

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

Kimberley A. MacKinnon, Susan Yoon, Gail Andrews

Ontario Institute for Studies in Education of the University of Toronto (OISE/UT)

kmackinnon@oise.utoronto.ca, syoon@oise.utoronto.ca & gsandrews@oise.utoronto.ca

ABSTRACT

In this study, small wearable microprocessor-driven GroupWear tags (Thinking Tags) are pre-programmed to run a genetics simulation and used in a science classroom in order to investigate the effects on the nature and quality of discourse among students. 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

Rosalind Driver, in her book titled *Children's Ideas in Science* (1985) 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. 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).

Heim (1991) states that, dominance and recessiveness of alleles is one of the most commonly misunderstood concepts in elementary genetics. 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 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 instantaneously.

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 reveal the eye colour selection, 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). We believe that the *Genetics Simulation* provides a concrete experience with the underlying rules for the process of acquiring inherited characteristics, and we anticipate that the saliency of the experience will stimulate an interest and quality of critical discourse that would otherwise be missed using traditional pedagogical approaches.

Ongoing research using Thinking Tag technology has shown promising results for prompting student interest, critical discourse and conceptual understanding. A companion study that examines understanding the importance of dental hygiene among kindergarten students, has shown that participatory simulations can have a positive effect on conceptual development in very young children (Andrews, MacKinnon & Yoon, see this volume).

Preliminary pilot data from the *Genetics Simulation*, collected from two groups of graduate students, indicate that discussion during the activity appears to be mediated by content-based inquiries. Furthermore, students seem to become immersed in a “first-person experience” (Colella, n.d.), identifying with the characteristics of their Tag, and gathering information from their interactions within the group, suggesting that the technology has increased their effort at meaning-making. Current investigations will be examining the effects of the *Genetics Simulation* and the Thinking Tag technology with intermediate, secondary and graduate (non-science) students.

ACKNOWLEDGMENTS

Special thanks to Dr. Earl Woodruff and the Thinking Tag Committee at OISE/UT for their support.

REFERENCES

- Andrews, G., MacKinnon, K. A. & Yoon, S. (2001). *Using “Thinking Tags” with Kindergarten Children: A Dental Health Simulation*. Poster session to be presented at the annual Computer Support for Collaborative Learning Conference, January 2002, Boulder, CO.
- Banet, E. & Ayuso, E. (1999). Teaching Genetics at Secondary School: A Strategy for Teaching about the Location of Inheritance Information. *Science Education*, **84**(3), pp. 313 – 351.
- Bereiter, C. (in press). *Education and Mind in the Knowledge Age*. Erlbaum, Toronto.
- Colella, V. (n.d.). *Participatory Simulations: Exploring Dynamic Systems through Real World Interactions*. Retrieved from <http://vanessa.www.media.mit.edu/people/vanessa/part-sims/index.html>.
- Driver, R., Guesne, E. & Tiberghien, A. (1985). *Children’s Ideas in Science*. Open University Press, Philadelphia.
- Heim, W. G. (1991). What Is a Recessive Allele? *The American Biology Teacher*, **53**(2), (February).
- Lewis, J. & Wood-Robinson, C. (2000). Genes, chromosomes, cell division and inheritance – do students see any relationship? *International Journal of Science Education*, **22**(2), pp. 177 – 195.
- Resnick, M., Berg, B & Eisenberg, M. (2000). Beyond Black Boxes: Bringing Transparency and Aesthetics Back to Scientific Investigation [Electronic version]. *Journal of the Learning Sciences*. Retrieved from <http://el.www.media.mit.edu/groups/el/Papers/mres/bbb-jls/>.
- Solomon, G. E. A., Johnson, S. C., Zaitchik, D. & Carey, S. (1996). Like Father, Like Son: Young Children’s Understanding of How and Why Offspring Resemble Their Parents. *Child Development*, **67**, pp. 151 – 171.
- Weissman, M. D. & Kalish, C. W. (1999). The Inheritance of Desired Characteristics: Children’s View of the Role of Intention in Parent-Offspring Resemblance. *Journal of Experimental Child Psychology*, **73**, pp. 245 – 265.