Teaching with Tangibles: A Tool for Defining Dichotomous Sorting Activities

Lori L. Scarlatos
Brooklyn College, CUNY
Brooklyn, NY 11210,USA
phone: 1-718-677-6170
email: lori@sci.brooklyn.cuny.edu

Audrey Mbogho
CUNY Graduate Center
365 5th Ave.
New York, NY 10016,USA
email: AMbogho@gc.cuny.edu

Magdalena Jaworska
Brooklyn College, CUNY
Brooklyn, NY 11210,USA
email: worska@yahoo.com

ABSTRACT

Learning activities with tangible user interfaces offer the benefits of active learning and working in groups while providing assistance from an autonomous guide on the side. Yet because these types of learning activities are non-trivial to develop or adapt to the curriculum, most teachers are unable to use this technology in the classroom.

This poster presents a new tool that gives teachers the power to create their own educational applications with tangible user interfaces. We developed a novel approach to tagging items, using a variation on barcodes, which allows multiple translation- and rotation-invariant tags to be read simultaneously. We then implemented a back-end system that allows teachers to define their own dichotomous sorting learning activities, and a front-end system that presents these learning activities to the students using tagged specimens.

INTRODUCTION

Scientists use dichotomous sorting – dividing objects and organisms into groups with common attributes – as a way to classify things. Consequently, this skill often appears on standardized tests. Teachers are therefore motivated to give their students as much practice as possible sorting objects by their attributes, especially in the fourth grade. To make the lesson more meaningful, teachers often have groups of students sort physical objects such as rocks, shells, and leaves. The drawback is that the teacher cannot be with all groups at once to provide appropriate guidance.

We have developed a novel system that allows teachers to build a customized application that guides students in the dichotomous sorting of physical objects. Teachers use their own collections of objects; and by defining the hints and help that students will be given, they can project their own teaching styles onto the system. Multiple activities can be rapidly defined and modified to fit a particular class, topic, or new set of materials. Our system serves as an example of how, with the right tagging scheme, the time and expertise required to implement tangible user interfaces can be reduced to a point where non-experts can do it.

UIST '04, October 24–27, 2004, Santa Fe, New Mexico, USA
ACM 1-58113-962-4/04/0010

To support this application, we have developed a unique approach to tagging objects that allows a computer to quickly recognize the attributes of multiple objects which are scattered across a work surface. In order to make the interface transparent to students, this approach does not require items to be scanned individually or aligned any particular way, unlike traditional barcodes or variations such as DataGlyphs [2]. Although we focus on one application – dichotomous sorting – our approach can be used in any application that needs to simultaneously recognize various properties of multiple objects without regard for orientation or position.

We are building on past work on Tangible Interfaces for Collaborative Learning Environments (TICLE) [4], for which we developed a TICLE table. This working surface has a camera mounted below the Plexiglas tabletop to "watch" as objects are placed on it and moved around. Observations of children using this system suggest that this interface keeps students on task and encourages meta-cognitive discussion. Students using our system were also far more likely to find a solution than the control groups using traditional puzzle pieces with written instructions.

Of course, others are working on educational applications that use tangible user interfaces [3] and/or are designed by end users [1]. Yet ours is the first application we know of that will allow teachers – anywhere, any time – to develop their own dichotomous sorting applications for the classroom, using tangible user interfaces.

IDENTIFYING ATTRIBUTES

In dichotomous sorting activities, students are asked to divide a set of objects into two groups: those that have a particular attribute, and those that do not. Specimens typically have several attributes that help to define what they are. For example, rocks might be characterized by their cleavage (crystal form), luster, or hardness. We needed a way of representing distinct values for several attributes simultaneously. We also wanted students to focus on the activity, not the interface, creating groups of objects without regard for orientation or having to scan objects individually.

