

An investigation into ways that cultural gender roles interfere with the learning of science and engineering.

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Abstract

This paper tries to explore the reasons why most of the girls who attend our “rethinking learning” workshops do not show at first the same level of interest in creating and developing meaningful projects involving physics, mechanics, control, feedback, and system through the manipulation of Lego.

The scope of this study is to investigate if cultural gender roles can hinder the learning in some areas of knowledge if not well addressed and identified. The results of this study may call the attention of facilitators and teachers to the fact that the background and prior experience of students in a subject matter may interfere with her current learning and interest.

Keywords

Learning environments, gender, science, engineering, rethinking learning.

Introduction

The Brazilian culture creates and maintains a nurturing role to their women. For the most part, girls grow up playing with dolls, telling stories, taking care of younger children, and helping with housework. Construction toys usually are not given to them. Most of the parents or educators do not give them incentive to manipulate cars or mechanical toys. There are exceptions, but in general girls grow up without any opportunity to build interest in mechanical, electrical or building activities. Sometimes there is initial interest, but not enough self-confidence or support; therefore most of them do not pursue their desire. The origins of those problems seem to come from social-cultural aspects versus

biological differences (Soares, 2000). Diniz (1999) also exams this issue in her book on Feminine Condition, as well as the renowned Brazilian sociologist Fanny Tabak (2002).

This paper tries to explore the reasons why most of the girls who attend our “rethinking learning” workshops do not show at first the same level of interest in creating and developing meaningful projects involving physics, mechanics, control, feedback, and system through the manipulation of Lego. It analyzes the factors that influence participating girls in order to help them to get started with the materials. This includes the influence of encouragement, reinforcement, role models, comfort, privacy, and project relevance.

This paper concludes with a discussion about the issues, determination of critical factors and speculation about how to not merely become more inclusive, but to re-frame the question to take into account epistemological and cultural factors.

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Theoretical Background

Papert and Turkle (1991) started their paper entitled Epistemological Pluralism and the Reevaluation of the Concrete acknowledging, “Women’s access to science and engineering has historically been blocked by prejudice and discrimination”(p. 161). They make the point that even if there is a different way of reasoning between women (soft) and men (hard), the hard way is not the only right approach to science and engineering. Both have their virtues and can be employed successfully in engineering without having to force the individual to change her/his natural path of reasoning, either based in attachment, close relationship to objects and concrete thinking (soft), or structured, distanced instance from objects, abstract thinking (hard). Children can learn those historical messages beginning at an early age, and the intensity of its negative meanings depends on the culture and institutions surrounding them; such as home, connected families and school. The ones whose parents and early age schoolteachers understand those dynamics and differences on learning styles are perhaps in better advantage to adventure into science and engineering.

Freire in the **Pedagogy of the Oppressed** states that the humanist educator takes the role of the students’ partner and engages together with them in critical thinking, trusting men and their creative power (1972, p.62). One of our basic premises is that the teacher should work together with their students as a peer and, albeit probably more experienced, partner on learning how to learn, building critical thinking and creative skills. We would like to see them teaching each other mediated by the world through their dialogs, inquiry, learning by doing and being conscious of their realities in order to act upon them (Freire, 1972).

One way to support them acting upon their world is to design a learning environment where they can learn by doing, discovering and practicing ways to transform or improve their world. The environment should foster richer and deeper interactions between students, teachers, and the reality surrounding them (Papert, 1980). Ideally the learning environment should be similar to an arts studio, where the students are allowed time to think, to dream, to gaze, to get a new idea and try it, drop it or persist, time to talk, to see each other's work and their reaction to yours (Papert, 1991).

Learning Environment

The “re-thinking learning” workshop implements a supportive environment where teachers and students can learn how to learn through the combination of hands-on projects and through reflection on their learning process. We suggest a generative theme “A Cidade que a gente quer¹” that provides a seed of ideas involving improvements or solution of community issues, as well as the creative expression of neighbourhoods or cities of their dreams. The participants discuss what they want to work on and then they use several kinds of materials to accomplish their goals. They usually start from materials that they are comfortable with, such as arts materials (cardboard, construction paper, painting, clay, foam, etc), constructing models for their solutions. Then they incorporate technological devices to animate their creations. We also provide a variety of technological devices such as Lego, Lego programmable bricks, found materials, sensors, Gogo board², electronic components, Logoblocks³, digital still cameras, and digital video cameras. Those technological tools are employed to mediate their learning, to help them express themselves through construction of computational models. They try their ideas together, comment on each other's artifacts and most of the times collaborate between themselves to accomplish the planned goal. We strive to create an atelier type of environment.

