Design and Experiences with Teaching Physical Computing in Family Workshops

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Teaching computing to kids in workshops, camps, online tutorials or within their school context has become a trend in education. However it’s not only the children who should be taken into consideration. Parents, family and community members play significant roles in the lives of children and their involvement also in computing education is important for several reasons. Parents and families have the most direct and lasting impact on children's learning and education. When parents are informed and convinced of the importance of computing education, their motivation, assistance and investment (e.g., in books or computers) helps their children to achieve more, exhibit more positive attitudes and behavior and increase attendance and engagement. Involving parents in computer science education is even more important as they probably have little computing knowledge themselves. Therefore, computing programs for kids should also reach out to families in order to build the kind of relationships that inform and engage them as active partners in their children's education.

As part of our Computing at School Initiative (Computacaonaescola.ufsc.br, 2013), we run family workshops in which learning of basic computing capabilities is supplemented by parent-child activity time. During these workshops, children along with their parents learn physical computing by programming an interactive robot. Within the context of a story on an otter that needs to educate an ogre to stop polluting his lake, the workshop participants make to come alive a super hero robot by making him firing lasers through his eyes, throwing mud balls against a picture of an ogre and, once sensing the presence of the ogre, making a sound in order to draw its attention.

Therefore, we created a simple, low-cost, platform-independent, reliable and stable strategy integrating a microcontroller and a blocks-based visual programming language. The robot is automated by an Arduino Nano microcontroller and few hardware parts, such as a servo motor, an ultrasound sensor and two LEDs (with an approx. cost under US$45.00).
In order to facilitate programming, we use the Scratch blocks-oriented programming language (Malan and Leitner, 2007, Monroy-Hernández and Resnick. 2008), a free programming language developed at the MIT Media Lab especially for young people by simply using drag and drop blocks to perform different commands or actions. We support both most used flavors of Scratch: Scratch 2 (Scratch.mit.edu, 2007) and Snap! (Harvey and Mönig, 2015), which are chosen depending on the environment where the workshop is held. To enable a quick learning experience and not having kids to hassle with jumper wires, breadboards and command line-based microcontroller drivers, we developed a set of tools:

- **Scratchduino** ([http://www.computacaonaescola.ufsc.br/scratchduino](http://www.computacaonaescola.ufsc.br/scratchduino)): a Scratch and Snap! to Arduino communication server. It is an easy to use, multiplatform GUI-based program that acts as a bidirectional protocol translator that provides interoperability between the Scratch Extension Protocol and the traditional Firmata microcontroller protocol. It allows driving microcontrollers using Scratch or Snap! programs in an intuitive, flexible and easy way.

- **Scratchboard** ([http://www.computacaonaescola.ufsc.br/scratchboard](http://www.computacaonaescola.ufsc.br/scratchboard)): a low-cost and easy to use Arduino Nano break-out board that allows rapidly building physical devices using telephone cable jacks and helps visualizing the structure and logic of the connections.

Scratchduino is an extension of the s2a_fm command line Scratch to Firmata protocol translator originally developed by Yorinks (2013). In order to avoid the usage of an Unix-like command line application, we developed Scratchduino with a simplified GUI, usable by kids, in contact with both the original developers of s2a_fm and Snap! and also provided the Portuguese localization for the Scratch and Snap! Arduino Blocks and the Brazilian Portuguese localization for the whole Snap! programming language. This allowed us to employ Scratch and Snap! in physical computing family workshops in Brazil.

The Scratchboard was developed as a printed circuit board with a DIP socket for the Arduino Nano, and eight 4P4C jacks, where the automation devices can be connected, as shown in Fig.2. These can be analog and digital devices, from actuators and sensors to simple handmade analog devices.
Running Family Workshops

In order to teach physical computing, we run family workshops either as part of school programs or independently. The workshops are aimed at children accompanied by a parent (or any kind of adult family member or friend).

During the 3 1/2-hours workshop participants learn step-by-step how to program the super hero robot. This involves learning the use of simple commands as well as events, conditionals, and loops using also sensing commands and operators. We also show how to create a function and how to use it. Implicitly are taught basic computing concepts such as an understanding of algorithmic problem-solving (problem statement, implementation and testing cycle), collaboration in form of pair programming as well as the understanding that a computer program is a set of step-by-step instructions to be acted out. The instructors are either professors or graduate students with the assistance of undergraduates of the Department of Informatics and Statistics at the Federal University of Santa Catarina (UFSC) in cooperation with the Federal Institute of Santa Catarina (IFSC).

So far we have run 5 family workshops. They took either place at the Federal University of Santa Catarina or in schools in the state of Santa Catarina/Brasil. In total, more than 65 families, with children ranging from 6 to 13 years, participated.
Logistics (registration, coffee-break and certificates) have been handled by administrative staff of our initiative. The workshops were offered for free funded by the Google Rise Award and governmental funding (CNPq).

Lessons Learned

All workshops have been very successful. We publicized the workshops via social networks and local press, observing an increased interest with each workshop with waiting lists already for the next ones.

During the workshops, participants actively take part and are able to follow the instruction. Especially when testing the steps, the kids express their enjoyment and satisfaction e.g., by moving the arm of the robot. Step-by-step instruction with immediate execution by the participants involving problem statement, implementation and testing, also allowed to implicitly introduce an understanding of algorithmic problem-solving. Using the scratchboard and the few-button interface communication server has also been shown to facilitate the learning process and enable a greater emphasis on programming aspects when compared with earlier concepts of the workshop using traditional breadboards and command line interfaces for establishing the communication. In the workshops, Scratch has also shown to be an extremely intuitive environment to teach programming.

Parents as well as the kids enjoy programming the super hero robot and we observed that they immerse into the story. One child for example had himself filmed by his mother re-telling the story while running the robot he programmed.

The children like the workshop a lot, expressing this in their comments: “Very cool and lot of fun”; “I loved the workshop”; and “Incredible – it’s magic” emphasizing especially that they liked make a robot move. As well as the parents who also demonstrated their contentment praising especially the didactic, dynamic and active format of the workshop in which it taught programming concepts in a creative and attractive way for the children. Several parents also cited as a strength the possibility of having this experience together with their child creating
valuable parent-child activity time. This positive evaluation has also been confirmed by post-
class surveys in which the workshop was highly rated: on a scale of 1 - poor to 4 - excellent,
the participant’s average ratings were 4 (median) for the workshop in general. The majority
of the children also considered the workshop easy and fun. At the end of the workshop the
large majority (60 children) think that they can make computer programs and want to learn
more about programming. The parents also expressed a very positive feedback indicating
that they liked very much participating in the workshop and learning on how to make com-
puter programs. The only improvement suggestions were related to offering more such
workshops including further functionalities such as a walking robot. Comments from the par-
ents also indicate that they recognize the importance of computing education as they expect
it also to contribute to logical reasoning, creativity and concentration/persistence. Parents
also commented that the workshop helped to demystify computing giving an example that
computing can be easy and fun to learn.

At the end of each workshop, most participants (parents and kids) were eager to continue at
home and/or through other workshops.

The positive potentials of such family workshops go well beyond computing education for
children by involving the parents to learn along with the kids and providing also valuable par-
ent-child activity time. The workshops yield benefits by contributing to the children’s educa-
tion through parental involvement, but also by reaching a different group - the adults – and,
thus, providing computing education to a larger share of the community.

Due to the success we plan to continue these workshops not only as self-contained events
but also as a part of the school programs. In order to widen their application we are also
starting to develop teacher courses. Furthermore we are developing additional activities via
online tutorials in order to enable participants to continue at home afterwards.

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