Integrating Technology, Authentic Science, and Inquiry Based Research in the Secondary Science Classroom

Introduction

A fulfilling science education should encourage students to develop insights about science as an intellectual activity (Stewart *et al.* 1992) and help students apply this knowledge to real life situations. In an attempt to generate student excitement and enthusiasm on the subject of genetics, a Punnett square activity was developed centered on the genetics of corn snakes to teach students about Mendelism and genetic diversity. This study will investigate multiple methods of authentic science applications and technology use and research will set out to determine best practices for science instruction and learning. Teacher involvement and collaboration with experts in the educational field will be implemented in an ongoing attempt to strengthen and clarify the teaching methods and visual presentation of confusing genetics concepts. The researcher will observe the level at which methodology is approached and how students retain knowledge through actively participating in a hands-on approach to science. Overall, these enhancement methods will investigate the effects of how genetics is taught and will provide students with opportunities for independent research, laboratory investigations, and long-range data collection**.** Science should do more for students than teach them to memorize formulas and regurgitate names of famous people. Science is an ever-changing field. If educators continue to teach with outdated materials and resources students will continue to tune-out in class, never realizing their full potential in the field of science.

Scope

Science education should make concepts relevant to students through methods that encourage interaction at various levels of cognitive involvement. A hands-on approach works well with 9th grade students and accomplishes both visual and tactile tasks. This methodology stands in agreement with Stewart *et al.* who states, " A science education should do more than instruct students with respect to the conclusions reached by scientists…science education should encourage students to develop both understandings about science as an intellectual activity and understandings of the products of science" (1992). To achieve these goals, a 6-week unit on genetics will be developed which involves reading Mendel's original paper on genetics in addition to the genetics unit in the biology textbook (Miller, 1998). The scope of this unit will include teacher observations, student participation in model-based activities, peer- problem solving activities, and laboratory investigations using a live reptile species, *Elaphe guttata*. Technology will be introduced by means of PowerPoint presentations, Excel graphs, animated gif files, genetics related screen captures, and video lectures throughout the study. All methods will be further investigated by the instructor to clarify which activities work best to relay concepts in this hands-on genetics investigation.

Aims

The purpose of this study is to achieve the following four goals.

Research Goals:

- Examine genetics through a hands-on approach
- Integrate technology and Internet resources into the science lesson

Instructional Goals:

- Determine best teaching strategies for student comprehension
- Measure the effectiveness of specific tools in the students' learning process

This research will incorporate studies based on five classes of students at diverse levels of understanding and will set out to determine if their individual levels of understanding and perceptions in genetics increases over time with the use of reptiles and technology or remains unchanged. Although many students lack the understanding of educational technology use (Stewart *et al*.1992), research supports that authentic assessment in the classroom coupled with computer technology opens up a wonderful opportunity for students to further their conceptual understanding and knowledge integration through a hands-on approach to science. The conceptual framework for science understanding was derived from the Sunshine State Standards and research in the educational field. To further this study professional literature was cited to support this research: (a) technology and science education (Linn 2003), (b) learning styles and technology (Cohen 2001), (c) contextualising authentic assessment (Cumming & Maxwell 1999), and (d) making authentic science accessible to students (Lee *et al* 2003), all of which will be discussed further throughout this study.

Objectives

The main objective of this study is to have science students obtain a clear understanding and mastery of genetics. It is important to determine if authentic assessment and inquiry based science research influence how teachers present the educational materials and how students learn and retain science content. In this study, 9^{th} grade students will observe and examine the dominant and recessive genetic traits in *Elaphe guttata,* and they will determine phenotypic ratios in F_1 and F_2 generations by recording statistical data using Punnett squares. Students will also calculate monohybrid and dihybrid crosses, and record growth rates and miscellaneous changes in *Elaphe guttata* over time using Excel charts and graphs, as well as lab reporting using word processing software. Through observation of a living species in the classroom, mock breeding experiments to determine various color morphs in corn snake phenotypes, authentic assessment using technology, and discussion of career possibilities as herpetologists and geneticists, students will have the tools for success giving them a clearer understanding of meiosis, independent assortment, and inherited traits.

Justification

Many students leave high school without a sound grasp of the importance of genetic diversity or how it applies to the world around them. Edelson (1998) as cited by Lee *et al. (2003) stated:*

> " Traditional learning situations that utilize lectures and demonstrations rarely challenge students to practice particular activities as the ordinary practices of the culture of the science community such as

> asking questions, planning and conducting investigations, drawing conclusions, revising theories, and communicating results. Often, real world science is not accessible to students because authentic activities that are interesting to students are too open-ended and require content knowledge and scientific thinking that students do not have the supports to realize"

Through interviews and conversations with high school graduates and on-lookers at reptile shows, it is evident that many students never learned classical genetics the traditional way using Mendel's pea plant experiment, instead they caught on to the concept through their fascination of herpetology. Based on this insight the idea for teaching Mendelism through corn snake genetics was born. Through successful completion of this unit students will have the knowledge and skills necessary to understand basic genetics and inherited traits in humans as well as other life forms. Students will also benefit from these concepts an other ways too in light of the fact the subject of genetics will be included on the mandated 2003 Science FCAT exam. And, just as music jingles help people to remember product names, this fun approach to heredity will serve as a genetics memory jogger.

