RETHINKING AND REDEFINING THE DEVELOPMENT OF TEACHERS AS GENERATORS OF CHANGE

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SYNOPSIS

The objective of this article is to help the reader understand the role mentors or teachers play within a Constructionist learning environment. In the first part of the article, Constructionism is introduced within the context of the academic theories that influenced the projects presented herein. In the second part, the mentor's role within a Constructionist learning environment is illustrated through several projects and reflections on the learning process during their performance. This reflection process is inspired by the Action-Reflection methodology of Donald Schon (1987). Finally, some implications that the work hereby described could have on the current research and development of teachers are presented, as well as how the right changes can empower teachers so that they become true agents of change.

I. FROM CONSTRUCTIVISM TO CONSTRUCTIONISM AND BEYOND

Like almost all learning theories, Constructivism has multiple roots from the philosophical and psychological point of view, especially in the voices of Piaget, Bruner, Dewey and Vygotsky (Saettler, 1990). Piaget's theory of cognitive development suggests that human beings cannot understand and immediately make use of any information given them, but must construct their own knowledge through experience (Gruber & Voneche, 1977). Experiences allow them to create mental models, which can be modified and extended, and be made more sophisticated through complementary processes of assimilation and adaptation.

The work and research herein presented are strongly influenced by the philosophy of Constructionism. According to Seymour Papert, Constructionism is a learning theory and, at the same time, an educational strategy (Papert, 1980) based on the constructivist theories of Jean Piaget, affirming that knowledge is not only transmitted from teacher to student, but also actively constructed by the student's mind. Constructionism additionally suggests that students are particularly committed to making some type of concrete expression, which reflects on them and that they can share with others. "Constructionism (vs. Constructivism) shares the Constructivist connotation of learning as "constructing" knowledge structures, regardless of the circumstances of the learning. To this, the idea is added that such construction especially takes place within a timely context where the apprentice is consciously committed to building a public artifact, whether it be a sand castle on the beach, or a theory of the universe."

In order to Design and Construct, the student needs tools. In Constructionism, the use of "computational tools" is proposed in order to support the students' construction of knowledge. In addition, it makes it explicit that not all tools are the same and that some are more appropriate than others for helping people build their knowledge about the world. Therefore it encourages the design of learning environments (Harel, 1991; Hooper, 1993; Cavallo, 1999) and construction toolkits that can encourage learners to make epistemological, as well as personal connections (Resnick et al, 1996.) Some of these construction toolkits, such as Starlogo (Resnick 1994) were purposely designedto help students achieve fundamental epistemological changes, so that they may overcome the "centralized mindset." The students use Starlogo to construct and experiment with decentralized systems. They are able to write simple rules for hundreds of objects and observe patterns that emerge from all the relations. Other construction toolkits lack a specific goal and can be used for many other functions, such as the programmable bricks (Martin, 1999) and their successors, the Crickets[1]. In the various activities described in this article, the Mindstorms or RCX brick is used- This technology is a small, portable computer placed inside a LEGO block, with which people can build all kinds of artifacts and program them to interact with the world through sensors and motors.

But the tools are not the only important element in Constructionism. There are others, such as the curriculum, practice and evaluation. In the following session, those elements will be presented according to the interaction that the teacher can have with each of them, since it is these interactions that determine the type of relations that can exist between the mentor and the apprentice.

1. The Mentor and the Curriculum

Following the influences of the Constructivists, Constructionism also proposes a change in the nature of knowledge. Papert believes that “the type of knowledge that children need the most is the one that helps them gain more knowledge” (Papert, 1998 p.139), the one that facilitates the construction of an external object. The main problem is to assume that knowledge must be learned in the same hierarchical way in which it is organized, since we do not think, therefore do not learn ¨that way. (Papert, 1993 p. 66). The projects included in the next section of the article propose a content or curriculum based on experiences or activities that are familiar to the apprentices, in a way similar to what Dewey proposes in his theory of experiences (Dewey, 1938). There are two ways of determining these experiences and activities: the traditional approach, which includes interviews and questionnaires, and the informal approach, which can happen at the beginning of each workshop through observation of and conversation with the participants.