During daily discussion the group reflects on their projects, designs, and problems, critiquing their work, and searching for improvements. We apply the same type of critical questioning on learning and attitudes about learning. Teachers have a chance to participate and practice with the facilitators about how we conduct the workshops, as well as to see how their students can surprise them by making explicit their learning styles. We try to have all the participants re-think their traditional way of learning and teaching, compare and evaluate it with a more progressive one.

We have been doing a one-week part-time workshop followed by another full-time one week about three months apart. Most of the times we have the same group of students. In some schools, the teachers also return for the second week, but not all of them. In others places like Manaus only one teacher was with us during the second week. We had on

¹ This translates as The City that we want.

² The GoGo board is a type of programmable microcontrol device (<http://learning.media.mit.edu/projects.html>).

³ A Java-based graphical implementation of Logo for controlling devices, found at (<http://llk.media.mit.edu/projects/cricket/software/index.shtml>).

average 30 students and 10 teachers with two or three facilitators from MIT and one other from Fundação Bradesco.



Figure 1. Teachers as partners and learners (1st. week)

Manaus Workshops

I am going to take workshops facilitated with the Fundação Bradesco in Manaus as a case study. Fundação Bradesco is a non-profit organization that manages thirty-nine schools and serves 103.322 students by providing free K-12 education. The Future of Learning group from the MIT Media Lab has led and facilitated several “re-thinking learning” workshops throughout this network of schools. In Manaus the first week of workshop occurred in the last week of August 2002 and the second in the last week of November 2002. The first workshop involved twenty-two students and thirteen teachers out of which nine were girls; thirteen were boys, eight female teachers and five male ones. They were supposed to work together on projects as peers and formed four groups.

In general there was a lot of construction, learning, involvement, intense work, exploration and excitement. Students and teachers were building models from construction paper, foam and others art materials, as well as Lego mechanisms. Some were taking pictures in order to produce Claymation; others were interviewing the groups and producing a video clip of the projects during the second week. They were playing and recording music using guitar and keyboard in order to incorporate to their projects. Students were constantly testing their Lego mechanism, debugging and improving the programs that automated the Lego artifacts.

In this environment most of the girls at first did not seem very engaged when faced to the challenges of building Lego artifacts. This was the case even when the artifacts were not cars, but were more familiar everyday devices such as food scales, elevators, recycling containers, etc.



Figure 2. Girls constructing with Lego (1st. week)

Knowing the culture, I believed they could not be completely uninterested in building those objects, especially because they were very involved and passionate about building with construction paper and other materials. The process of arts making is by nature constructionist and the students usually enjoy to work on hands-on projects. At a glance I perceived that all the girls were very comfortable with building the models for their projects. They dove into the art making, but were hesitant to touch and manipulate the Lego pieces.

During the first two days of workshop there was one girl actively building with Lego and two others helping the boys and teachers to build, mainly by giving ideas or handing the Lego pieces to them. I tried to encourage the female students to build, to just try it out. I invited them to build houses or other small objects in order to figure out how the pieces fit together. Slowly I saw them trying to build small objects, but nothing related to the projects they were working on.

At first I tried to engage them with programming the Lego devices. We were using Logo Blocks, which is a visual tool used to program the Yellow Brick. They agreed to lead that process, so they would discuss with the boys and the teachers what they want the Lego objects to do and would start programming in order to automate them. Programming the brick and debugging it through the reaction of Lego artifacts is another area of technology and it is distinct from the physical construction with Lego. It is another point of entry into their learning interest.



Figure 3. Girls programming the Yellow Brick (1st. & 2nd. weeks)

Towards the end of this first week, I noticed one other girl observing all the Lego construction and programming. Another tried for a couple hours to build an animal, but she did not continue because she had to work on the model. She did get involved with the programming part, as well as with taking pictures to create a computer animation.

I continued to encourage them, but there were so much to do on their models that they got busy and they were not willing to try a new challenge. Partly this was due to the artificial time limit of the workshop, where the groups demonstrate their projects at the end of the week. Naturally, they want to have beautiful projects to show and thus attend to beautifying and completing them. It is also possible, perhaps in part, which they did not return because they did not believe they were capable of accomplishing the goal.

Therefore by the end of that week in August, we had only three girls building with Lego, but ranging in intensity; one of those three was actively participating, observing and helping everybody else to solve issues of Lego construction, even without manipulating it. A fourth one was observing and following the building and the programming while a fifth one had experimented a bit with construction and programming. A sixth one was engaged with programming the yellow brick, while the others three seemed indifferent to any of those activities.

Perhaps they heard me talking to the principal and other teachers, or they just were listening to my continuous plea that they could of course build and play with that technology as well as the boys. I was not really building with them, but I would stay close and suggest the use of some pieces, or possible ways of constructing. My main input was on the process of programming the brick, and this might be why by the end of the first week there were more girls involved with the programming than with the Lego building.

