Physical Computing for bringing K-6 STEM to life:
(New Hands-On Materials and Approaches for use with Elementary Children)

from the US/UK Collaborative Initiative in DE&T*
supporting the ITEEA EbD Program

Special Sessions; Thursday and Friday (3/28-29/2019), 11:00 am to 12:30 pm

Note: Physical computing may not be a familiar idea to some of us, although it is being used more frequently in computer science. However, instances of physical computing have been used regularly in technology education but with different names. One long-established and more comprehensive name is “systems and control” that involves using programs and devices that can sense and control aspects of the real world. The similarity of the two concepts is evident when “physical computing” is seen as building interactive physical systems by using software and hardware that can sense and respond to the real world.

Physical Computing; a dimension of Systems & Control

Electronic Sentences
Physical computing as well as systems and control are rather daunting concepts and intimidating subjects for elementary children and their teachers. So the US/UK Collaborative Team set out to develop an approach that is fun, practical, appropriate and enabling for even very young children. That approach is called Electronic Sentences, with initial ideas emerging from work of UK colleagues reaching back into the 1980’s and 90’s. After more than two decades of incubation, the US/UK Collaborative Team working with Mindset/Redfern representatives, with support from the ITEEA, has designed and developed a new generation of Electronic Sentences that fulfills the fun, practical, appropriate and enabling requirements. (Note: By enabling, we mean that the children will be prepared for ongoing and progressive growth in skills and knowledge in DE&T and computer science.)

* DE&T (Design, Engineering and Technology) as used herein includes D&T (Design and Technology) as used in the UK.)
A short visual tour of the Electronic Sentences program follows:

Let's consider a few important points before you take the following tour.

- The US/UK Collaborative Team will continue to identify possible cross-curricula connections the Electronic Sentences program could support and enhance, particularly those that link with the language arts.

- The Electronic Sentences program will provide practical examples and the necessary resources for staging hands-on experiences for students in physical computing that reflect the current thinking within the computer science education.

- The Electronic Sentences program will lay a foundation for continued student learning while also helping provide a planned “progression of learning” in practical and integrated STEM.

- The US/UK Collaborative Team will continue to model a “progression of learning” perspective by linking Electronic Sentences activities with Crumble-related activities developed by Team members and participating classroom teachers.

Fig. #1 Aspects of the US/UK Team efforts: (L) training of teachers and Teacher Trainers, (M) testing and improving the ES system, and (R) developing age-appropriate Physical Computing examples.
Fig. #2 Each ES tile has a unique bar code, that provides a machine-readable version of the English word/phrase on the tile.

Fig. #3 The ES tiles fit into four categories, the three regular ones of input, process and output. The additional category of grammar provides tiles that help form meaningful sentences.
**Fig. #4** Grammar tiles provide structure to sentences thus; “If it is <condition> then <result>.”

**Fig. #5** Input tiles describe the conditions to be sensed: hot, cold, dry, wet, dark, light, a magnetic field or an on/off switch being used. Output tiles indicate the results that happen.
Fig. 6 Sensors detect energy in such forms as magnetism, light, heat and force. The moisture sensor detects the flow of electricity between two probes when both become wet.

Fig. 7 Motors are common output devices (as drive motors or to power fans and pumps). Other devices include LEDs, buzzers, and lamps (for light and/or heat.)
The ES tiles: linked together make a “control sentence” when scanned by a Smart Block.

Fig. #8 By scanning the tiles in the sentence, the Smart Block captures a machine-readable version of the control statement that can then be used to control the operation of a device or system.

Electronic Sentences System in use: Controlling a Merry-go-Round with a Smart Block.

Fig. #9 After the above sentence is scanned, an input device (a switch) and an output device (a motor) can be attached to the Smart Block so it can operate/control the Merry-go-round.
Fig. #10  The Smart Block scans the sentence tiles and captures the control program, it provides ports for connecting the input and output devices and provides power for the system to operate.

Introducing problem solving activities

The Electronic Sentences system provides problem solving experiences across a range of contexts. Five initial contexts are proposed

The context areas progress from the familiar (At home) to the less familiar (in the world). Within each context there is a range of activities from the simple, with a limited choice of solutions, to the more open, with a wider range of possible solutions. Each activity in a context forms a mini design brief.

Fig. #11  The above illustration portrays the structure and the plan of progression of learning activities that will be provided within the Electronic Sentences program.
Fig. #12 The ES cards provide Problem Solving activities for students in a range of contexts. The language used in the cards engages the students in an introductory form of a “design brief.”

Fig. #13 This Alert System help a human (Grandpa) to pay attention to something that will require him to takes some action. In this case it will be to water the plant.
**Fig. #14** As shown here, a more demanding design brief leads to a more sophisticated solution.” The system waters the plant automatically. Grandpa only needs to keep the container/reservoir filled.

**Fig. #15** The ES cards provide age-appropriate activities for students. They also serve as templates for further activities as teachers gain skills to modify these or develop new cards that better fit the established curricula and standards.
Now, in closing, let's turn attention to the following:

US/UK Collaborative Initiative to Support K-6 Hands-on Activities in Physical Computing

Questions
Concerns
Possibilities
Ongoing work
links to Engineering by Design (EbD) K-6

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Selected Websites

- https://redfernelectronics.co.uk/projects/
- https://redfernelectronics.co.uk/crumble/
- https://teachergen.com/collections/crumble
- https://redfernelectronics.co.uk/getting-started/guide-to-using-crumbs/
- https://sites.google.com/a/vt.edu/crumble/
Bibliography

