‘REGIME OF COMPETENCE’ IN A SCHOOL PRACTICE WITH ROBOTS

Sónia Martins

Louros Middle School

This article analyzes and discusses some topics that highlight the social nature of learning (Lave & Wenger, 1991) particularly analyzing how the ‘regime of competence’ (Wenger, 2008) is defined in a school practice when students work with robots. The learning scenario presented here followed a project work methodology and involved two primary school classes. The research reported in this paper is qualitative and participant observation was a central strategy in data collection. The unit of analysis was constituted by people in action. From the presented discussion relevant considerations emerged about how competence is usually defined in the school context.

INTRODUCTION

In the context of school, learning is often understood as an individual process, resulting from the act of teaching and where it is best to disengage it from other students’ activities. By taking this idea, classrooms are often organized as a place where students, away from the distractions of participation in the outside world, pay attention to the teacher and focus on ‘making’ exercises. This model is clearly insufficient if we take learning as a social phenomenon (e.g. Boaler, William & Zevenbergen, 2000; Fernandes, 2004; Lave, 1996; Lave & Wenger, 1991; Santos, 2004; Wenger, 1998). Aspects of mathematics and mathematics education, largely ignored in the past, have gained, in the last two decades, a renewed interest within our scientific community. The classroom as a social context with different backgrounds, beliefs, agendas and expectations of its players has been a focus of much research in mathematics education (e.g., Atweh, Forgasz & Nebres, 2001; Boaler, 2000; Valero & Zevenbergen, 2004).

Lave’s studies (1996) of the acquisition of mathematical competence based on practices involving adults in workplace situations, specifically, within tailoring apprenticeships led her to argue that cognition is located in particular forms of situated experience, not simply in mental contents. In the work that she developed together with Wenger, in 1991, it is clear that the focus moves away from cognition, and the new approach is related with learning concerns. Lave and Wenger (1991) organize their perspective on learning and clarify the relations, which they consider essential between participation and learning. The approach used by these two authors was based on the idea that learning is a deepening process of participation in communities of practice.

By understanding a community of practice (Lave & Wenger, 1991) as a social learning system, Wenger (2010) locates learning in the relationship between the person and the world. This is a relation of participation where the social and the

individual constitute each other and where meaningful learning requires both participation and reification to be in interplay. Overtime, this interplay creates a social history of learning which gives rise to a set of criteria and expectations by which participants recognize membership, or by others words, participants define what counts as 'competence'. According to Wenger (2010) this competence includes being able (and allowed) to engage productively with others in the community and using appropriately the repertoire of resources that the community has accumulated through its history of learning (p. 180).

Our aim in this paper is to discuss some ideas that enhance the social nature of learning, focusing on the 'regime of competence' (Wenger, 1998) of students, from two primary school classes, working together in a project work with robots [1].

EXPERIENCE AND COMPETENCE

The term participation used by Wenger (1998) describes the social experience of living in the world in terms of membership of social communities and active engagement in social enterprises. To participate is also to belong. This at once is both personal and social. It is a process that combines doing, talking, thinking and feeling. It involves the whole person, including body, mind, emotions and social relations. Engagement in social settings involves a dual process of meaning making, resulting from the interplay between participation and reification (Wenger, 2010, p. 179). Wenger (1998) uses the word reification to refer to the process of giving form to our experience by producing objects that congeal this experience into "thingness" (p. 58). By doing that we create points of focus around which the negotiation of meaning is organized. Although participation and reification mean different things, we cannot conceive one without the other. They complement each other (Wenger, 2010). On the one hand, we engage directly in activities, conversations, reflections and other forms of personal participation in social live, on the other hand we produce physical and conceptual artifacts, such as words, tools, concepts, methods, stories, documents, and others forms of reification that reflect our shared experience and around which we organize our participation. This interplay between participation and reification creates a social history of learning, by which participants define a 'regime of competence' (Wenger, 1998).

