Mendelian Genetics: The Game

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Design Problem

- Virginia Virtual Schools want to be able to approximate a “hands-on” science laboratory experience for their students.
- Activity must align to VA standards of learning.
- Activity must promote scientific inquiry while maintaining a scaffolded environment for students working asynchronously.

The Learners

- Middle school students (ages12-14).
- Most have attended Virginia Virtual in previous years.
- Students vary in their experience with online learning.
- Students have experience with a variety of gaming styles, particularly puzzle/trivia, strategy, and simulation games.
- All students have taken previous science courses, though with little focus on the nature of science (courses were heavy on content but light on process).

The Challenge

- Teach Mendelian Genetics in a virtual environment in a way that promotes an understanding of the **nature of science** and **scientific inquiry.**

- Nature of Science: “Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. Scientists believe that through the use of the intellect, and with the aid of instruments that extend the senses, people can discover patterns in all of nature.”

-American Association for the Advancement of Science

The Challenge

- Available Mendelian interactive products do not succeed at communicating information about the nature of science and scientific inquiry. The interactives are more of a series of multiple-choice questions.
- Available Mendelian interactives communicate genetics content, but outside of the historical context of how these principles were discovered. The historical context helps communicate the nature of scientific inquiry.

Instructional Objectives

- Action: Students will identify Punnett squares as one of the primary strategies used to analyze genotypes and phenotypes when studying hereditary patterns among generations of cross breeding.
- Condition: Students will receive an introductory tutorial that exposes them to the Punnett square and use it as their primary tool for investigation.
- Standards: Every organism requires a set of instructions for specifying its traits

Instructional Objectives

- Action: Students will recognize (generalize) that Punnett squares can be used for any organism, and can be used to examine multiple alleles.
- Condition: Students will use these squares throughout the game to meet various challenges.
- Standard: The characteristics of an organism can be described in terms of a combination of traits.

Instructional Objectives

- Action: Students will apply their understanding of Mendel's historical work to novel problems outside of Mendel's experimental organisms.
- Condition: Students will play the game first as Mendel's apprentices, and later move on to make exciting findings on their own.
- Standard: Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

Instructional Objectives

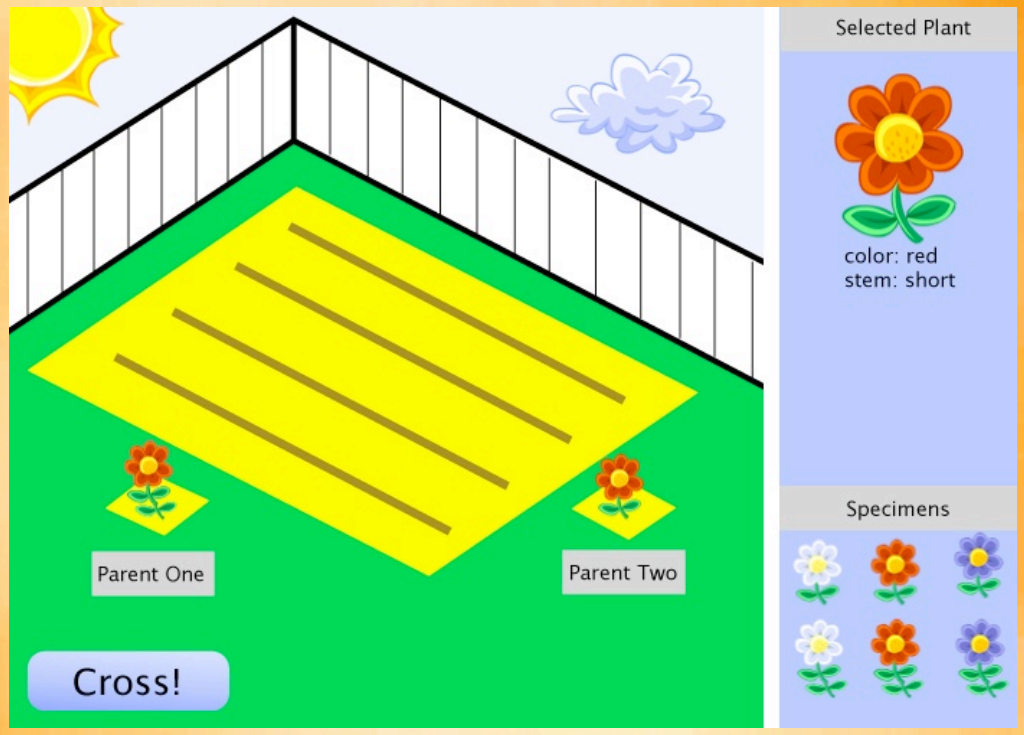
- Action: Students will be able to generate tentative observations and use these to design targeted cross-breeding investigation in order to yield more specific data in increasingly more complex situations.
- Condition: Students will be able to choose from multiple organisms in the game. As they test more organisms, they progress in the game, receiving points and unlocking new challenges.
- Standard: Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories

Instructional Objectives

- Action: After performing appropriate cross-breeding investigations, students will be able to defend their hypothesis about heredity patterns within a select organism.
- Condition: Students will enter a phase of the game in which they are presenting and defending their findings to Mendel. Students will select (from several options) the conclusions they want to present to Mendel and drag and drop the appropriate date to defend their conclusion. Mendel then gives students feedback about how solid their arguments are.
- Standard: It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists.