2. The Mentor and Evaluation

The structured form of curriculum in the traditional schools has a strong influence on how students’ progress is evaluated. Constructionist learning experiences cannot be evaluated with traditional techniques (Bers & Urrea, 2000) but, rather, require a more creative method of evaluation and observation.

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[1] Crickets are mini-computers developed at MIT-Media Lab. For more information on this technology, go to: http://agents.www.media.mit.edu/people/fredm/projects/cricket/

As a mentor or guide in these experiences, I have used a combination of the following strategies: interviews with the participants; observation of interpersonal relationships and the use of new technologies, and changes in how problems and controversial issues are confronted; review of personal notebooks, posters and other material used during presentations and demonstrations; and analysis of final projects , reflections and presentations of the participants. Workshops and diverse experiences are recorded on videotape due to several reasons, to document the experiences and to facilitate reflection in action (Schon, 1987) of the role of the mentors during the workshop. The Reggio Emilia School in Italy (2001) has been a pioneer in the use of documentation techniques for obtaining information on children's learning and their progress, which could not be demonstrated by the classical exams and checklists employed in traditional schools. It is important to note that "the powerful contribution of documentation" that they promote "is possible thanks to the fact that the children are interested in undertaking complex, interesting projects worthy of being documented" (Katz & Chard, 1996).

3. The Mentor and His/Her Practice

In his book, "The Children's Machine", Seymour Papert (1993) refers to the "teachers as technicians" who exercise control through the teaching and knowledge of the subject they impart. Constructionists construe a more creative role of teachers, allowing them to keep control over what is happening with the student. Students participate and help to decide what, how and when they want to learn and which tools they prefer to use for learning. "A teacher can, therefore, take on the role of guide to the benefit of the rest of the group, not as an exponent of personal power, but in a more fair, balanced manner" (Dewey, 1938).

The teacher becomes a mentor who does not necessarily have the absolute truth, but rather acknowledges and accommodates different learning styles, what Papert and Turkle call "Epistemological Pluralism" (1991); and who listens and reflects on his/her practice, as explained by Schon in saying (1970), "when a teacher focuses his/her attention on listening to what the children have to say, the teacher's practice itself becomes a form of reflection-in-action, and I think that this formulation helps to discover what the art of teaching is made of. It involves really being in touch with what the children are doing and saying..."

Teachers in the traditional system have personified the control the system has imposed on them. They have gained a false sense of security in believing that the only way of controlling the students is through the mastery they have over the area they teach. There is another type of intervention that does not involve the negative connotation, but that has to do with guiding and providing advice during the children's learning process. This positive intervention can become a reality by designing a different curriculum, taking into account the needs and interests of the students, listening to them, and keeping themselves from learning because they are "teachers" (Papert, 1983). I believe in the design and creation of "experiences" (Dewey, 1938) that better prepare the students for a life of appreciation, independence and development, experiences that drive the students to confront and improve the world they live in (Freire, 1970).

Now that the theoretical position has been established, I would like to invite the reader to explore and learn about the role of the mentor in a Constructionist environment, with the characteristics described above. The goal is to facilitate a construction process such as the one promoted by the theory of Constructionism, through the presentation of various projects and reflection on the learning process in each of them.. Two experiences in particular will be described: Con-Ciencia (a word play in Spanish which means Conscience and, at the same time, With-Science) and Comunidades Rurales (Rural Communities), along with their objectives, contents and the context in which they were developed.

II. THE CONTEXT OF REFLECTION

This section is the reflection of the author's practice as a mentor within different Constructionist learning environments. The process is inspired by the book, *The Reflective Practitioner,* by Donald Schon (1987). In his book, Schon indicates that the notion of "reflection-in-action" involves examining our experiences, getting in touch with our feelings and paying attention to the theories in use. It also requires the construction of new understandings to inform our actions in the situation in which they are deployed. To better illustrate the practice, some of these characteristics will be applied in the context of a project.

