High school Biology Classroom

Hardy Weinberg equation

The central focus of this unit is to determine the allele frequencies of the class population using the Hardy Weinberg equation. The students will determine their genotype for a set of traits that they were able to identify through the lab. The students will need to understand that if they show the dominant feature of a trait the student will only be able to determine one allele and if they show the recessive feature they will be able to correctly identify both alleles. This will be essential to using the Hardy Weinberg equation for calculating allele frequencies. At the completion of this lesson the students will be able to calculate the allele frequencies for each trait using the class data.

The standards that will be addressed during this learning segment are:

CCSS.MATH.MP5: Model with mathematics

CCSS.MATH.CONTENT.HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

NGSS HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

The learning outcomes for the learning segment are:

Students will be able to:

1. Determine their phenotype of their visible traits and will then determine their genotype. (HS-LS3-3)

2. Use the class data to determine the allele frequencies. (MP5 and HSN.Q.A.2))

3. Interpret the class data and determine how the allele frequencies are different for different populations. (HS-LS3-3)

The students will be exploring genetics throughout this learning segment. The students will be learning the difference between genotypes and phenotypes in the biology portion of the unit. They will learn how to complete a Punnett square and identify the phenotypes based on the genotypes and the alleles. During the genetics activity, the students will get to explore how the allele from each parent will determine the genotype. The students will also be exploring how the phenotype is directly related to the genotype.

The lab the students will be performing during this learning segment will wrap up the unit on identifying genotypes and phenotypes of the class. The students will identify their phenotypes for a given set of traits and from those phenotypes will identify their potential genotypes. After the students have discovered their possible phenotypes the lesson will progress into the students determining the allele frequencies for each allele. The students will be use data that they have collected during the lab to determine the allele frequencies using the Hardy Weinberg equation. Through doing this lab activity the students will be working towards meeting the learning outcomes and the standards.

Students will use their knowledge of genetics throughout this learning segment by determining their traits with a partner. Once the students have determined their traits the students will use their genotypes to calculate the allele frequencies of the class. Students will be making the connections to the real world and will relate the mathematics to biology. The lab will require the students to think about what might change the allele frequencies and if they believe there will be a difference between classes, the whole school, and larger populations. By having the students relate their genetics to the class and beyond the students will be making a personal connection to the content and will also be expanding their mathematical understanding of frequencies.

Students will be given the opportunity to express their understanding throughout the lab and during the math instructional period. I will walk around the class asking the students how they are doing and ask each student to assess their level of understanding. During my direct instruction, I will assess student understanding by having the students give me a thumbs up if they understand, a sideways thumb if they are a little iffy, and a thumbs down if they have no idea what is going on. This will allow me to modify my instruction to meet the needs of the students will also allowing the students to have an input without having to wait until the very end of the lesson.

The learning outcomes are written on the lab handout for each student which allow them to refer to them throughout the activity. The learning targets will be posted on the board and I will ask the students to rate their level of understanding to each learning target at the end of each lesson. If students are not where I think they should be at the end of the lesson I will plan a warm up activity to start the next lesson that will reengage the students with the learning targets.

Students know what a genotype and phenotype is. The students have been working on determining the genotypic and phenotypic ratios of the offspring from two parents. The students have a range of math skills that will affect the lesson when determining allele frequencies. However, every student will be able to reach the learning targets by the end of the lesson through additional support. All students have taken at least algebra 1 and understand how to determine a percentage. The prior knowledge of the students will be critical to the success of the lab. The lab will help the students fully understand the difference between phenotype and genotype by having each student identify their traits and they will then record this information in a table that will be used to determine allele frequencies. The lab is attached in my lesson plan.

My students are interested to see how genetics plays a role in their lives and this lab will help each student understand those traits. The lab will allow all students to see a trait they may have and identify the difference that appear in their classmates. All students will be encouraged to express what makes them unique in the lab when answering questions that are specific to their phenotypes. Once the students begin to calculate the allele frequencies for the class I will ask if the students believe if these frequencies are true for all population sets or if we might see differences based on more diversity or less diversity. The students will then get to express their beliefs and can provide input on what they see in their family and or friends. Every student has a different genetic make-up and this lab will allow for students to celebrate their differences and to see how we are also similar to one another.

The students will be applying mathematical principles to data they have collected which will all the students to see that math plays a role in the biology classroom. The students will also be encouraged to share their strategies to solving the allele frequencies. By using the students genotypes the class will be more connected to the mathematics and it will have more meaning.

The students think math can be useful but overall feel that math can be boring. I have students that really excel in mathematics but struggle with the biological principles and vice versa. This activity will really help the students apply mathematics to real world data that they will be collecting. Having this connection to the data will help the students take pride in their work and realize that math is used in the real world. My students are confident in their math skills but are not as confident in the application of the mathematic principles to real world scenarios.

The students know how to determine the phenotype from the genotype and in this lab they are going in reverse order. I have chosen to use a lab that provides the students a guide to follow for identifying their phenotype based on the trait they have identified. After the students have identified their phenotype they can follow the lab to fill in the chart. By having these explicit instructions my students that may struggle in one area will have the resources to guide their learning and the students that are faster paced will be able to complete the table without necessarily reading every step of directions. The lab will help my all of my students succeed even if there is a gap in prior knowledge. After the students complete the part of the lab where they have identified their own genotype I will bring the class back together and have the students walk me through the Hardy Weinberg equation. This will allow all students the opportunity to explore this equation for the first time while also allowing the advanced students the opportunity to work ahead. As a class, we will have to share data so that we are working with the same set of numbers and then we can have a class discussion about what the allele frequencies mean.

