PegBlocks: a Learning Aid for the Elementary Classroom

Ben Piper and Hiroshi Ishii
Tangible Media Group,
MIT Media Laboratory, NE18-5F, 77 Massachusetts Avenue, Cambridge, MA 02139
{benpiper, ishii}@media.mit.edu

ABSTRACT
In this paper we describe the implementation of *PegBlocks* – an educational toy that can be used to illustrate some basic physics principles to elementary school students.

Keywords
Tangible media, haptics, force feedback, telepresence, educational toys.

SCENARIO
A group of kindergarten children and their teacher sit around a classroom table. The teacher produces a set of wooden toys – PegBlocks – and lays them out on the table. Together the children and their teacher set about networking the blocks together using a set of electrical cables. When a network is complete the children physically manipulate the PegBlocks and observe how the kinetic energy they put into the system is distributed through out rest of the network. Through this kind of physically interactive play the children begin to develop a more intuitive understanding of a number of abstract physics principles.

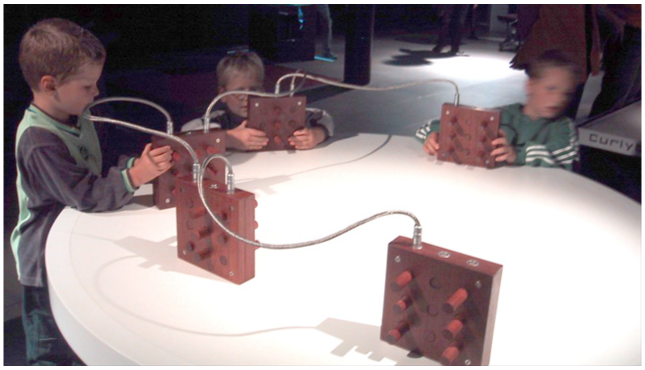

Figure 1. Discovering the relationship between kinetic and electrical energy by playing with the PegBlocks.

INTRODUCTION AND RELATED WORK
Things before words, concrete before abstract.
– Johann Heinrich Pestalozzi (1803)

Conventional methods of teaching physics often involve abstract, mathematical forms of representation. These require a certain student proficiency before they can be used effectively in the classroom and as a result subjects such as physics are conventionally taught relatively late in a child's formal education.

However, children naturally learn about physics through their informal education. In playing with and being physically engaged in physical objects, children build up highly complex (subconscious) model of physical behavior. *PegBlocks* aims to build on this notion of learning through physical interaction by providing a toy that allows an intuitive understanding of the relationship between kinetic and electrical energy.

This approach is heavily influenced by the educational vision of the 19th Century Fröbel who put physical objects and physical activity at the core of the kindergarten. More recently Seymor Papert and Mitch Resnick [1] have demonstrated the value of a hands on approach in programming Logo™ and Lego® Mindstorms™. This work demonstrates how it is often more effective for children to 'learn by doing' and stresses the importance of physical as well as mental involvement in the classroom. *PegBlocks* is intended to provide a constructivist learning aid for teachers to tangibly illustrate abstract notions found in physics.

Ananny's *TellTale* [2], a physical toy aimed to improve literacy skills through play and Brave's *InTouch* [3], a haptic input device were highly influential in the approach that we took.

IMPLEMENTATION
PegBlocks are a set of five wooden blocks that each supports nine protruding pegs. The blocks can be networked together to form a variety of configurations. Each peg is coupled to an electric dynamo/motor that converts the kinetic energy from the physical movement of the child's hand into electrical energy. This electrical energy is converted back into the motion of another peg at another point in the network. The whole system requires no external source of power.

The first implementation was prototyped using standard Lego® blocks. Lego® motors were used to act as dynamo/motors. While this version proved the concept it was too fragile for use in the classroom. Furthermore, the Lego® version did nothing to hide the internal workings of the device; we wished to provide a simple, clean design that would lend itself to the toy application.

The second version of *PegBlocks*, shown in figure 2. hid the internal working with a laminated plywood box. Each layer of the box was cut out using a laser cutter and the entire assembly was bolted together. While the aesthetics were improved in this design the soft birch pine used for the pegs and block housing was quickly damaged by repeated use. Furthermore, the pale color of the wood meant that it quickly took on a dirty appearance as school children and other users played with the blocks.

