Using "Thinking Tags" to Improve Understanding in Science: A Genetics Simulation

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ABSTRACT

In this study, small wearable microprocessor-driven GroupWear tags are used in a science classroom in order to investigate the effects on the nature and quality of discourse among students. The Thinking Tags are pre-programmed to run a genetics simulation for the purpose of exploring concepts related to inheritance, such as genotype, phenotype, probability and frequency. Preliminary data suggest that Thinking Tags provide an effective method of instruction that can be used to address misconceptions in science that persist despite traditional pedagogical interventions.

Keywords

Science, technology, GroupWear, Thinking Tags, genetics, probability, participatory simulation, discourse

INTRODUCTION

Driver (1985), in her book titled *Children's Ideas in Science*, discusses how children bring pre-conceived ideas about the world to science class, and that often these ideas have been reinforced from a very young age (p. 6). Hence, science lessons may be perceived as counterintuitive when these ideas do not correspond to accepted theory. It is therefore important for students to be able to understand and evaluate a variety of conceptions. One means of accomplishing this goal may be via students' collaborative discourse since emergent ideas are brought out into the open and treated as artifacts that can be modified and improved (Bereiter, in press).

"One of the commonly misunderstood concepts in elementary genetics is that of dominance and recessiveness of alleles" (Heim, 1991). Inheritance is an important and basic component in the study of genetics, yet it has been shown that students of all ages have much difficulty with its related concepts (Heim, 1991; Solomon, Johnson, Zaitchik & Carey, 1996; Banet & Ayuso, 1999; Weissman & Kalish, 1999; Lewis & Wood-Robinson, 2000).

In a study by Lewis & Robinson (2000) students nearing the end of compulsory science education showed a marked level of misunderstanding, even of the most seemingly basic concepts of genetics. They went on to explain that, "[a]lthough there was some recognition that sexual reproduction leads to an increase in genetic variation there was little awareness that this is the main purpose of sexual reproduction and is achieved through the process of fertilization – the fusion of genetic information from two different individuals" (p. 187).

THINKING TAGS IN SCIENCE

The MIT Media Laboratory has been at work developing small wearable microprocessors called *Thinking Tags* (Tags). These Tags are about the size of a small palm pilot and are equipped with infrared ports and sensors, lights and a small display panel however, they can also come with motors and various other sensory equipment.

A recent project at the MIT laboratory used these devices with children for the purpose of creating their own scientific instruments. Through a series of narratives they tell how the children, through working with the Tags, showed a marked level of motivation and critical capacity. They go on to say that, a constructionist "scientific instrument design has the potential for sparking interest in scientific issues among students who otherwise would avoid the subject altogether" (Resnick, Berg & Eisenberg, 2000).

One of the most salient features of the Tags is their ability to create a system of feedback, from which the students may gain increased understanding. Each Tag has the ability to send and receive information via an infrared signal, and can also display information, using lights, sounds and a mini digital display screen. Each of these features is then able to function in a constant loop of sending, receiving and displaying information, allowing students to obtain information from their Tag, almost intantaneously.

THE GENETICS SIMULATION

Using the programming language *Cricket Logo*, a simple genetics program was created to introduce students to some basic concepts related to inheritance.

In the *Genetics Simulation*, each Tag is programmed with a specific genotype that is not initially known to the students. The only information given to the students is their eye colour (phenotype), which is either green (dominant) or red (recessive), and their task is to meet with other Tags and observe the total probability and random selection of eye colour of their "virtual offspring".

In the simulation, four lights, each lighting up as either green or red depending on the genotypes of both Tags that are meeting, denotes the total probability of eye colour (phenotypes) for the "virtual offspring". For instance, if a heterozygous green-eyed Tag met a homozygous red-eyed Tag, the total phenotypic probability would show as two green lights and two red lights. Then, to find out which eye colour will be chosen, students press a blue button on the Tag so that one of the lights is randomly selected to remain on, while the other three are shut off. Students then record this information following each meeting and discuss their ideas about the results.

DISCUSSION

Banet and Ayuso (1999) state that, "traditional teaching strategies have little effect on students' acquisition of meaningful understanding of inheritance, which suggests that significant changes should be made in both curriculum planning and the sequence of teaching" (p. 314). Based on pilot data collected from two groups of graduate students, discussion during the simulation activity appears to be mediated by content-based inquiries. Comments such as, "No matter who I meet, I only get green lights" were quite common. Furthermore, some individuals seem to display a sense of personal identification with the characterisitics of their Tag, reinforcing the authenticity of the activity. One male student announced that he needed "a strong red female" in response to the fact that he was only ever getting green lights as a result. Post-activity feedback was also quite positive whereby many students demonstrated a keen interest in confirming their theories about their Tag's genotype.

In conclusion, we believe that the *Genetics Simulation* provides a concrete example of an inheritance situation, and we anticipate that the saliency of the experience will stimulate an interest and quality of critical scientific discourse that would otherwise be missed using traditional pedagogical approaches.

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