1. Con-Ciencia

The premise of Con-ciencia is that a *holistic* learning experience must respect and encourage curiosity in children, through the creation of a space where they can explore the moral and technical aspects in a joint manner (Bers & Urrea, 2000). The workshops that applied the Con-Ciencia program included the following characteristics: the design-based constructionist approach to learning; use of new technologies, such as the LEGO “Mindstorms Robotic Kit” to transform the designs into mechanical artifacts; creation of narratives to complement the physical artifacts, and the collaborative work of parents and children, learning while they constructed and programmed artifacts that reflected their sense of identity and the values they lived by. The first pilot experience of this project[2] took place in the “Arlene Fern Jewish Community School” in Buenos Aires, Argentina, during the Jewish Holidays, for a period of ten days. This example was a concrete illustration of the goal of the project, which seeks the integration of technology and values within a *holistic* learning environment.

To collaborate with the experts. Given the fact that the objective is not to impose a particular set of values, it was decided to collaborate with Rabbi Bergman, who works at the school and was also participating in the workshop. He directed an activity to explore the values of the most important days of the Jewish Holidays. During a long discussion, the participants suggested a list of values that were important to them, such as forgiving, friendship, celebration, memories, balance and judgement. Cards were made with each of the values proposed, thus, when the groups began to select the materials to be used for their final projects (for example, sensors, engines, posters) they also chose one or more of the cards with the values they wanted to explore.

All of the projects were classified into three diverse categories, according to how the technology was used to explore values. First: technology for representing symbols. Some of the artifacts created during the workshop were similar to Jewish symbols; there was no more in-depth exploration of the values represented by them. Second: technology for representing values. The projects in this category included artifacts and stories, which made the value selected more explicit. And finally, technology for evoking reflection and conversation. The artifacts classified in this category dealt with values in an elaborated manner; these artifacts gave others the chance to experiment the complexity of the values and, therefore, were able to generate discussion.

To help the students express their ideas. In one of the projects in the second category, technology for representing values, the value of “friendship” was worked on through the creation of a puppet theater (see FIGURE 1). The theater had a curtain that would open to show two LEGO dolls hugging each other after having fought. Marcia, a nine-year-old girl, made up a story, the story of the two girlfriends, and included some of the values of the Jewish Holidays, such as *reconciliation*. “This project tells the story of two girls after

[2] The complete experience is documented at http://el.www.media.mit.edu/projects/con-science/

fighting, who hug each other and become even better friends," said Marcia. "This project illustrates reconciliation, which allows us to correct our mistakes. The friends reconciled and became friends again by giving each other a big hug." Marcia made the dolls out of LEGO pieces, using colored strips of paper for their hair and putting motors in their arms to make them move forward and backward, simulating a hug.

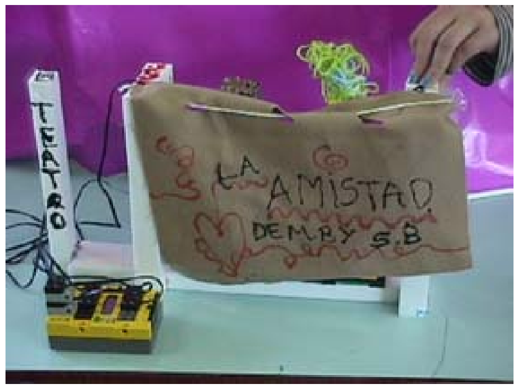

FIGURE 1. The Friendship Project

To support different learning styles. The "friendship" project not only used technology, but also narrative. Given that the value selected was the main element of this project, the group felt the need to tell a story in order to reinforce the interpretation of the value. They wrote the story in a best-wishes card that was distributed among the visitors during the final presentation. Telling a coherent story evolving around the robotic creation was as important as correctly building and programming the mechanical part. They used technology to represent a value as a powerful idea that needs to be supported by a physical device and a fascinating story.

To create the opportunity for discussion. Marcia had difficulties in building the mechanical arms, as well as writing the program to control them. Her dolls seemed to be hitting each other instead of hugging each other. Upon showing the project to the visitors, one of the children exclaimed, "This project isn't about friendship! The dolls are not hugging, but slapping each other." The boy was referring to the fact that both arms did not go up at the same time and failed to reach the same level. Marcia tried to convince him otherwise by telling him a much more elaborate story about another kind of hug. But the boy did not give up and invited his friends to give their own opinions. After a long discussion on what friendship means, each one gave the opinion that the project was not about friendship but about fighting.

