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## Citation

## As Published
http://dx.doi.org/10.1145/2701973.2702001

## Publisher
Association for Computing Machinery (ACM)

## Version
Author's final manuscript

## Accessed
Fri Mar 08 09:26:38 EST 2019

## Citable Link
http://hdl.handle.net/1721.1/105272

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Social Robot Toolkit: Tangible Programming for Young Children

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ABSTRACT
Teaching children how to program has gained broad interest in the last decade. Approaches range from visual programming languages, tangible programming, as well as programmable robots. We present a novel social robot toolkit that extends common approaches along three dimensions. (i) We propose a tangible programming approach that is suitable for young children with reusable vinyl stickers to represent rules for the robot to perform. (ii) We make use of social robots that are designed to interact directly with children. (iii) We focus the programming tasks and activities around social interaction. In other words, children teach an expressive relational robot how to socially interact by showing it a tangible sticker rulebook that they create. To explore various activities and interactions, we teleoperated the robot’s sensors. We present qualitative analysis of children’s engagement in and uses of the social robot toolkit and show that they learn to create new rules, explore complex computational concepts, and internalize the mechanism with which robots can be programmed.

Categories and Subject Descriptors
K.3.1 [COMPUTERS AND EDUCATION]: Computer Uses in Education; I.2.9 [ARTIFICIAL INTELLIGENCE]: Robotics

Keywords
Robot Programming, Ambient Computing, Relational Bots, Child Programming

1. INTRODUCTION
Recent years have seen a growing interest in approaches to introduce children to the concepts and applications of programming. In order to meet 21st century digital literacy requirements, many curricula have been suggested to promote children’s understanding of the underlying principles of computer science, as well as pragmatic applications of programming, e.g., game design and robotics. While initially targeting young adolescents and high school children, recent advances in education, system design and affordable and usable media have enabled researchers to promote programming education to younger children. Furthermore, simplifying the interface, via either visual languages, e.g., Scratch [1] or tangible programming [2, 5] has allowed kids as young as pre-schoolers to learn basic concepts of programming. A more engaging and real-world application of these concepts manifests in robots designed to be programmable, in situ, by children of a wide age range, e.g., Lego Mindstorms [3]. Most contexts involving robot programming have been focused on behavioral tasks, e.g., navigation and manipulation.

In this contribution, we present a novel approach to programming, namely, the Social Robot Toolkit. It explores several fronts of computer science education: (i) tangible interface of custom-made vinyl stickers that is understandable and appealing to children; (ii) a social robot, DragonBot, designed to be engaging for children and; (iii) a context of social interaction, i.e., the children program rules that “teach” the robot how to socially interact. We present early observations of pre-school children using this toolkit in an exploratory study that demonstrate promise that children can use the Social Robot Toolkit to explore new computational concepts, such as event-based logic, action sequences and non-determinism, while interacting with a socially engaging robot.

2. TOOLKIT DESIGN & EVALUATION
We use the DragonBot platform as the social robot to be programmed by the child. This is a squash-and-stretch expressive robot in the form of a cute furry dragon [4] controlled by a smart-phone. Dragonbot can express a wide range of body and facial expressions, as well as speak. In this exploratory pilot study, the robot was teleoperated by the experimenter via a tablet, to enable sensing. Later versions of the toolkit will support autonomous sensors.

The programming interface is comprised of a set of reusable custom-made vinyl stickers that represent triggers and events in a physical rulebook. Template stickers represent triggers (blue diamonds) and actions (green squares) with a black arrows that specifies order, Figure 1. The child can place a circular icon sticker for actions she can perform (e.g., clap hands, say “hi”), or a circular icon for actions the robot can take, e.g., facial expressions or saying something.