During the second workshop eight of those nine girls were constructing Lego objects and programming them. Actually the group of the girls was the one who came up with the most sophisticated program among all the groups. They had three different automated artifacts, which had to be controlled by only one brick and therefore only one program. They had to exchange one sensor and one motor during their presentation.

Some girls joined this group later constructing a movable house, which was built on top of wheels and designed to move along in case of a flood. Towards the end of the second week, this group had five girls all building and programming.



Figure 4. Girls building and testing the mobile home (2nd. week)

Eight of those girls were involved building security gates, trash collectors, a bus for handicapped with elevator and sensors, automatic trash containers, sensors to read colored bar codes, canes for the blind, and the house on wheels. All those girls were also programming, debugging and testing their artifacts. Some of the girls worked better with boys, perhaps because those boys were more receptive.

The boys were building cars, buses, trash collectors, a mechanism to capture solid residues from an arm of river, a wheel chair to climb stairs and any obstacle found on streets, and a pump out of found materials. They were introducing found motors into

Lego structures, because there were not enough Lego motors for everybody. In summary they were all busy in engineering activities. There was only one boy who had built and programmed with Lego during the week in August who decided to film and learn how to edit a video. He and a girl that had worked with him before were responsible to cover and interview the groups during the last three days of work. Below is a summary of activities versus participants of our first week together:

Activities/Actors	9 Girls	13 Boys	8 Female Teachers	5 Male Teachers
Discussing project ideas	100%	100%	100%	100%
Planning construction paper model	100%	100%	100%	100%
Constructing 3D paper model	100%	100%	100%	100%
Painting model and figures	100%	80%	100%	80%
Making clay figures and others props	80%	40%	50%	-
Helping boys with Lego building	33%	80%	38%	40%
Manipulating Lego	55%	100%	38%	40%
Building with Lego	11%	100%	-	-
Using Sensors	11%	80%	-	-
Building Sensors (2nd week)	55%	50%	100%-1	100%-1
Programming YB	33%	80%	-	-
Watching others programming YB	55%	20%	25%	40%
Testing/debugging mechanisms	22%	80%	25%	40%
Taking pictures of clays & models	55%	40%	100%	50%
Producing claymation	22%	15%	25%	-
Playing/recording music		15%	7%	20%
Planning interview & video shooting	11%	11%	-	-
Shooting video	11%	33%	-	-
Creating digital diary	50%	50%	100%	20%

Table 1 Activities performed by participants during first week

The workshop in November was very successful involving girls. I believe there are several factors involved in delaying their involvement, but the encouragement was probably influential as a booster. It is worth mentioning that during this second week most of the participants were students with the exception of the informatics and electronics teachers. The two of them were alternating roles of learners and facilitators, even though they did not need to act as facilitators.

Analysis of survey results

After the two workshops I sent a questionnaire to all the girls who participated. My goal was to ascertain their previous experience with Lego, construction toys, and other toys, as well as their experiences with mechanical devices, engineering, repairing, and construction. I asked if they want to learn how to program. I also asked if they thought it

was important or relevant to them to have received encouragement and support on their endeavors of Lego building during the workshop.

In summary some of the answers were the following:

- Some of the girls played with Lego or others construction toys in their childhood.
- Six out of nine played with Lego in their childhood. It is relevant to say that Lego used to have a factory in Manaus.
- One out of eight used to take toys and home appliances apart. She also played with Lego. She takes apart the computers at school.
- One girl said that “like in all families, I used to play with dolls and my brother with cars and balls”
- Some of them stated that they wished they had played with Lego or other construction toys because they would be able to invent news “artifacts”.
- If they have had the chance to play with Lego and other construction toys in their childhood they would be able to learn in a pleasant way.
- Some thought that building with Lego was one way to express their creativity and knowledge
- One enjoyed building with Lego during the workshop because she has learned that when she wishes something if she persists she will be able to accomplish it.
- They all answered that they have interest and motivation to learn how to program.
- Peer/teacher support motivates her to want to learn and to accomplish hard tasks, helps her to realize that she is capable.
- The encouragement/support needs to follow the student’ s desire
- The person who gives encouragement become special when we understand she is genuinely supportive and is on our side. Without the support we would have gave up and not continue the project.
- One feels more capable and confident to accomplish the task when encouragement is available.
- Encouragement helps to alleviate the fear of failure.
- The encouragements made her try and then realize that she could do and build something that usually just the boys do.
- One girl initially thought that one needed experience to build with Lego, but with my encouragement she realized that creativity was the primary constraint.