To help the students reach their goals. Marcia was not happy about what had happened during the discussion and had two alternatives. She could change the story and the value chosen for the project or she could work more on the programming in order to make the arms of the dolls move at the same time. Despite the fact that Marcia did not like to program very much, she decided to do it because friendship was a very important value to her. We helped her write the program she needed to fix her project. She eliminated the errors from her program and played with the mechanisms until she was able to make the movement look like a hug.

To evaluate the learning process. Marcia's story is about how technology was used to engage a student in a highly intense intellectual effort. The friendship theater Marcia built and the fact that it failed to work as expected, generated a deep discussion on values and the meaning of friendship. In a normal classroom situation, this philosophical discussion might have been started by the teacher (for example, the teacher tells a story about friendship and asks the children to comment on it) or at a very high personal cost (for example, there is a fight in the classroom and the conflict needs to be solved). The personal bond Marcia created with the value she chose motivated her to work harder on debugging her program. Given Marcia's preferences, it would have been easier for her to change the theme of the project rather than debug the program. Nevertheless, she benefited from learning how to find a solution with technology.

2. Rural Communities

This experience took place in San Marcos de Tarrazu, a town with a population of 25,000 in the mountains of Costa Rica, south of San Jose. The teachers and students of a small rural school were invited to participate in a series of workshops for exploring future collaboration in a research program with the MIT- Media Lab. The workshops were carried out in LINCOS[3], a modern community center The school principal, four teachers and some of their own children participated in the first workshop. The work in this experience in particular was strongly influenced by the work of Freire (1970). The goal of this project was to discover the type of experiences that motivate the participants to fight for cultural transformation, in order to face the challenge of changing the world they live in.

To discuss with the students the content of the experience. The content of the workshop was defined around the basic aspects of the

[3] For more information on this project, visit http://www.lincos.net/

community that are important to its members. The workshop began with a discussion in order to define what elements the participants were interested in exploring. Three groups were formed and the rest of the time was spent designing and constructing the projects. Teachers as well as children worked collaboratively on the formulation and construction of each of the projects, which they presented to all of the other participants at the end of the experience.

There are important characteristics in the diverse projects constructed that are worth mentioning: the participants built projects that reflected the problems or needs of their community; others not only built the projects but also thought of how these projects related to different items of the school's curriculum; and other participants built projects that clearly showed the interest they had in technology.

To help the students work as a team. The project described below is a concrete example that shows the participants' interest in technology (see FIGURE 2). The intelligent automobile was a project created by James, the son of the kindergarten teacher. James arrived the first day to bring his mother to the workshop, but decided to stay and participate. He was very interested in technology and was willing to make any project as long as he could play with the Mindstorms bricks and use them to construct something. He wanted to build an intelligent car, and had problems incorporating his ideas with the rest of his group, comprised of his mother and his younger brother. His mother was interested in working on the energy-savings problem, and had the idea of building a classroom that could detect when people go in and out in order to turn the lights on or off. After several discussions moderated by the mentor, the group decided to build an intelligent garage, instead of an intelligent classroom. Consequently, James was able to build his car.

FIGURE 2. The Intelligent Automobile

To collaborate with the participants. The mentor actively supported James in the design and construction of his car. James wanted to build a car that could detect obstacles. The initial idea was to use four sensors, which would be located in each of the corners of the car, but the mentor told James that the Mindstorms brick has only three ports for sensors, also encouraging him to work out a solution. James initially thought of building a car with two programmable bricks, but they are large and heavy, so he discarded that idea.

To give support in problem-solving. James and his mentor spent a lot of time working on different ways to connect the four sensors, but finally found a solution. Now James needed to make it all work. As shown in FIGURE 3, numbers 1, 2 and 3 represent the sensor inputs the Mindstorms brick has. The boxes represent the number of sensors the car needs. The first top left-hand sensor is connected to inputs 1 and 2, the bottom left-hand sensor is just connected to the No. 1 inputs, and so on. When the brick detects a change at input 1, it checks to see if there is a change at input 2. If the change is detected only at input 1, it knows that the obstacle is around the rear left side and takes the necessary action.

