Shape Changing Tangible Interface Designed for Supporting Exploratory Learning: A Flower on a Pot

Matthieu Tessier, Masahiro Ura, Kazunori Miyata
School of Knowledge Science, JAIST

Figure 1: *Our proposition of an animated object working as a tangible interface, here the flower is being showed in its 3 main states (From left to right) Blossoming, Pollination, and End of Life.*

1 Introduction

Integration of tangible interfaces [Raffle et al. 2004; Resnick et al. 1998] as well as a more mainstream implementation of tablets and interactive board are rapidly changing the way we perceive and define learning method to follow in a classroom.

In this work, we argue that instead of replacing old support by new support (books by tablets), reconsidering the interfaces through which education is being provided could bring interesting learning opportunities for students. We propose our vision of embodied tangible interface with the project "A Flower on a Pot" which uses an animated tangible flower as its communication device. We support the idea that a subject (flower in our case) could be the best support for representing itself via a tangible artifact.

2 Our Approach

We base our idea on exploratory learning [Bonawitz et al. 2009; Mitra et al. 2005] and we propose an interface with which student will be able to interact with and obverse various behaviors and results (shape, color, animation, texts).
Current tangible interface designed for school are bounded in fixed shapes. We see interesting features in Tangible interface with shapes evolving throughout the interaction process, by stretching, bending or folding its surface(s). This requires the interface to have elements that can be reshaped automatically during the course of the interaction without requiring the student to replace a part X by a part Y to simulate an evolution or a change.

We also consider each subject proposed to student as a 3 dimensional element or space, and we see an innovative way to display said subject by creating tailor made tangible interface that look and behave accordingly to the subject they are representing.
To define how an interface could represent a subject or its feature, we made the following list. It describes how we approach different types of tangible interface to differentiate: Scale (real scale or altered), simulation of abstract concept or observable concept, personal or group experiences.

Classification and types of representation :

A. Embodiment of the subject
B. Simulation of the subject dimension and scale
C. Recreation of the subject environment and action

(The following class content example are taken from Japanese text books, New Science Grade 4 to 6.)

A. Embodiment of the subject (medium sized object): Subject where a real scale representation can be achieved and suitable for direct manipulations (plants, human anatomy). Example: minute interaction such as activities on insect might require the subject to be scaled up in order to appreciate and analyze a specimen with more accuracy.

B. Simulation of the subject dimension and scale (for large object and abstract concept): Subject where a real scale representation isn't achievable nor suitable for direct manipulations (atoms, insect, trees, cloud formations, stars and planets).

C. Recreation of the subject environment and actions: Subject in which scale is not the key feature as we consider a subject in it's entirety and the recreation of its mechanics and physicality.

3 Our system

For the project "A Flower on a Pot", we focused on the representation type A for an interface representing the life cycle of a flower. We chose to work with flowers since a natural flower won't allow students to see its life cycle in real time in a short period of time. A flower is big enough at real scale to allow someone to work on it without having to modify its dimensions for interaction purposes. We aimed at representing the physical evolution of a flower during its growing process.

In order to control the interaction with the flower, a dial is located on top of the pot/base, and rotating this dial counter clockwise will make the flower aged. The flower life cycle is split into 3 periods: Blossoming, Pollination, and End of Life, as shown in figure 1.
The main part of this work was to define a way to physically represent a subject, in this case the flower behavior and the petal motion of the flower, as shown in figure 2. Each petals (6 in total) are made out of plastic, thin enough to be actuated by 2 strings, one pulling up and one pulling down. This allow both bending upward and downward for each petal, allowing each to go from fully close to fully open.

