Make to Think: Ideas, Spaces and Tools

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Abstract:

The purpose of this essay is to share a learning experience research designed for, and developed by, an interdisciplinary group of faculty members of the University of Costa Rica. The proposal was put into practice in the form of a workshop, which used Scratch programming language and PICO Boards as an opportunity to model a constructionist learning environment. Powerful ideas, spaces, and tools were made available to the participants for the construction of digital stories, models, and simulations. The final goal was to enable the teachers to experience, through a hands-on experience, the environment, ideas, and tools of constructionist learning, so they could extrapolate them later on into their own fields and lessons.

Keywords:

Constructionism, Scratch, PICO Boards, Higher Education

Introduction

A workshop “Ideas, Spaces and Tools: Thinking by Doing” was an initiative of the Institutional Network for Faculty Training and Evaluation (RIFED, Spanish acronym) and the University Chair for Transdisciplinarity, Complexity and Eco-education of the Academic Vice-Presidency of the University of Costa Rica.

The initiative was designed for faculty members from various areas and disciplines, to the purpose of modeling a constructionist learning environment. Using Scratch programming language and PICO Boards (which will be explained further on), participants were able to design digital stories, models, and simulations, individually and in groups.

As will be presented further on, Constructionism is Seymour Papert’s educational proposal for the creative use of new technologies in learning, involving communication, information and collaboration. The Scratch Language and PICO Boards are digital tools designed at the Media Laboratory (Media Lab) of the Massachusetts Institute of Technology (MIT), by the Lifelong Kindergarten group led by Dr. Mitchel Resnick.

As to learning models and simulations, these creations aim to illustrate scientific phenomena, obtain a better understanding of an observed phenomenon, or explain to other people specific ideas or data regarding a research (Colella et al, 2001). According to these authors, there are several types of models:

- Illustrative: those that show scientific processes or systems. For example: planetary orbits of the solar system, DNA chain models that can be manipulated to show the replication or transcription processes, or transparent human bodies showing internal organs. All these capture an angle of a scientific system or process, helping us to understand it in new ways.
- Analytical: based on mathematical equations, they enable the exploration of a variety of scenarios. For example, an economics professor could discuss a described supply and demand model by means of equations. Or a physics professor could want to do a model explaining how, in a given equation, position depends on acceleration and time.
- Simulative: instead of solving equations, the underlying mechanisms are described, letting them run through time to see what happens. These models can easily include random and probabilistic events, reflecting important features of the world that surrounds us. These characteristics of simulation models allow us to perform explorations difficult to achieve through analytical models, and impossible to achieve with illustrative models.

The "Ideas, Spaces and Tools: Make to Think" workshop was designed, planned and developed by an interdisciplinary group of faculty members, for the benefit of a faculty group also interdisciplinary. It was carried out on May 16-20, 2011, with the participation of 16 teachers from the following schools: Computer Science, Evaluation, Communication, Economics, Human resources, School Administration, Law, Sociology, Architecture, Mathematics, Chemistry, Medicine, and Geography and History.

The general purpose of the workshop was to enable the teachers to experience, through a hands-on experience, the environment, ideas and tools of constructionist learning, so that they could extrapolate them later on into their own fields and lessons.

On Constructionism: Make to Think

Based on the constructivist ideas of Jean Piaget and on Lev Vygotsky's thought, the well known thinker Seymour Papert proposed Constructionism as an innovative educational vision on the use of digital technologies to support people's learning. But far beyond this vision, Constructionism makes it possible to understand the way in which society and the individual take possession of digital technology (Papert, 1990). For the author, knowledge is something that is built in the mind, while something tangible, which must also be meaningful, is constructed in the physical world (Papert, 1990).

In this educational approach, Papert granted an active creative role to the apprentices, placing them as designers of their own projects and builders of their own learning. It is a question of empowering apprentices, so they can take on this active role. Opposed to computer-assisted instruction (CAI), which promotes that the computer teaches and programs the user, Papert proposed that the apprentice should be the one to program the computer, since by doing so, he/she acquires *"... a sense of command over an element of the most powerful and modern technology, establishing at the same time an intimate contact with some of the most in-depth ideas of science, mathematics, and the art of constructing intellectual models"* (Papert, 1987, p. 17-18). Papert maintains that the best learning will not come from finding the best ways to teach, *"... but rather from providing the students with the best opportunities to construct"* (in Fabel, 1990, p. 2).