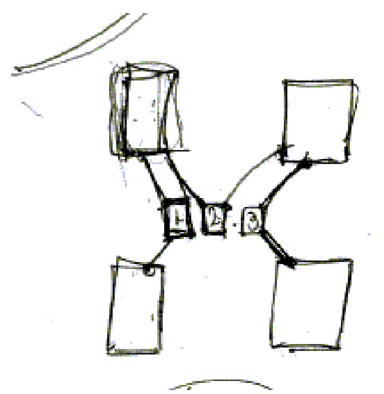

FIGURE 3. Sensor Connection Diagram

To introduce new concepts whenever necessary. James built the car and connected the four sensors to the ports. Now it was necessary to begin testing the program with the different sensor values in order to achieve the car's correct performance. James and his mentor also spent a great deal of time writing the program. It was necessary to create a mechanism for saving the initial values of the sensors and thus comparing them with the new values received while the car was moving. The mentor saw the need of introducing to James the concept of variables, their function and use. James spent the rest of the workshop writing the commands and running tests until programming the performance he wanted for his car.

To evaluate the learning process. As part of the workshop evaluation, a final presentation was held with the participants. When James presented his project to the rest of the group, he said, “This car has four sensors that work independently.” James was proud of his creation, but not all of the participants would be able to understand the major learning experience behind the simple car that they were watching. He continued with his presentation, saying, “When the car starts, the initial sensor value is stored. While the car is moving, it changes direction according to the values it receives from the four sensors, which it compares with the initial values.” James finished the presentation of his project by saying, “My idea was to make the car turn, but we didn’t have time to build a rotating system for the front wheels.” In fact, James did not have enough time to finish the car he had originally planned; he spent most of his time building this *simple* car.

III. IMPLICATIONS IN PRACTICE AND IN RESEARCH

It is not an unknown fact that the subject of formation and development of teachers is a priority in the educational agendas of most countries. Because the impact and benefit of investment in education is acknowledged, especially the formation of teachers, it is sought to improve not only their competitive level, but also their social level and well-being (MEN Colombia (Colombian Ministry of National Education), 2000). Such is the case of rural education in Colombia, according to the Ministry of National Education, where “the search for basic education constitutes another fundamental task. On one hand, ensuring the universal contents of education necessary for developing competencies, which requires the appropriate curricula, well-formed teachers, educational technology support, educational materials and propitious learning environments and, on the other, instilling the significance of education in the rural environment, taking advantage of the pedagogical benefits to be found in co-existing with nature and the rural community…"(MEN Colombia, 1998). But there are still problems in the conception and formulation of strategies for certifying and forming teachers. There should not be so much debate about how much preparation is necessary in a given area of knowledge, or a specific teaching style in particular, or how to create new mechanisms for evaluation. What is needed is a radical change in the creation of curricula and the management of computational tools, research and practice need to be more closely linked and, finally, the teachers should be given the freedom and autonomy necessary to manage their own reality in the classroom.

A radical change is required in the creation of curricula. We do not necessarily have to eliminate the “hierarchy of knowledge” (Papert, 1993, p.66) that currently exists, it can be used to reference different concepts when necessary. As shown in the previous section, the mentor designed the content or curriculum of the workshops based on experiences and activities that are familiar to the apprentices, similar to Dewey’s theory of experiences (Dewey, 1938). In order to be able to create projects, design experiments, and build devices under the context of such workshops, the students need to refer to facts and concepts, not learn them in an isolated manner, and must make use of tools that support the construction of such knowledge, as proposed by Constructionism.

Research and practice need to be more closely linked. There are a number of interesting research projects regarding learning theories, digital educational technologies, etc. (Schon, 1987), but the probabilities that all of these innovations reach the world of educational development and influence the decisions made regarding the formation of teachers are still low. More collaboration is needed among those who create the theories and technological tools and those in charge of applying them in the classroom. If the idea is to wait until such research and digital tools are finished in order to hand them over to the teachers, the chance will be lost for them to actually include them in their practice and use them productively. A space for collaboration needs to be made available, where the teachers not only have access to research work and projects, but also (and more importantly) where they can challenge, and collaborate in their creation and improvement.