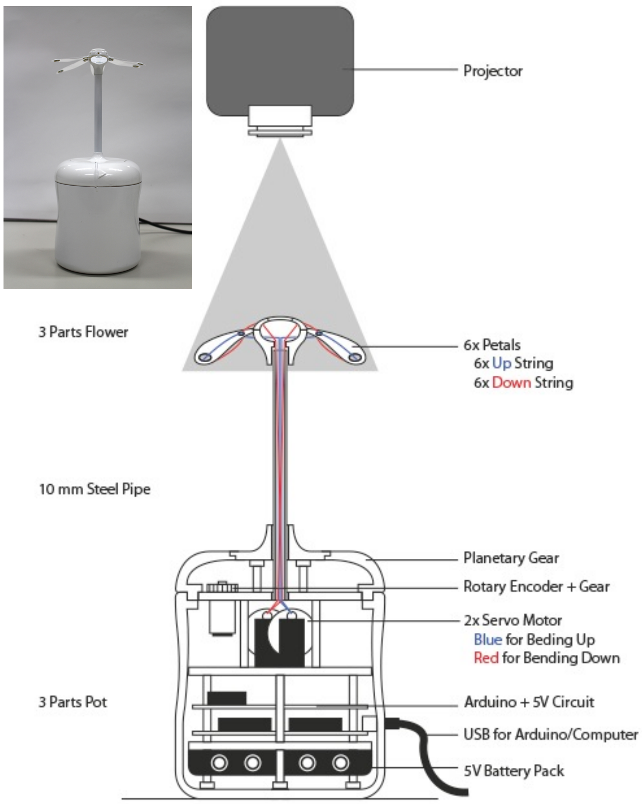

Figure 2: Prototype Schematic and prototype (left corner).

We are also working on projection mapping to represent petal colors and wild life such as bees during the pollination state, as shown in figure 3. We are keeping track of the value sent to the servo from the dial rotation through the Arduino, so we know in real time the angular positions of both servos. Then, via the Arduino USB port we can transfer those information to a computer, generate graphics corresponding to the flower's age (color, animals or none) and project it on the petal's surface.
This tangible interface is now ready for experimentation with primary school student.

4 Conclusion

With our incoming experimentation, as well as expecting an increase in focus and interest for the subject due to the novelty of the interaction process, we look forward to changes or increase in curiosity and/for discovery; the way students consider, approach and question a subject. We aim at further improving the effectiveness of exploratory learning by providing engaging and dynamic tangible interfaces.
With this work, we aim at understanding if allowing students to interact directly with a dynamic representation of their school subject will bring new ways of: Representing school content, accessing and browsing school content.

We propose an idea where digital content can be represented as tangible interfaces with animated parts to reduce the cognitive load required to process the visual representation of a subject. We consider that having an object already shaped as the subject itself could reduce his cognitive load and let students focus directly on the events occurring on said object.
If proven efficient, this proposition could bring a large array of design possibilities, each subject being in the capacity to receive a tailor made solution. The principal counter point for this idea is related to the shape of the object. If the student wants to study 2 subjects that are different, he will require 2 different interfaces. This is where such tangible interfaces have limitation with current materials and fabrics.

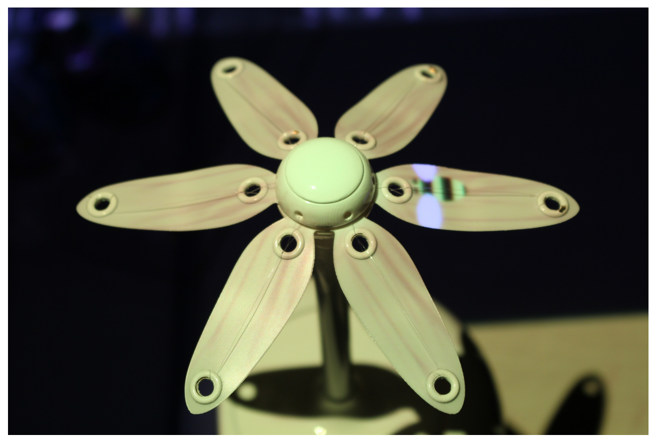

Figure 3: *The flower during the pollination period. Early graphical representation of the flower texture and bee.*

References

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition*, *120*(3), 322-330.

Mitra, S., Dangwal, R., Chatterjee, S., Jha, S., Bisht, R. S., & Kapur, P. (2005). Acquisition of computing literacy on shared public computers: Children and the" hole in the wall". *Australasian Journal of Educational Technology*, *21*(3).

Raffle, H. S., Parkes, A. J., & Ishii, H. (2004, April). Topobo: a constructive assembly system with kinetic memory. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 647-654). ACM.

Resnick, M., Martin, F., Berg, R., Borovoy, R., Colella, V., Kramer, K., & Silverman, B. (1998, January). Digital manipulatives: new toys to think with. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 281-287). ACM Press/Addison-Wesley Publishing Co..