Through this survey I found that the first three girls engaged building with Lego and programming the brick were the ones who had played with Lego or other construction toys during their childhood or had enjoyed taking apart dolls, others toys or home appliances. But, I also noticed that the ones who did not seem interested at first, had extended their model construction with the Lego building after observing all the work around Lego and LogoBlocks and giving themselves a chance to manipulate the Lego.

There was one girl who had a high level of engagement with Lego building and started right away together with the boys to manipulate and construct artifacts for the group project. She was leading all the others girls during the second week. She was not happy with my repetitive calls for them to try. She thinks encouragement/support needs to

follow the student's desire, so if some of the girls did not want it, I should have accepted their choice. This seems like a very rich data and a very important one for us to reflect upon. I need certainly to gather more data and probably interview this student one more time.

I sent a survey to the boys after I had started coding the data in the search of more information about the relationship between them and teachers, as well as their level of comfort with Lego and if they used to take apart toys and electronics. I got responses from half of the group (six boys). The results are:

- All of them played with Lego when they were children
- One of them never had interest and never took apart electro domestics or toys.
- All but one felt comfortable manipulating Lego and all the others technological materials
- All of them prefer to work in group then alone
- All of them claim to work fine with either boys or girls. While two of them thought it is special to work with girls because they are more patient and eager to learn.
- They all claim to have had very good relationships with the facilitators and their teachers.

At the same time I sent a second survey to the girls also trying to get more information about the relationships between themselves, boys, teachers and facilitators. I got seven responses out of nine girls. The summary of their responses is:

- Two of them felt very uncomfortable with Lego and were disappointed that the boys of their group were not willing to take their ideas and help them to build. All the others felt privileged to have had the opportunity to work with technology.
- All except one prefer to work in-group.
- Three of them prefer to work with girls. One claims she could work with both, but some of the boys don't let the girls touch the Lego.
- All but one built and programmed together with another girl.
- Five of them had difficulties with the materials first, but as they were getting more used to it, the learning also improved. One felt comfortable from day one, and a second did not really built with Lego.
- All of them claim to have had a very good relationship with the facilitators, but having some trouble with the language sometimes.
- All of them except one had a good relationship with the teachers. One girl said the learning in their group was pretty much individual, they did not know the teachers and they were very serious. She felt intimidated by them.

The results of those surveys make evident the importance of peer support and good relationship with teachers as peers, and facilitators to the individual and group learning process.

Some teachers expressed in their digital journal that the girls were the artisans and the boys the engineers of the group. This division of task was evident during the first few days of the first week, even though few people expressed it explicitly. But, as it shows on

the surveys, some of the girls express a similar thought when they say that the boys have more practice with the Lego.

Conclusion

It requires exploring and analyzing why is there such a difference between genders. Is the difference innate between genders or between different ways their parents and society have guided their plays, toys and activities when they were little children?

This inquiry is just starting and I need to facilitate and observe more of those “re-thinking learning” workshops in order to investigate further the issue of level of female engagement on engineering and programming areas.

For now I conclude that my support might have helped to alleviate the level of fear and insecurity most of the female students had when faced with a “boy toy”. It also translates in the level of comfort the girls might have when presented with the material that seems to fit boys.

As I have observed some boys were more supportive to the girls and helped them getting acquainted with the materials and worked together exchanging ideas, and or building the artifacts. Others boys did not even want to be helped by others boys, while the majority of the boys worked in groups of two or three. This relationship between them made clear the factor of peer support, how it can be positive or negative to the learning process of the students in general, and in this case how the support of the boys have affected the girls engagement.

I also noticed that some teachers did not give support to the girls on using Lego, even though they were not necessarily conscious about it. A couple of the teachers were not able to work as a peer, what maybe was an intimidating factor to the students in general. This unnoticed behavior of the teachers is related to the historical prejudice towards female in science and engineering, which is a proven factor interfering on self-esteem and therefore possibly hindering the learning.

Given my active role on programming the brick with the girls and their success on getting engaged with that activity, and also based in others studies where the facilitators participate on the construction together with the learner (Harel & Papert, 1991), I infer from this kind of relationship that this level of support has a similar effect as the peer support and therefore can be very positive to learner. It is also important to observe that programming computers and system analysis are relative new professions in Brazil and do not carry that strong stigma of a male profession like Engineering does.

Factors interfering in the learning of science and engineering X Intensity	Girls	Boys
Historical Prejudice	High	None
Level of comfort with materials (Lego, sensors, motors, gears, programable Brick)	Low	High
Peer support	High	Medium
Facilitator incentive through words	High	nodata
Facilitator support through building/programming together	High	High
Presence of regular teachers as not supportive	Medium	Low

Table2 Factors interfering in the learning of science and engineering versus its intensity

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