New evaluation methods need to be implemented. The way in which the progress of the students is evaluated is related to the way in which the curriculum is designed. Due to the fact that traditional curricula are based on disconnected concepts and facts, teachers are forced to use traditional exams, instead of interviews, observations, analyses and reflections that will give them the information on the progress of the children’s learning process (Reggio Children, Italy & Project Zero, 2001). If standard exams are imposed for measuring the progress of the students’ learning, the teachers are forced to ignore the different ways of thinking and building knowledge (Truckle & Papert, 1991).

The teachers must have the freedom and autonomy necessary for managing their own reality in the classroom. Teachers have very few opportunities to play a creative role and design better educational experiences if they do not have the freedom and autonomy to make decisions within their own classrooms. Teachers continue to play out the role the system imposes on them, and have very little space for providing the students with a better preparation for appreciating life, independence and development. Teachers need to reflect on their practices; design, investigate and create different contents and evaluations; and master technological tools, but they also need the autonomy and freedom to do so. In this way, they will become the agents of change needed to carry out a genuine educational reform aimed at improving people's quality of life.

REFERENCES

Bers, M. & Urrea, C. (2000). Technological prayers: Parents and children working with robotics and values. Robots for kids: Exploring new technologies for learning experiences (Druin, A. & Hendler, J. (Ed)), ACADEMIC Press, 193-217.

Cavallo, D. (1999). Project Lighthouse in Thailand: Guiding Pathways to Powerful Learning. Logo Philosophy and Implementation. Sharnee Chait.

Dewey, J. (1938). Experience and Education.

Freire, P. (1970) Pedagogy of the Oppressed. New York: Seabury.

Gruber, H. (Ed.), & Voneche, J. J. (Ed.). (1977). The Essential Piaget. New York: Basic Books.

Harel, I. (1991). Children Designers: Interdisciplinary Constructions for Learning and Knowing Mathematics in a Computer-Rich School. NJ: Ablex.

Hooper, P. (1993). They Have Their Own Thoughts: A story of Constructionist Learning in an Alternative African-Centered Community School. Constructionism in practice (Kafai & Resnick (Ed.)) NJ: Lawrence Erlbaum Associates.

Katz, L. G. & Chard, S. C. (1996). The Contribution of Documentation to the Quality of Early Childhood Education. ERIC Digest. ED393608

Ministerio de Educacion Nacional de Colombia (1998). Educacion para la Poblacion Rural: Balance Prospectivo. Serie documentos de trabajo. Santa Fe de Bogota, D.C.

Ministerio de Educacion Nacional de Colombia (2000). Acreditacion de Calidad y Desarrollo de las Escuelas Normales Superiores. Serie documentos de trabajo. Santa Fe de Bogota, D.C.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books.

Papert, S. (1991). "Situating Constructionism," I. Harel and S. Papert, Editors, Constructionism, Ablex Publishing, Norwood, NJ.

Papert, S. (1993). The Children's Machine. New York: Basic Books.

Reggio Children, Italy, & Project Zero (2001). Making Learning Visible: Children as ndividual and Group Learners. Illus. Softbound.

Resnick, M. (1994). Turtles, Termites, and Traffic Jams. Cambridge, MA: MIT Press.
Resnick, M., Bruckman, A. & Martin, F. (1996) Pianos Not Stereos: Creating computational construction kits. Interactions, Vol 3, No. 6 (September/October 1996).

Saettler, P. (1990). The evolution of american educational technology . Englewood, CO: Libraries Unlimited, Inc.

Schon, D. A. (1987). Educating the reflective practitioner. San Francisco: Jossey-Bass.
Turkle, S. & Papert, S. (1991) Epistemological Pluralism: Styles and Voices within the Computer Culture. In Harel, I. & Papert, S., eds. Constructionism. Norwood NJ: Ablex.