These premises imply that people possess a natural ability to learn from experience, creating mental structures that allow them to organize and combine the information and knowledge built throughout their lifetime. According to Papert, knowledge is constructed in an especially fruitful manner when apprentices consciously involve themselves in a public construction, which may be exhibited, discussed, proved, examined or admired (Flabel, 1990, p. 2-3). In this sense, Papert warns that in order to do so, it is not enough to ask students to take charge of their own learning: they need to be equipped with the proper tools for them to do it.
Papert (1990) says that Constructionism is more than learning by doing. He states that it is doing with an intrinsic motivation; doing with the drive of personal values and desires; doing with an understanding of what is done. Above all, it is to take possession of knowledge; to make it one's own. According to Papert, this is finally achieved when the construction tools become invisible and the apprentice focuses on his/her own learning and knowledge.

On Two Powerful Ideas: Technological Fluency and Collaboration

A constructionist learning environment focuses on the exploration and construction of *powerful ideas*, as well as on their reflection and articulation (Papert, 2000). Powerful ideas are not important due to the place they occupy within a curricular framework, but rather because they give the apprentice the autonomy to approach a topic and study it in depth, by means of an actual construction process that puts it into context. Some constructionist learning tools enable the exploration of far-reaching powerful ideas: algorithmic thinking (Logo: Papert, 1987), decentralized thinking (StarLogo; Resnick, 1994), mentoring (MOOSE Crossing: Bruckman, 1998), moral values (Zora: Bers, 2001), collaboration and remix (Maloney, Resnick et al, 2010; Seneviratne, & Monroy-Hernandez, 2010).

The workshop in question took on the challenge of proposing situations in which the participants could experience some powerful ideas, and even the most powerful of all: **the idea of powerful ideas**. This time, two ideas in particular caught the general interest: technological fluency and collaboration. These two ideas not only constitute an important part of the learning process in which the teachers/apprentices were involved; they also nourished the design and development of the constructionist learning tools that were being used: Scratch and PICO Boards (explained further on).

Technological Fluency

Technological fluency refers to the use and appropriation of technological tools to do or construct a task; to create, communicate, and design. According to Papert's and Resnick's (1995) description, technological fluency involves much more than the ability to use technological tools, which would be equivalent to understanding some common phrases in a language. In order to be really fluent in a language (such as English or French), the person must be capable of articulating a complex idea or telling a "fascinating" story; that is to say, he or she must be capable of "doing things" with the language. Analogically, the concept of technological fluency not only implies knowing how to use technological tools, but also knowing how to build meaningful things using those tools. A technologically fluent person must be able to go from the source of an intuitive idea, to the execution of a technological project.

Moreover, technological fluency refers to the ability to program, which broadens the possibilities of what can be created, and what can be learned. It allows reflection on personal thought, and even reflection on the activity of thinking itself. For Resnick and the Scratch group, "… technological fluency means designing, creating, and remixing, not just browsing, chatting, and interacting" (Resnick et al, 2009, p. 60). This is why Scratch was created as a learning environment:

1) in a ground floor or with an easy access, meaning that its users can easily manage this constructionist learning tool, even if they have no previous experience in programming;
2) with a high ceiling, meaning that projects can become more complex as the users acquire experience and fluency with this tool; and
3) with thick walls, enabling the creation of different types of projects, involving people with different interests and learning styles.

Collaboration

The Scratch design, as a learning tool, is accompanied by its own website. The MIT Media Lab group that designed this tool is convinced that "… for (its) success, the language must be linked to a community where people can support, collaborate, criticize, and construct based on each other's work" (Resnick et al, 2009). Collaboration, besides being a powerful idea promoted from the Scratch design and experience itself, was essential to the workshop.