The lab activity will be a partnered activity to allow for individuals to get the opportunity to ask a classmate for clarification and to have a second opinion on which trait they are showing. By having the students work with a partner they can bounce ideas off of each other and they are given the opportunity to use the academic language in a low stress environment without the fear of speaking in front of the entire class. Research supports the use of peer learning and small group activities when exploring new concepts. The opportunity to work with a partner during the lab will also help the students develop a mental framework of acting like a scientist would. These strategies are important to developing the students to have an expert mental framework and to be given the opportunity to explore science as it really occurs.

Once we have shared the class data we will go over an example of how the Hardy Weinberg equations relates the genotypes seen in the class. The gifted students will be allowed to work ahead and complete the table at their pace. Once the gifted students have completed the table they will be asked to expand on what they have learned and compare the allele frequencies with data from previous class periods. By allowing the students to look at other data they will gain more understanding of how the data changes for different populations as well as identifying any possible trends they might find. These students will be asked to share what they found in small groups or to the entire class. While the gifted students are able to look at more data the rest of the class will continue working on the table after we have worked through an example. Once the entire class has finished the table we will come back together as a whole class and discuss what we have seen. The class discussion will be student lead and I will ask Socratic questions that will lead to further understanding of the content. I will ask students to explain how the allele frequencies relate to the Hardy Weinberg equation and Punnett squares. The students will need to make these connections to ensure they have a deeper understanding of how the mathematics connects to the biology. Depending on if my gifted students feel comfortable sharing with the class I will ask them to share the similarities and differences they have discovered with looking at more data.

The students will be given the learning objectives on their lab handout as well as printed on the whiteboard. I will bring the students attention to the learning targets at the beginning of each lesson and take moments throughout the lesson to ask the students to rate their understanding of the material as it relates to the learning targets. Each student will be given the opportunity to assess where they are at when I ask the questions to the whole class and when I am walking around the classroom. I will ask the students how they are doing when I am walking the classroom to give the students more opportunities to assess their understanding and mastery of the learning targets.

One common mathematical error that might happen during this learning segment is rounding errors. Students have difficulties knowing when and where they need to round a number. One example of an error I might see during this activity would be the students have $\frac{9}{26}≈0.34615$, I am asking the students to give me two decimal places, some students will correctly answer 0.35 and other students will give 0.34 or even 0.3. This rounding error will be addressed during the example. Rounding errors are common and by reminding students that if the number one place to the right is less than five you do not change the number and if the number is greater than or equal to five you round up. Ensuring the students understand this concept will help the students be precise in their answers.

Students will need to be able to *compare/contrast* the allele frequencies from their class with other populations. Students will work towards the language demand during the lab activity. The students will need to interpret their data and determine how other populations might be similar or where the populations could be different. (Learning outcome 3 Interpret the class data and determine how the allele frequencies are different for different populations.)

Students will use the following vocabulary in the lesson:

•Percentage

•Dominant

•Recessive

•Genotype

•Phenotype

•Frequency

•Homozygous

•Heterozygous

•Hardy Weinberg equation

 p2+2pq+q2=1.

The students will have the opportunity to use the vocabulary throughout the unit and will need to use the academic language correctly when working with their partner.

During the math portion of the lesson the students will be working towards mathematical precision, syntax and discourse. Mathematical Precision: Students will be required to write their answers to two decimal places ensuring that they are rounding correctly.

Syntax: Students will need to complete the steps in the correct order to determine the allele frequencies. Students will be required to use their understanding of mathematics to determine the allele frequencies for the class.

Discourse: Students will be able to explain the Hardy Weinberg equation and how it relates to their genetics. Students will also use the vocabulary when talking with their peers as well as when answering questions from the teacher.

Students will have already been exposed to and understand the language demands for this unit. The students have been using the academic language throughout their genetics unit and during this lab the students will have support on the handout to help with further understanding of the language. I will be available to help the students reach the language targets and correct any misuse of the vocabulary. Students will be able to ask me questions if they have any confusion and I will help students use the academic language correctly in small group discussions.

I will assess the students final table to evaluate their mathematical precision and accuracy. This will give me the opportunity to see if the students have made any common errors and if they will need further support prior to the summative assessment at the completion of the unit. I have planned for informal assessments to occur throughout the activity. I will give the students feedback on their work during the lab when I am walking around the classroom. During this time, I will make notes on if students are making any common errors so that I can bring the class back together to reteach a certain component or I can let the class continue working and work with the individual to help clear up any misconceptions. I will ask the students to self-evaluate how they are doing throughout the lesson to ensure I am not leaving any students behind and to ensure I am not moving too fast.

My planned assessments will meet the needs of all students. For my gifted learners I will go over and ask them how they are doing after I have gone through the demonstration with the rest of the class. At this time I will be able to assess where they are at and determine if they are understanding the relationships between the different data and why they data may not match their class data. I will also provide the gifted learners the opportunity to self-evaluate throughout the process to ensure they are achieving the learning targets. All students will be assessed informally during the lab activity and I will formally assess all students on the lab when they turn it in.

I will elicit student voice throughout the lab activity. One way I plan to elicit student voice towards the learning targets is by asking the students to share the class data with me and by starting a conversation on what we might see in data. Another way I plan to elicit student voice is to ask the students throughout the demonstration if they are understanding the concepts by giving me a thumbs up. This will allow me to do a quick glance throughout the class and determine if the students are ready to move on.

Students will monitor their own learning by self evaluating how they are doing when I ask the class to give me a thumbs up or down. This will require the students to be aware of where they are at and where they are going. If I notice students not responding giving other clues to them not understanding I will rephrase the material until I get all students where they need to be. Students will also be able to ask any questions or ask for clarification to ensure they are understanding the material and meeting the learning targets.

See attached document for the lab handout.