Wenger (2010) defines a 'regime of competence' as a set of criteria and expectations by which the members of a community recognize membership. In this sense, communities are seen as social configurations in which their members experience competence and are recognized as competent (Wenger, 1998). Therefore, it doesn't make sense to talk about competence disconnected from a particular practice. What is seen as competence is constructed and defined within the community. "It is by its very practice – not by other criteria – that a community establishes what is to be a competent participant, an outsider, or somewhere in between" (Wenger, 1998, p. 137). To be competent includes the understanding of what is important and what matters in the community, reflecting the accountability to the joint enterprise. It

means to be able (and allowed) to engage productively with others in the community and to use appropriately the repertoire of resources that the community has accumulated through its history of learning (Wenger, 2010). According to Wenger (1998) this competence is not merely the ability to perform certain actions, the possession of certain pieces of information, or the mastery of certain skills in abstract. Competent membership would include three features: **Mutuality of engagement**: the ability to engage with other members and respond to their actions in order to establish relationships in which this mutuality is the basis for an identity of participation. **Accountability to the enterprise**: the ability to understand the enterprise of a community of practice and take some responsibility for it and contribute effectively to its pursuit and to its ongoing negotiation within the community. **Negotiability of the repertoire**: the ability to make use of the repertoire of the practice to engage in it. This requires enough participation in the history of the practice to recognize it in the elements of its repertoire and it requires both the capability and legitimacy to make this history newly meaningful.

The interplay between a 'regime of competence' and the experience of meaning allows learning by practice. According to Wenger (1998) there are moments when competence may drive experience and others moments in which the opposite occurs. Competence may drive experience when newcomers transform their experience until it fits within the regime, in order to achieve the competence defined by the community. On the other hand, the members of a community also need to transform and increase their experience. However, new experiences may lead to the need to redefine the enterprise and the requirement to add new elements to the repertoire of their practice. When one or more members have had some experience that currently falls outside of the 'regime of competence' of a community to which they belong, they may very well attempt to change the community's regime so that it includes their experience, negotiating its meaning with their community of practice. They invite others to participate in their experience and they seek to reify it for them. If they have enough legitimacy as members, they will have changed the 'regime of competence' of the community and created new knowledge in the process. Learning can be thought of as a process of continuous interaction between experience and competence, "whichever of the two takes the lead in causing a realignment at any given moment" (Wenger, 1998, p. 139). A certain tension between experience and competence is what promotes learning.

METHODOLOGY

The phenomenon under study in the research reported in this paper is *learning*. The research sought to understand how the use of robots can contribute to the development of mathematical and other competencies, and to the appropriation of mathematics concepts by primary school students. To do this, a learning scenario, was designed, which involved two primary school classes (2nd and 3rd grade, 24 and 16 students, respectively) from a school in Funchal – Madeira island – Portugal. In this learning scenario the children worked together with robots.

In this section we will describe the learning scenario and the methodological options, establishing a connection between the nature of the phenomenon under study and the theoretical background.

Learning Scenario

We conceptualize scenarios as "stories about people and their activities" (Carroll, 1999, p. 2). Scenarios have some characteristic elements, such as a context, a setting, the agents or actors and their goals. It includes a sequence of actions and events to be developed in order to achieve certain goals. These goals are changes to be accomplished by the actors in the circumstances of the plot. The scenario's narrative is fundamentally a description of people accomplishing tasks, pursing goals and using technologies to achieve those goals. The learning scenario was constructed by the research team, the teachers from both classes and by their students. At the beginning, the research team presented, to both teachers, a draft of the learning scenario to be implemented. That initial draft was discussed and modified, according to ideas presented by teachers and students. In this process students voiced options, which were very important for them and for the success of the project. Between the working sessions, teachers often contacted the researchers to convey students' opinions and expectations. The learning scenario was developed in two stages: the first between May and June 2011 and the second between April and July 2012. The scenario's activities followed a project work methodology.

In this project, students worked with Lego robots: RCX and NXT. In both RCX and NXT models, the programming environment is a very intuitive icon-based drag-and-drop programming language, designed for an easy introduction to programming. By choosing program blocks that work with the motors and make the sensors react to inputs, students simply build up their program block by block, and they could create programs that range from simple to complex. Students and teachers had never worked with robots before.

Students worked in heterogeneous working groups with students from both classes. Teachers had to support students in their work and the researchers sought to support students and teachers and to take advantage of situations that could contribute to facilitating the emergence of mathematical concepts. Based on that intention, researchers assumed a questioning attitude towards students' work in their practice with robots.