The interface of the Scratch learning tool was also designed with the goal of enabling collaboration. For instance, the page includes the "share" button, which means that a single "click" is needed in order to do so. Furthermore, when a person decides to share his/her project on the Scratch website, it is made available to all the other users. Apart from viewing it and getting inspiration from it, they can use it, reuse it, rate it, and assess it. This multi-channeled feedback gives shape, gradually, to a community, becoming one of the greatest motivations to create and share projects. Community members are continuously adapting and creating projects, based on the ideas of other members. The reuse and enrichment of projects is known as "remix". Information on how often and who has remixed a project is available at the site.

On the other hand, Scratch has been translated into more than 40 languages, raising collaboration to international level. The Scratch infrastructure not only favors its translation into several languages, but also accepts the use of any type of character.

In the workshop held at the University of Costa Rica, the participants worked in groups on the design and creation of their Scratch projects. They also had the opportunity to share their projects on the website, making them visible to the world at large. Some of the subgroups found their inspiration in projects available at the Scratch website, to conceptualize and design their own. In this occasion, and due to time restrictions, communication and feedback among participants was not carried out through the site, but rather in person. Each one of the subgroups had the chance to share their ideas, receive feedback from others, and reflect upon it so as to improve their projects. In addition, all of them could "borrow" ideas from the others, incorporating them into their designs.

On the Tools: the Scratch Programming Language[1] and the PICO Boards

As we mentioned above, both the Scratch Programming Language and the PICO Boards are digital tools designed by the Media Laboratory (Media Lab) of the Massachusetts Institute of Technology (MIT), by the Lifelong Kindergarten group led by Dr. Mitchel Resnick.

These tools inherit Papert's constructionist ideas and derive from previous proposals, such as the

[1] Scratch can be downloaded for free from the page http://scratch.mit.edu

Logo Language[2] and the programmable bricks[3], also from the Media Lab. Resnick and his group (2009) not only meant to provide new generations with powerful digital tools for learning, but also with an entire environment of mutual support and collaboration.

The Scratch programming language is based on professional programming languages specifically developed for young programmers, such as Flash/ActionScript or Alice 7and Squeak Etoys 5. However, its designers searched for a threshold that would make programming learning more accessible, offering a larger variety of options to develop logic-computational thinking. According to Resnick (2009), they designed a digital language more *tinkerable*, more meaningful and friendlier than other programming languages. For this reason, the Scratch language's grammar is based on a set of programmable digital blocks that assemble together, just as the physical blocks do when children and young people play with them. Scratch programmable blocks are designed to assemble only if by their joining they achieve a syntactical meaning. The language control structures (such as *repeat* and *forever*) are shaped as a C, indicating that the programmable blocks must be placed inside. The shape of the value-producing blocks depend on the value they return (ovals for numbers and hexagons for Boolean functions). The conditional blocks (such as *if*, or *repeat until*) have an incomplete hexagonal shape, indicating that a Boolean function is required.

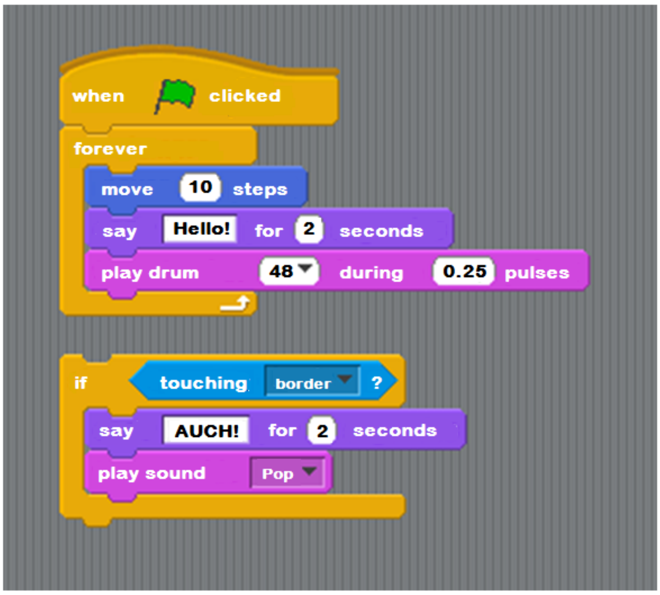

Figure 1. Examples in Scratch programming

Besides being a programming language, Scratch also aims to satisfy the diversity of learning styles. That is why it promotes its use among programmers who plan in a vertical way (from top to bottom), as well as among those who prefer to tinker with a thought and plan from bottom to top. In like manner, the programming activity of this language consists of mixing graphics, animations, pictures, music, and sounds.