A rule is created by placing a blue trigger sticker with icon on the page, followed by a black arrow, pointing to a green
taught" the robot a new rule that the robot would perform
unique feature of the toolkit is its playful relational quality
interaction by showing the robot more event stickers. A
to do. Furthermore, all were enthusiastic to continue the
enthusiasm and excitement in "teaching" the robot new things
answered "It can be any order." asked "How does the robot know the order?" the child an-
also explored non-determinism with the toolkit by having a
response action which leads to another action. One child
also experimented on their own with different types of ac-
perceiving the triggering event. Several children
whenever it hears "hi". The robot can be programmed
rule she creates to "teach" it to the robot. The robot says "I
situated, in the sense that the child "shows" the robot the
rules. The vinyl stickers can be written upon with
dry-erase markers, which also enables children to experiment
with their own writing, drawing, and creative ideas.
The programming interaction with the robot is socially
situated, in the sense that the child "shows" the robot the
rule she creates to "teach" it to the robot. The robot says "I
got it!" upon seeing the rule and then can perform it, e.g.,
laugh whenever it hears "hi". The robot can be programmed
with several rules, enabling experimentation with sequences
and non-determinism.
The exploratory pilot protocol consisted of teaching the
children to use the toolkit and observing their abilities and
questioning them on their comprehension before, during and
after the interaction.
3. RESULTS
Qualitative analysis of this exploratory study, with 3 boys
and 5 girls, ranging in age from 4 to 8 years lead to impor-
tant preliminary findings. The children explored different
computational concepts. All children created simple rules
with a single trigger and event. When asked what the rule
means, one girl's rather typical answer, was: "when I clap
my hands, the robot will do like this" and made a funny face,
consistent with the robot action in the rule.
Children also learned about event-based logic and rules,
i.e., the dissociation between commanding and program-
ning. Commands which they showed the robot and the
robot immediately performed; and programming, where they
"taught" the robot a new rule that the robot would perform
whenever perceiving the triggering event. Several children
also experimented on their own with different types of ac-
tion sequences, i.e., an action chain where a trigger leads to
a response action which leads to another action. One child
also explored non-determinism with the toolkit by having a
single trigger point to several actions, see Figure 1. When
asked "How does the robot know the order?" the child an-
swered "It can be any order."
Children were highly engaged; they frequently expressed
enthusiasm and excitement in "teaching" the robot new things
to do. Furthermore, all were enthusiastic to continue the
interaction by showing the robot more event stickers. A
unique feature of the toolkit is its playful relational quality
(social interaction context). Indeed, children communicated
with the robot, e.g., "Hi", made silly faces to the robot and
even petted the robot and taught it to say "I love you".
The children could also articulate ideas about program-
mapping, i.e., we asked one 8 year old boy: "How do robots
decide what to do?" Before the session began, he answered
"They are probably ... wires and everything that make them
do things and everything, electric gadgets and everything.".
After the session with the toolkit, his answer changed to
"That electric gadgets and everything make something in-
side of it get programed to what you say and what you do,
so that the robot does what you want."
4. CONCLUSIONS AND FUTURE WORK
We have presented a novel educational tool, the Social
Robot Toolkit, aimed at pre-school aged children. It is based
on a tangible interface which is appealing for this age group.
Our early observations hold promise that young children are
highly engaged with and can derive educational benefit from
using the social robot toolkit. The children explored compu-
tational concepts while engaging in a social interaction with
the teleoperated robot.
We aim to extend the toolkit to include additional events
and actions, e.g., enabling the robot to react to faces the
children make. Further, we intend to make the toolkit au-
onomous with more sophisticated sensing through machine
vision and speech recognition. We shall also conduct a more
comprehensive study with pre-school children to evaluate
and quantify their understanding and engagement with the
Social Robot Toolkit.
5. ACKNOWLEDGMENTS
This research was supported by the National Science Foun-
dation (NSF) under Grants CCF-1138986. Any opinions,
findings and conclusions, or recommendations expressed in
this paper are those of the authors and do not represent the
views of the NSF.
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