In the first part of the scenario's implementation, students had to construct robots and define their physical and emotional features. Their creations would become characters in a play-story written by them all. After writing the story, students had to program their robots in order to perform their roles in the play. The initial goal was to accomplish those tasks in order to make a play with the robots as characters. The play was not done in this first part of scenario's implementation.

In the second part of the scenario's implementation, students, teachers and researchers decided to produce a film, using the written story as its storyline. Students

established new tasks to produce the film and created teams to accomplish those tasks. Each student chose in which team(s) they wanted to work. In this paper we will focus on the teams that were responsible for programming the robots.

Methodological options

The nature of the research related in this article is qualitative and it was given particular relevance to the process and not to the product of the developed activities (Bogdan & Biklen, 2006).

By taking the phenomenon under study – learning – not as an individual attribute but as something connected to participation in specific practices, it became important not only 'to observe' but also 'to participate' in the activities in which students were involved, in its natural context. In fact, assuming a situated perspective of learning as theoretical framework implies assuming as well a particular position in methodological terms, namely that investigation is participation in the constellation of practices in which the research occurs (Matos & Santos, 2008). This was the position of the researchers involved in data collection. Participation was also learning. Thus, participant observation was a central strategy of data collection. The challenge was to maintain a genuine participation and be able to reflect on it (Matos & Santos, 2008). In this research there was a close connection between the phenomenon under study and the theoretical framework. The unit of analysis in this research was constituted by people in action analysed in the dialectic between the theoretical framework and the observed, experienced and reflected practices that instantiate empirically the problem under study (Matos & Santos, 2008).

The study involved semi-structured interviews with some participants in order to clarify some aspects of the practice that raised doubts or were insufficient when the data was analysed. The working sessions were video and audio recorded with a focus on students' interactions. Not every phenomenon could possibly be recorded so researchers wrote down what occurred in the form of extensive field notes. Soon after, these notes were analyzed in order to note patterns of behaviors, events and phenomena to be investigated in further observations.

WHAT DOES IT MEAN TO BE COMPETENT IN THIS PROJECT WITH ROBOTS?

A 'regime of competence' is defined as a shared process of definition of a community's joint enterprise (Wenger, 1998). In this study, student's joint enterprise was the construction of robots that were to be characters in a play-story written by them all (Martins & Fernandes, 2012). That joint enterprise allowed opportunities for students' engagement across distinct forms and levels. In that process of engagement the competencies of each member were jointly constructed, what was important for each one to know and the ability to make a connection with what each one didn't know. In the project work with robots students often needed to establish a division of tasks. That aspect contributed to the mutual recognition of competencies in the

ongoing practice. In that process students assumed responsibility for distinct aspects of the joint enterprise. The choices they made were intrinsically linked to their individual preferences but were also in accordance with what was considered as important to pursue within the community's joint enterprise (Martins & Fernandes, 2012).

In this practice some students were responsible for specific tasks. Once students agreed on what was important to do in order to accomplish a specific task, they jointly gave legitimacy to those students who were responsible for it. Students revealed an ability to understand the community's joint enterprise and to be responsible for it, revealing their accountability. In this sense, required competences are neither merely individual nor abstractly communal. They implied a negotiated definition of what the community is about. What makes engagement possible is a matter of diversity and constant negotiation of meanings, reflecting the way participation occurs in ongoing activities (Wenger, 1998). As we saw earlier, to produce the film, new tasks were jointly defined. We will focus on the teams that were responsible for programming the robots. Those two teams (NXT team and RCX team) had to learn to program the robots in order to correspond to the remaining teams' solicitations when the shooting began.

R and M were two students who worked in the RCX team. In the extract presented here, these students were working together on the same computer, although they had two computers at their disposal. They were trying to program the RCX robot, T-Rex. These two students were initially disappointed because they were having some problems uploading the program to the robot, using the USB tower. One of the researchers, Res, helped them to solve that problem. Throughout this process students' difficulties were discussed. The researcher noticed that the program they were trying to upload was very long and students were using the programming blocks without having the notion of the action that the robot will execute when programed. The researcher challenged them:

> Res: I want you to program the robot in the computer. Don't ask him to do too many things…. Then you can write in a paper what robot is going to do when you run the program.