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2 Commercial versions of the Logo Language, known as LogoWriter and MicroWorlds.

3 Commercial versions known as MindStorms and PicoCrickets

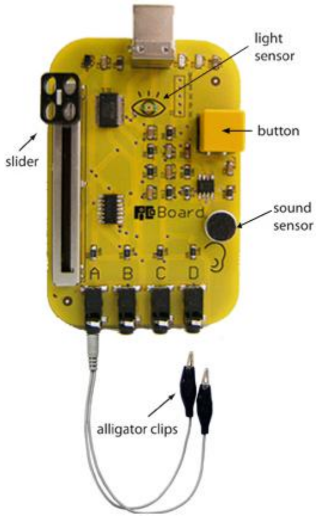

Figure 2. Picoboard

The PICO Boards (Fig. 2) are electronic cards that allow Scratch-programmed projects to interact with the physical world, by means of light and sound sensors. They also have a slider that controls the value of the entries (resistance), a button that reacts to contact, and a pair of loops that detect when the cards are connected. Therefore, these cards allow projects on the screen to react before stimuli (light, contact, resistance, or sound) coming from the outside world, making them interactive.

On the Workshop's Design and Development

The design of a constructionist educational activity requires previous and careful planning, in order to guarantee a reference framework that is solidly supported and, at the same time, very flexible. This combination of conceptual solidity and methodological flexibility is what grants complexity to the constructionist design of a learning environment. But only through careful planning is it possible to accommodate emergents and active participation from all the people involved, without running the risk of promoting a senseless activism. In this context, and in agreement with Papert's ideas, "objects-to-think-with" must be available; and the construction of meaningful projects on the part of the participants constitutes the fundamental strategy of learning. Hence the workshop's name (title of this paper): thinking by doing.

With these ideas in mind, the workshop included a dynamic combination of lectures about powerful ideas (regarding Constructionism, as well as on the potential of the Scratch language and PICO Boards); demonstrations; guided exercises; design and construction of individual and group projects; and sessions of reflection and reconstruction of the experiences and learnings (Fig. 3). The title "Ideas, Spaces and Tools" was chosen because it reflects the workshop's educational spirit or vision: to create a space where the encounter between ideas and tools could become a reality.

The Workshop was carried out at a computer lab of the Department of Computer and Information Sciences (ECCI, Spanish acronym) of the University of Costa Rica (UCR), lasting four days (Monday 16, Tuesday 17, Thursday 19 and Friday 20, May 2011). Each day, the four-hour work blocks (1:00 to 5:00 p.m.) were separated by a short recess and refreshments. Since the workshop dates was held close to the celebration of the World Scratch Day (May 21, 2011), it was entered as part of Costa Rica's Scratch Day activities.

Figure 3. Working sessions, of the organization team

The workshop was launched with an introduction called "The Workshop's Spirit", which included a Scratch project to describe the purpose of creating a space where all participants, apprentices and mediators alike, would have the opportunity and tools for "thinking by doing" as a team. Scratch, PICO Boards and construction materials (including waste material) were presented as the tools which would enable them, in this case, to think and do together, so as to find ways to improve university teaching (Fig. 4). Constructionism, collaboration, technological fluency, and the creation of models, simulations, and digital stories were presented as ideas especially placed in this space, to encourage innovation in the university learning environments. In other words, the educational vision of the workshop was briefly presented at this stage.