Scope of Prototype

- Wireframes describing the game's concept, objectives, and flow:

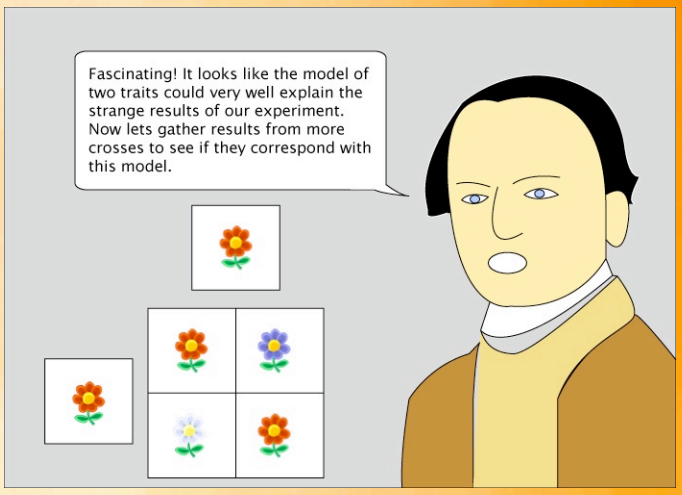


Technical Specifications

- Browser-based game
- Can be embedded or linked to from within a learning management system
- PC or MAC with at least 256MB or RAM
- DSL or broadband with an Internet connection speed of at least 129 kbps)
- Adobe Flash Player (Version 10 is the most current, but the game will be backwards compatible to version 8)
- Internet Explorer 6.0 or later, Mozilla Firefox 3.0 or later, and Apple Safari 3 or later)

Online Activities

- Hypothesis testing
- Data analysis
- Scientific argumentation
- Historical case-study



Learner Assessment

- There will be two types of learner assessments:
  - The game as assessment- One of the strengths of using a video game format is that it will provide learners with an ongoing assessment of her understanding. She will have ongoing feedback and opportunities to test her knowledge and improve understanding. The learning design graphic organizer above illustrates the opportunities for iteration and feedback.
  - A Virginia SOL exam: This will be an “objective” test that measures content knowledge about genetics, alleles, and heredity. This will be administered as a pretest and post-test to determine a change in understanding. Additionally, we will administer pre-post tests of constructed response asking students to tell a story of scientific inquiry.

Learner Assessment

Sample questions:

- 1) Examine the phenotypes of the parental (P) and generation 1 (F1) offspring. The tall plant (T) is dominant and the short plant (t) is recessive.
- If two of the offspring (F1) were crossed and had 6 offspring, what would their predicted phenotypes and genotypes be for that generation (F2)? Label each. Offspring with its correct phenotype and genotype.

Formative Assessment of Module

- Several methodologies were employed as a formative assessment :
  - Needs Assessment: presents Virginia Virtual's challenge in teaching inheritance and Mendel's genetics, thus outlining the service we hope to provide.
  - A survey of existing web materials presents the landscape of how others have approached similar problems, and shed light on what this project will need to do differently.
  - A Task Analysis unpacks what the learner will need to do and a learner analysis provides insight into where the learners are in terms of understanding and comprehension prior to the activity.

Formative Assessment of Module

- The paper prototype will be assessed in one-on-one assessments with online and face-to-face teachers. The goal will verify teachers are comfortable with the content.
- A functioning alpha will focus primarily on usability questions, including finding technological bugs that may emerge via a variety of computer platforms.
- A beta version of the game will focus on “learnability issues” and making sure the game is communicating data to teachers.

Summative Evaluation

Evidence of the impact of the instructional program will be gathered through:

- Student usage logs collected while students played the online interactive, including completion rates and time spent using the interactive.
- Mastery of tasks in the game.
- Scores from portions of the Virginia SOL that address Mendelian genetics, and
- Interviews of student and teacher participants (perceptions of the game and its effectiveness).

- **Orientation of the Evaluation :** A mixed-methods approach (both quantitative and qualitative data) was determined to be the most effective evaluation approach. Quantitative data will be collected and analyzed from all student participants. Qualitative data will come from a random sample of student and instructor participants that will be interviewed via phone or in person.

Summative Evaluation

- **Design of the Evaluation:** Data will be collected in several stages. Student data will be collected through actual game usage, pre and post tests which will address Medelian genetics questions from the Virginia SOL, and student/teacher interviews from a random sample of the participants.
- **Evaluation Measures:** Test measures will reflect genetics questions and topics addressed in the game interactive. Transcriptions of student/teacher interviews will be measured using open coding to identify themes.