We decided to use a bi-directional barcode to represent the different values of an attribute. Barcodes are popular for tagging objects because they can contain a great deal of information that can be read with a relatively simple device. However, typical barcode readers cannot scan multiple randomly placed objects simultaneously. We use highly saturated background colors for our barcodes, and place them on a black background, so that our software can easily find all of the barcode boundaries and determine their orientation. By using different colored backgrounds to represent different attribute types, we can put several barcodes on each object and have the software focus on one attribute at a time.

Our color code reads the same forward and backward, for ease of processing. It represents 16 values but can be easily extended to encode as many values as necessary. The method for reading the barcode requires three distinct colors: one for the background, one for binary 0, and one for binary 1. Two guard bars, one at either end, mark the beginning of the code and represent the width of a bar corresponding to one bit. The guard bar also gives the color representing binary 1. Four bars following this are read as binary digits from left to right. The remaining half of the code is a mirror image of the first half.

DEFINING THE LEARNING ACTIVITY

Our goal was to produce a tool that would enable teachers to define their own dichotomous sorting activities, using physical objects that fit their lessons and guidance that reflected their individual teaching styles. Rather than replacing themselves, we wanted teachers to be able to duplicate themselves: letting a computer (running their own creation) prompt and guide one student group while the teacher is busy with another.

Our system allows teachers to define a new topic of study or edit an old one. Teachers define categories of attributes (e.g. crystal form, luster, and hardness for rocks) and all the possible attribute values (e.g. luster can be metallic, shiny, glassy or earthy). They also provide a series of queries or prompts for the students (e.g. “Place all rocks softer than a copper penny on the left side of the table”) and a series of hints to provide if the students ask for help or have trouble completing the required task. Hints are listed as URLs, so that teachers can use either online references or their own custom hints which can be anything that can be opened in a web browser. When all the attributes and their values have been defined, the system will print out a set of barcode labels and instructions for placing them on the physical objects that the students will work with.

USING THE LEARNING ACTIVITY

We developed a front-end application that uses the teacher-specified information to guide the students through their dichotomous sorting activities. A log file keeps track of how well the students do and what hints they see. This allows the teacher to later review what all of the student groups actually did.

Students sort the tagged objects on a TICLE table. A nearby computer monitor displays instructions and hints. A button on the (touch) screen allows students to indicate that they have completed a task, which the computer should check. The application responds with either congratulations or suggestions, depending on whether the answer is correct or not. Other buttons allow students to review background material or ask for additional hints.

FUTURE WORK

We have a teacher (who is also a graduate student in the School of Education) who worked with us on this system to develop a lesson on what makes aircraft fly. She plans to bring the resulting application into her 4th grade classroom as part of her research requirement. Her observations will help us to determine how effective this approach is as a learning tool. Next semester, we hope to have others in this program create their own activities with our system. Their feedback will help us to refine our application, making it easier to use and more effective as a teaching tool.

Finally, we intend to make our applications freely available to teachers through our web site. Included will be instructions for constructing a TICLE table from low-cost and readily available materials.

ACKNOWLEDGMENTS

We wish to thank Dr. Eleanor Miele, who teaches science education in the School of Education, and Denise Dixon, our first teacher/user, for their valuable ideas, suggestions, and effort. This work is being supported by the National Science Foundation under Grant No. 9984385 and 0203333, and by a grant from PSC-CUNY.

REFERENCES

1. Guha, M.L. et al. Mixing Ideas: A new technique for working with young children as design partners. In *Proceedings of Interaction Design and Children* (IDC 2004), 35-42.

2. PARC. DataGlyphs®: Embedding Digital Data, http://www.parc.com/research/asd/projects/dataglyphs/ March 2004.

3. Resnick M. et al. Digital Manipulatives: New Toys to Think With. In *Proceedings of CHI 1998*, 281-287.

4. Scarlatos, L.L. TICLE: Using Multimedia Multimodal Guidance to Enhance Learning. *Information Sciences 140* (2002), 85-103.