Figure 4. Construction materials and PICO Boards

Immediately after, there was a first demonstration of the basic operation of Scratch, followed by a period of free exploration of Scratch projects, included in the original gallery of this programming language. The second and third days began with similar demonstrative sessions, covering the operation of the PICO Boards and useful capsules of programming concepts. The "Sensorboard 1 Sunrise" project was used to demonstrate PICO Boards, taken from the examples on motors and sensors originally included in Scratch, which includes a cottage built with cardboard and waste materials (Fig. 5).

After the Scratch free exploration period, a group dynamics was carried out, collecting the first impressions and initial ideas of the participants. This first encounter turned out to be vital within the programmatic logic of the workshop, to the extent that it allowed the creation of a propitious and evocative atmosphere. Moreover, it enabled participants and facilitators to find convergent interest lines and specific expectations for the development of the workshop. The exercise was intentioned, aimed at targeting a contextual construction of the reality shared by the set of participants. In Resta's words, "behavior, thought and content are the bases that structure teaching and learning – at least in what pertains to organized teaching –. These structural elements become accessible by working on the design of 'authentic' realities in the classroom practices" (Resta, 2004, p. 184).

The proposed problem-inducing node aimed at discussing the different expectations held by the participants regarding the workshop. The development line was designed in terms of a possible project or topic, and its expected impact on the teaching evolution of each participant. Apprentices were asked to write down their answers on a piece of cardboard, all of which were then adhered to the blackboard. Once their answers were displayed, discussion started to the purpose of gathering common ideas, mainly those related to the three thematic areas: digital stories, simulations, and models. Participants analyzed different ideas, enriching the discussion and enabling the appointment of work teams, for the process developed throughout the week (Fig. 6).

Figure 5. PICO Board demonstration

Figure 6. Team work discussion

Powerful ideas were presented on the first and second day, followed by an open plenary session. The topics developed followed thematic lines broached and discussed from the start. Likewise, new theoretical-practical enrichment axes were presented: technological fluency and collaboration, their current importance, and the manner in which they appear in Scratch. As was mentioned above, the spirit and intentionality in the design of this training space was the construction of a formative scenario, which would enable the apprentices' immersion into a constructionist environment.

This environment would be innovative in nature, by developing a setup with non-traditional elements for an interdisciplinary group of faculty members. Although Scratch, the tool, represented an important appeal, it was always assumed and promoted as a cognitive medium that allowed different interaction levels. In Papert's words, it became an "*object-to-think-with*".

Cabero described it as: "In short, what we want to say is that the system's technical determiners will not be what mark its quality and efficacy, but rather the attention we pay to the educational and didactic variables put into operation. Nowadays, problems are not technological, but derived from knowing what to do and how to do it, and why we want to do it" (Cabero, 2006, p. 8).

Four work teams were formed at the end of the second day, granting them a period to start planning a group project with Scratch and PICO Boards. Days 3 and 4 were mainly devoted to the development of these projects. Two groups focused on the development of simulation projects, while the other two created digital stories.

Due to the workshop's constructionist approach, the groups shared their learnings after each work session, through dynamics where each group showed the others their ideas, progress, and difficulties. This favored a greater exchange of ideas and learnings among the participants, based on a process of reflection upon the work developed in the projects. Closing each day with a reflection and reconstruction period on the process experienced was equally important.

A demonstration on the way to integrate the international community of Scratch, by means of its webpage (www.scratch.media.mit.edu), was performed at the end of the workshop.

The projects developed by the participants were shared with the international community through this means.

On the Findings

Although the technological tools played an important role in this workshop, let us recall that they always did so as objects-to-think-with. The goal was to try out and reflect on a constructionist learning environment, as an educational alternative to traditional university teaching.

Expectations and First Reactions

Most of the participants started the workshop with the following expectations: to discover innovative forms of education, realistic and applicable in their courses; to discover new ways to approach knowledge, for both them and their students; and to acquire more instruments to make their lessons more attractive, by allowing the students to lead the knowledge construction processes. Participants were asked to express their first reaction with a short phrase. Some of their answers were:

Knowing by doing

A return to wonderment

Programming through play

I fill like I'm stuck (not too much) at the threshold of an interesting adventure.

