Multi-user Interaction on the DNA Workbench [sap_0394]

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The DNA Workbench investigates multimodal learning from the standpoint of multi-user tangible media applications. We developed an interactive display system that distinguishes itself from traditional computing interfaces by implementing touch and gesture-based input in which multiple participants can engage and collaborate to form a communal learning environment. A critical aspect of this module includes intuitive interface design and a visual feedback system that is responsive to variations of input generated by group participants.

This project has evolved from the growing awareness of the many learning styles in today's classroom, and effectiveness of creating kinesthetic learning experiences for teaching science. The DNA Workbench is a prototype for an interactive exhibit on DNA structure and function hosted by COSI (Columbus Museum of Science and Industry).

1. Background and History

Traditionally, and across the country, science is taught using a standard pedagogical approach of presenters lecturing to students or asking learners to absorb material from text. Recent research suggests that as few as 30% of learners learn best in this modality (Meyer and Rose 2000)[i]. Multimodal presentation of complex information is demonstrably more effective for typical learners and is paramount in the instruction of people with disabilities.

Kinesthetic learning is a learning modality that allows a student to physically engage in comprehension of an abstract concept. The goal of our project is to set up touch and gesture driven systems that teach fundamental concepts of DNA structure and function.

The primary focus of DNA structure exploration is the concept of complimentary base pairing. DNA polymer consists of up to 220 million nucleotide pairs held together by sugar and phosphate residues[ii]. The four nucleotide/base types are adenine (A), cytosine (C), guanine (G) and thymine (T). Within each pair the nucleotides are connected by hydrogen bonds. It is the specific number of those bonds that determines correct complimentary base pairing, ensuring that A always pairs up with T, and C with G. Multiple enzymes play various functions in building and maintaining DNA structure. The most relevant to our topic is editase and its proofreading role in base pairing process.

2. Technology and Process

Objectives of the DNA Workbench concept include design solutions for a large format rear-projection display system configured as a tabletop work surface, responsive to touch and gesture input. Graphical interface elements and animation allow multiple users to manipulate nucleotides projected onto the work surface, in order to form complimentary base pairs. A primary challenge in this project consists of designing a feedback system and timing logic that engages the participants in a learning process leading to an understanding of complementary base-pair theory, the function of editase enzymes in the correction of formation of base pairs, the process of DNA replication, and the impact upon genetic structure through the variations in the base-pair coding process. The system is designed to integrate with other learning modules in a large scale installation for continuity and relevance throughout the learning environment. An example includes projection of computer graphics animations on other screens, networked with other interactive modules in the project, showing the genetic outcomes from the variations in which participants complete their DNA strand models on the workbench display.

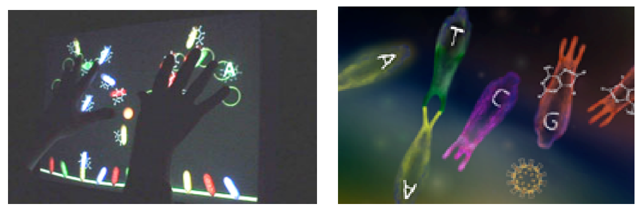

Figure 1: Hardware and interface development for the interactive DNA workbench

Our interface incorporates a hybrid, dynamic system of representation for DNA structure allowing a full range of age groups to observe relationships between components of DNA and how different modes of representation translate between one another. This system aims to promote more sophisticated levels of understanding and to be responsive to participants based upon interface elements with which they elect to interact.

Examples of tangible media systems that help to inform this approach are the "reacTable" developed at the Universitat Pompeu Fabra in Barcelona Spain, 2006[iii], or the Multi-Touch Screen developed by Jeff Hahn and New York University, 2006[iv]. Our proposal was to develop a similar, low-cost implementation of a multi-user touch-based display, using this format to promote a community-based collaborative environment for learning as well as representing a complementary component to our overall multimodal learning environment in which this particular display system interface operates as an analogy to the mechanical / physical processes in which DNA may be manipulated in nature or in the laboratory.

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[i] Meyer, A. and D.H. Rose (2000). Universal Design for Individual Differences. Educational Leadership. 58(3): 39-43.
[ii] http://en.wikipedia.org/wiki/DNA
[iii] http://www.iua.upf.es/mtg/reacTable/
[iv] http://cs.nyu.edu/~jhan/ftirtouch/