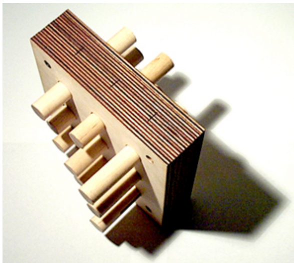

Figure 2. A Plywood PegBlock

The final implementation used a dark maroon hardwood for the pegs and the same hard wood was used to veneer the faces of the block housings. This proved to be much more resilient to wear and the darker surface, which was also oiled, hid the build up dirt from the user's hands.

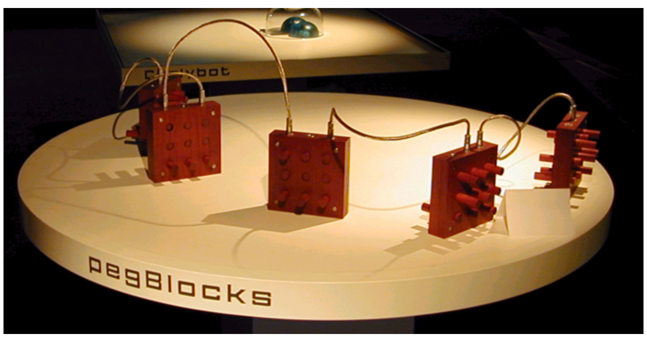

Figure 3. The final implementation of PegBlocks

Internally each *PegBlock* consists of nine Lego® motors each supported above wooden peg. A 'rack and pinion' gear coupling transfers the transverse movement of the peg into the rotational movement of the motor (or vice versa). Each motor is wired to a common ground and a unique pin of a ten pin out-put socket. A ten-core stainless steel sheathed cable transfers the output of the ten-pin socket to another *PegBlock* in the network.

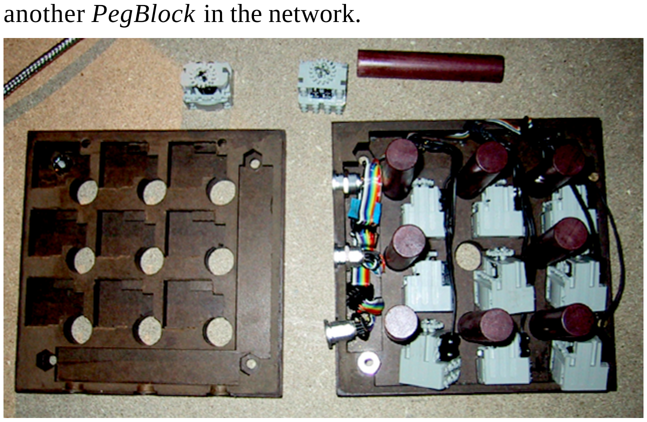

Figure 4. Internal workings of a dismantled PegBlock

EVALUATION AND CONCLUSIONS

PegBlocks has not been formally tested in a school environment. However, we were able to informally observe a great number of children (and adults) interacting with the device when it was displayed as part of a one-year exhibition at the Ars Electronica Center in Linz, Austria.

Group Interaction

One of the most important aspects of the *PegBlocks* interface is that it allows for group based learning and encourages group participation. There were many cases where visitors to the exhibition would interact with a *PegBlock* and inadvertently interact with a bystander who was also playing with one of the blocks. This kind of accidental interaction would often lead to laughter and encouraged children who did not know each other to interact through a common toy.

Physical Principles

The transfer of energy from one PegBlock to another fascinated the children. Many asked if the blocks used batteries and were often surprised to learn that the toy used only the energy that the children put into the system. This physical phenomenon clearly illustrated the 'conservation of energy' principle. It also allowed the children to see the relationship between electrical and kinetic energy. The blocks also demonstrated the combined effects of friction on the system; children frequently wired all five blocks in series and observed the resulting attenuation of energy through the array. The possibilities for various configurations allowed the children to explore the difference between series, parallel and circular networks and discover for themselves the implications of such configurations.

While the *PegBlocks* don't teach the reasons behind these physical phenomena they do offer an engaging form of play and a useful platform for discussion that helps to make abstract notions in physics more tangible to elementary school aged children.

REFERENCES

1. Resnick, M., et al.: Learning with Digital Manipulatives: New Frameworks to Help Elementary-School Students Explore "Advanced" Mathematical and Scientific Concepts, *Proposal to the National Science Foundation* (2000).
2. Ananny, M.: Supporting Children's Collaborative Authoring: Practicing Written Literacy while Composing Oral Text. *In Proceedings of Computer-Supported Collaborative Learning Conference*, Boulder, Colorado, January, 2002.
3. Brave, S.: InTouch: a Medium for Haptic Interpersonal Communication, in *Proceedings of Conference on Human Factors in Computing Systems (CHI '97)*, ACM Press.