Nevertheless, some of the people enrolled placed their expectations on technology itself, on learning to use it so that it would help them to continue teaching their students in the traditional way.

Assessment

At the end of the workshop, and by means of an online survey completed by 14 of the 16 participants, different angles of the workshop were evaluated.

The majority (78%) considered that the objectives set out in the program were accomplished.

Likewise, the majority (93%) expressed that the contents learned during the workshop were relevant for their teaching work, while 86% felt that they could adapt what they learned to mediate in their students' learning.

Regarding the participation and organizational aspects of the activity, most participants (86%) considered them satisfactory, and a similar percentage (85%) was pleased with the work carried out by the facilitator team, expressing that they would recommend this workshop to other faculty members.

The less appreciated feature was the physical space; only 35% thought the physical space was appropriate for the execution of the activity. The placement of the furniture, computers, and other equipment did not favor the visual traffic or movement of the participants, and their rearrangement to accommodate small groups or plenary sessions was difficult.

The general rating of the workshop was positive; in a scale of 1 to 10, 43% rated it with a 10, 21% with a 9, 21% with an 8, and only 14% marked it with a 7 or lower.

The survey included an open section for observations and suggestions, opinions summarized as follows.

In general terms, the enthusiasm and good opinion expressed by the participating faculty members show a favorable reception and satisfaction levels. Their appreciation regarding the elements surrounding the dynamics, the thematic pertinence, and the results were rated in a positive way. On the one hand, many of their thoughts were gathered during breaks, as well as during the presentation of their projects. The general opinion was that the workshop offered a set of ideas that they could develop, in a similar manner, in the classroom with their students. Thus, the workshop's original objective was reached: to model with a view to subsequent implementation in the participants' specific learning environments.

Figure 7.Simulation project in progress

Figure 6.Digital story group discussion

In other cases, participants were mainly concerned with finding some follow-up means to continue working as they did during the workshop. There was a general feeling concerning the need to have participation and experimentation spaces for the teachers, a non-traditional element in their routine at the University of Costa Rica.

This factor is especially important, since it poses new lines of development towards future complementary projects. These should be considered in the logic of the network structures already developed within the Institutional Network for Faculty Training and Evaluation (RIFED), among others.

In like manner, one of the participants expressed dissatisfaction on most of the aspects assessed, justifying it by saying that:

"There was no support material for the tool itself; it is as if someone said, we're going to do an Access workshop, the tool is there, now use it and discover how. That is not the way to do it."

Since the workshop design included continuous support on the part of the facilitators, by means of demonstrations and one-to-one work, complemented with support materials on the Scratch tool available online, this comment was interpreted as a reaction to the habit of participating in traditional learning environments, more structured, more linear, and usually based on theory. In this case, the participant did not understand nor accept the constructionist vision.

In general terms, a percentage of people are expected to react defensively facing innovations, for they prefer the comfort zone of the familiar.

One of the workshop's more positive results was the type of projections expressed by the participants following the experience, documented by means of interviews. For instance, there was a case in which the workshop enabled a person to find in Scratch the necessary tool to study the development of peace processes among young vulnerable local groups, as part of a Ph.D. research. Several participants recognized in Scratch a tool they want to use, to help programming students with their studies. Though the workshop did not restrict itself to presenting Scratch and its operation, but rather its use to enable the immersion into a constructionist environment (as was previously explained), the knowledge and identification of the tool is still worthwhile, due to its use in different contexts.

The interviews complemented the survey data, agreeing in the favorable opinion of the participants and the acknowledgement of a new way to learn, as can be seen in the following comment:

"The workshop was very interesting; it makes you feel free to create. And they kept their promise: it has changed my perspective on learning."

In short, it is valid to say that the UCR faculty members who participated in this constructionist experience positively assessed the execution of this kind of activities, not just for the reasons mentioned above but because it promotes the interaction between teachers from different disciplines and academic units, and for the level of freedom to learn and create offered by the constructionist approach.

Acknowledgement and Recognition

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