Aligning Design of Educational Technology with Learning Goals

Tom Lauwers

Carnegie Mellon Robotics Institute

PURPOSE

A new class of educational tool is being made possible due to the revolution in embedded computing devices. These tools are capable of sensing and acting upon their environment, allowing students to explore laws of nature, engineering design, and programming through a physically instantiated object.

Learning occurs through interactions, be it a teacher lecturing to a class, a student reading a textbook, or a user playing an educational computer game. The interactions opened up by physically interactive media are qualitatively different; notably, a physical and intelligent device can impart concepts by demonstrating them in the real world while also interfacing with a computer to perform experimental analysis. The design features of a given physically interactive device relate directly to the types of concepts which are appropriately demonstrated with the device - imagine attempting to teach about acceleration with a device which is not capable of either moving or registering motion. Given this insight, I posit that it should be possible to design a device by considering the learning goals of the curriculum in which the device will be used. This marks a significant departure from common practice today, in which curricula and goals are adapted to existing educational tools.

By using the learning goals as the foundation for determining design constraints, I am extending the curriculum design principle of alignment to encompass educational tool design. Traditionally, designers using the principle of alignment start by formulating the learning goals of their curriculum, and then create assessments and instructional materials which align with those learning goals, as well as with each other. I propose that to create educational tools which are relevant to a given curriculum the feature set of a given device must spring from the learning goals and be aligned with the instruction and assessment methods. I present a framework to guide both technologists seeking to develop physically interactive media for an educational application and educators seeking to choose an educational tool to facilitate interactions that will lead to learning.

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Bibliography

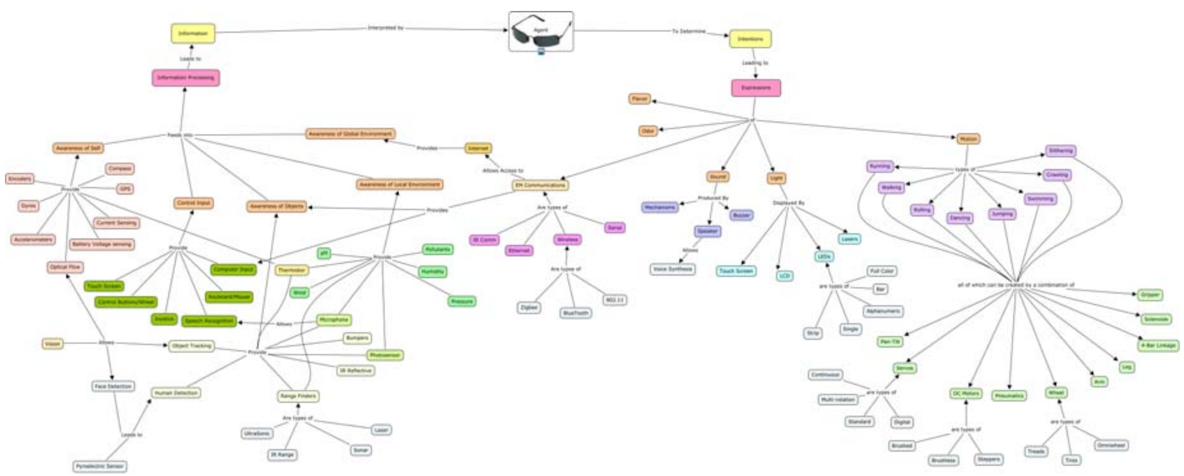
1) Grant Wiggins and Jay MacTighe, "Understanding by Design", ASCD, 2005.
2) N. Kalra and T. Lauwers, "A Braille Writing Tutor to Combat Illiteracy in Developing Countries ", AI for ICT and Development workshop, IJCAI, 2007.
3) I. Nourbakhsh et. al., "TeRK: A Flexible Tool for Science and Technology Education", AAAI Spring Symposium on Robots and Robot Venues:Resources for AI Education, 2007.

DESIGN FRAMEWORK

The design framework presented here is an early attempt to produce a principled way to feed learning goals into the design constraints of the device – will test and refine this framework based on how well it applies to the studies presented in the 'Testing the Framework' section. The basic idea behind the framework is to extend the principle of alignment as presented in Understanding by Design [1] to technology design. I have produced two concept maps, presented below, which show how this extension can be performed.

In the first concept map, the traditional alignment of instruction and assessment with learning goals is presented on the left in blue. Instruction is then broken down into a list of potential teaching styles. Some of these styles are much more amenable to the use of physically interactive devices – generally those styles which lend themselves to student experimentation and exploration. I have color coded the styles based on how well matched they would be to the use of a device – Techniques colored green can be directly aided by physically interactive media, techniques colored in yellow can be facilitated with physically interactive media, and techniques colored in red likely would not be aided by physically interactive media.

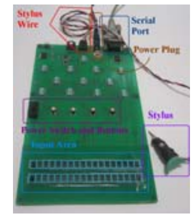
Based on the result of the first matching step, a teacher or technologist may decide that a device can be used in the class. If this is the case, the second concept map can act as an aid to choose which design features would provide the most useful interactions to students. Physically interactive media can interact with the real world in two ways – by sensing it, and by acting on it. The concepts marked in orange can be used to determine which interactions are appropriate to the lesson plan; specifically, which types of interactions the physical media must engender, while the lowest and most extensive layer of concepts can be used to choose specific design features of the device.



TESTING THE FRAMEWORK

I have been involved with a number of studies in which educational technology has either been introduced into an existing curriculum or in which a curriculum has been created due to the development of a new educational tool. Many of these studies are ongoing, with both curriculum and technology being iterated, and provide a fertile ground for me to study and test the design framework. I am focusing my energies on four case studies, described individually below, which will highlight implementations of the framework and shed some light on whether alignment matters to learning outcomes.

Regardless of whether a technology was inserted into an existing curriculum (Braille Tutor, CS), or enabled a new one (Robot Diaries, Neighborhood Nets), each of these studies follows a basic iterative cycle. The educational technology is designed before or at the same time as the curriculum, after which a pilot study is conducted. The features and interactions which supported learning are determined from the pilot, and the technology is redesigned such that the technology is appropriate for the future curriculum. The studies described are at differing stages of this design process, but none are past the pilot stage. As a major technology designer on each study, I aim to use the design framework to determine the educational tool's design constraints.



The Braille Writing Tutor [2]

The aim of this project is to teach children in developing countries to write Braille with a slate and stylus (akin to pen and paper for the sighted). The project employs a novel input device connected to a computer to provide immediate feedback. Piloted in August 2006 at the Mathru school for the blind in Bangalore, the device is now being redesigned to reflect feedback from students and teachers.

Robots in Computer Science [3]

Low retention and declining admission rates have led to a crisis in Computer Science education. One culprit is the Introduction to Computer Science class, which sees drop rates of 30-50%. Our project seeks to introduce a robot with the correct feature set to revitalize this curriculum.

Robot Diaries [3]

Aimed at middle school girls, this project marries internet connectivity with new robotic technologies to allow girls to design and program home robots which express their and their friends' emotions. The curriculum aims to teach design principles, programming, and technical literacy.

Neighborhood Nets

Neighborhood nets rests upon a new low-cost device, the Canary, that is capable of both sensing weather and air pollution and of expressing this data with motors, audio, and lights. By providing members of local communities with Canaries, we hope to engender both technical literacy skills and community empowerment.