retention.

Secondly, I noticed that individualized help during individual work time is beneficial to student understanding. When I taught this lesson in the past, students who didn't understand the Bacterial Transformation Worksheet during individual work time quickly gained understanding when I helped them connect the worksheet content to the Paper Plasmid Activity they had just completed. This ties back into connecting content material to hands-on learning experiences. Students understood what they did with the hands-on Paper Plasmid Activity, but they needed guidance to connect that information to the concepts on the Bacterial Transformation Worksheet. If left alone to make this connection, many students would fail. This is why it is important for a teacher to have that one-on-one interaction with students during individual work time.

Next, I found that instruction may look different for each class and this instruction must be tweaked to fit student needs. For example, the first day I taught this lesson, I taught it to three classes. These three classes varied in ability level and participation. One class, which had the highest ability level, needed less guidance on the activities but did not want to participate in discussions.

On the other hand, a different class was very engaged during the lecture and answered and asked questions but needed more guidance. Every class is different, and instruction should reflect this difference.

As many educators and researchers have found, connecting new content information to students' prior knowledge is helpful to form a bridge over the gap in their understanding. I highly suggest building this connection using probing questions throughout the lecture. I practiced this by asking students about their experiences with genetic engineering and what they knew about the topic. At some point during the lesson, I also ask students if they have any ideas for a new GMO, which gets students thinking about ideas in preparation for the Design Your Own GMO project.

Overall, this lesson incorporates a variety of learning modes to increase student comprehension. This allows for all students to have their learning styles met and greatly increases their chances of success. This lesson can easily be adapted to meet the needs of students. As with any lesson, keeping your audience in mind is crucial to the success of the students.

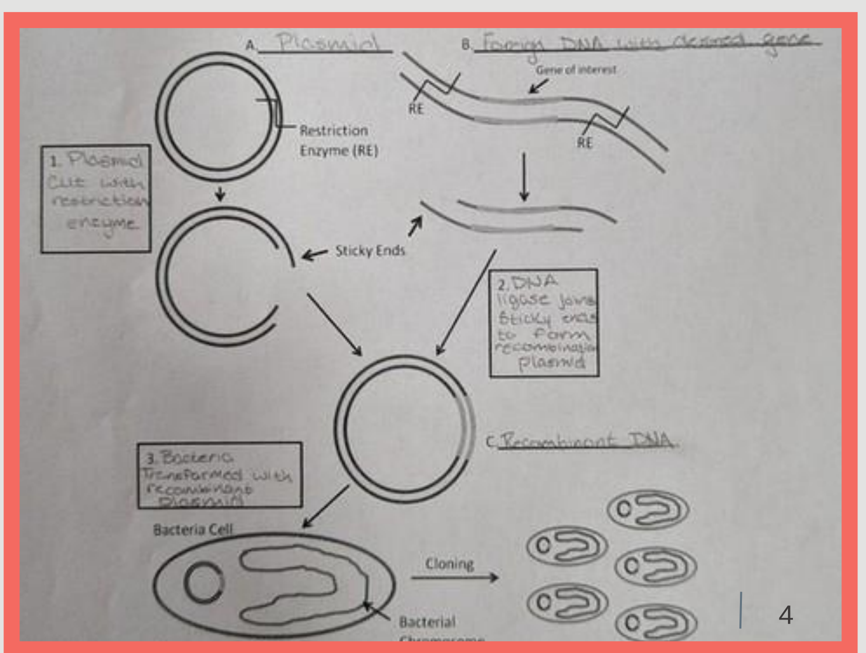


Figure 4: *Student Example of Bacterial Transformation Worksheet*

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Resources

- Genetic Engineering Slide Share Notes
- Plasmid Activity Cutouts
- Plasmid Activity Answer Key
- Plasmid Activity Instructions and Guide Video/ Lesson Plan
- Design Your Own GMO
- GMO Quizizz
- Bacterial Transformation Worksheet
- Bacterial Transformation Worksheet Answer Key
- Quizlet Formative Assessment
- Group Member Grading Rubric

Design Your Own GMO RUBRIC

Category	1 Point	3 Points	5 Points
Global Issue - A current world or local problem is listed that is in dire need of fixing. The problem is real and not made up.			
Original Organism - The original organism chosen has characteristics listed that fit well with solving the global issue			
Modification - The modification made would help solve the global issue and is practical enough to be done on the original organism (based on its size, shape, functionality, etc.)			
Creativity - The project shows great creativity in all aspects. The modification made on the original organism was well thought out and is unique from other students' modifications			
Neatness & Color - The project is organized, making it easy to read and follow. It is legible, well formatted, and eye-catching. There is a great use of color and pictures are included for each of the four steps.			

Figure 5: *Design Your Own GMO Rubric*