Review of the literature

How science is taught has become a quickly growing controversial issue. Schwab, as cited by Lee, refers to science as an integration of thinking and learning experiences (2003) and that the curriculum is ever changing, creating a need to prioritize the content and thinking skills (DeBoer as cited by Lee 2003) required to succeed in the science of today. The contemporary researchers of today find interactive computer programs help put real-time activity in front of the students, and enable them to be actively involved in events that might otherwise be very abstract without this form of authentic science instruction (Lee, et el 2003). Although many students lack understanding of educational technology use (Edelson *et al.* 1999), research supports that authentic assessment in the classroom coupled with computer technology opens up a wonderful opportunity for students to further their conceptual understanding and knowledge integration through a hands-on approach to science. This study will be further expanded to explore best practices for science instruction and authentic assessment using inductive (tacit) theories and measures appropriate for the study of genetics utilizing multiple forms of technology.

Methodology (*indicative)*

Students will work with their peers to solve scientific problems of heredity, dominance, co-dominance, color morphs, sex-linked, sex-influenced, and sex-limited traits using Punnett squares and a phenotypic/genotypic matrix (examples provided to each lab group) on corn snakes. The students will practice model-using and model-solving strategies (Lee 2003) with their peers within the confines of their lab groups. The students' development of knowledge and scientific inquiry will be assessed through recording statistical data using dihybrid ratios which will allow them to set up Punnett squares, calculations of phenotypic ratios in F_1 and F_2 generations, and by the students' ability to record growth rates and miscellaneous changes over time using charts and graphs.

In preparation for this study, parents will be notified through a class newsletter that reptile research will be taking place in the classroom throughout the year. Parents will be sent consent forms stating they agree to allow their children to participate in this study, and will also be sent model release forms consenting to the publication of student photographs during laboratory investigations. Students participating in this study will be notified in advance they

will be participants in an educational study and will be required to take and pass a laboratory safety test prior to participation in any laboratory activity. Students are given the choice of having their findings made public and they also have the final say whether or not they want their photographs used in any publications. Students' test scores will not be released to the public and only student ID numbers will used to anonymously record statistical information regarding assessment and achievement levels.

Qualitative and quantitative studies will be conducted comparing 154 students consisting of five groups of pre-existing students, three classes of Integrated Science and two classes of Biology Honors. Surveys will be issued as a tool for comparison of student's prior knowledge of technology (computers, computer programs, Internet searches and keyboarding) in relation to those students without prior knowledge of computer technology (Lee, 2003). Peer interviews will be conducted with coworkers who use varied forms of technology in the classroom. Interviews with students will also be conducted along with feedback from parents, and personal observations and database records will all help shed light on this new approach to genetics instruction. This study will also help set a baseline for further investigations using future classes. Without this information it would be difficult to predict if there is an increased awareness of classical genetics due to the method of instruction or which method of technology is most effective.

Students involved in the corn snake study are never forced to hold or get close to the live reptile specimens, but are encouraged to at least look at specimens through the glass tank. Any student who hold live specimens (under the strict supervision of the teacher) is instructed to wash their hands thoroughly with anti-bacterial soap and warm water immediately following their experience. All student and animal rights are observed in conjunction with ethical, legal, and social implications as set forth by IRB guidelines (http://grants.intrasun.tcnj.edu/irb.html) and NSTA (*National Science Teacher Association*) guidelines (http://www.nsta.org/159&psid=2).

There is certainly a need for further investigation in this study as to whether learning styles are intrinsically set or if the external environment can manipulate education having an affect on the educational outcome (Cohen, 2001). Additional studies will also be conducted to verify which forms of authentic science make substantial differences in teaching and learning.

Provisional work schedule

Although the genetics portion of this study will last 6 weeks, a continuing effort over the course of the school year will persevere to research effective methods of introducing science materials to students using alternative teaching strategies. These findings will be collected and measured to compare and determine the most effective techniques of teaching modern science and will serve as a baseline for further investigations through out the school year.

Resource requirements

Computer access and a way to project PowerPoint presentations on a large viewing surface in the classroom are both necessary for this study. Connection to the Internet is also necessary to access and present online video clips relating to the subject matter. Students will need exposure and access to computer labs to complete this lab experience. Access to copy

machines and a supply of paper is also essential to print handouts and lab protocols for all participating students. Corn snake cards (playing card size) made by the instructor are also crucial for visual integration and comprehension.

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