Later the researcher found that the students were programming on distinct computers and the programs were clearly 'shorter'. M continued programming the T-Rex and the other student, R, was programming another robot. The researcher asked M:

> Res: So, can you tell me what the robot is going to do when you run the program? [Student whispered:]
>
> M: I can't talk now. I don't want that R listen what I'm saying.
>
> Res: Why?

M: Because we are doing like this: I´m programming my robot and R is programming his robot. Then we are going outside. The programs will run and we have to discover the programming from each other´s robots… looking to the robots.

The researcher continued observing. Both students finished programming and they were questioning each other: "Can we go outside now?" "Did you finish your programming?" and the answers were something like: "Just a minute." "I'm uploading the information." After that students went to the courtyard to test the programs they've made. In the courtyard the researcher realized that students began to identify the blocks they used in programming in the robots' actions.

In this extract we saw that at the beginning when students couldn't upload the program to the RCX brick they were very disappointed. In that moment some mistakes were made and students experienced some conflicts, advances and retreats. All those components have proven to be learning opportunities. In the interactions between students and researcher were established relations of mutuality, in which was jointly defined what was important to learn. To achieve the competence defined by the community, students transformed their experience of programming in order to fit within the 'regime of competence'. When the researcher challenged them to write on paper the robot's actions she expected that students could achieve a better understanding of the program blocks used. Both students revealed accountability and tried to develop that understanding about programming. However, instead of writing on the paper the actions of the robot, they assumed that knowing how to program also meant recognizing in the robot's actions the program blocks used. This was a big step in the learning of programming. This context is clearly distinct from other school practices where it is expected that students reproduce literally what is solicited by the teacher.

We will now analyze an episode with the other programming team. The NXT programming team was constituted by 7 students who were working on 2 computers. In the first session as a team, 3 students programed the Lama and the Spider and the remaining students programed the 2 twin dogs. In following session, students had 3 computers available and the researcher, Res, suggested swapping the robots. All students agreed except H:

H: I was in the working group that built the robot Lama. In the previous session I was working in Lama's programming and I want to continue doing it. I don't want to program the other robots.

Res: But which is your team now?

H: NXT programming.

Res: So there is not a specific team responsible only for Lama's programming, right?

H: No it doesn't exist.

Res: If you have programed the Lama and the Spider I think you now must change, for all of you have the opportunity to program all NXT robots.

H: Then I will not do anything.

The other groups took Spider and Lama to be programed and H returned to his group which didn't choose any robot. Later a student from H's group, A, said:

A: Can we program one of the twin dogs?

Res: Of course. H said to me he didn't want to program a dog…

A: He doesn't want but we want to. We don't want to stay without doing anything.

After that, the researcher noticed that H was not programming the robot. This was very opposite to his behavior in the past working sessions, in which he was always very involved in the activities. The researcher noticed, as well, that the students that were programming the Spider and the Lama were having some difficulties in doing it. So, she said to H:

Res: Can you help your colleagues with the Spider and Lama's programming? I think they're having some problems with that, but I can't help them at this moment. I really think that your team' colleagues are having some difficulties with the dog's programming too and they do need some help.

H: Can I?

Res: Of course. But don't program the robots alone, without teaching them. You have to find a way to make them understand how to program. I think you can do it.

H: Ok.

After this moment H started to support the 3 programming NXT teams. This episode reveals that H was not revealing mutuality in his engagement with the practice of programming. What the researcher and his colleagues expected from him was not the same as what he considered important. That ambiguity ended up compromising his engagement in the ongoing practice. After the researcher recognized H as competent to program any NXT robot he was committed to help other students with that task. The legitimacy that the researcher recognized in H was a turning point in H's participation in the practice of programming NXT robots. In fact, granting the newcomers legitimacy is important because they become aware of what community regards as competent engagement (Wenger, 1998).

CONCLUDING REMARKS

In the school practice under analysis, the comprehension of what was considered as competence was defined in the relationships in which mutuality was the basis of membership's recognition by the community (micro-level). Those relationships were guided by the negotiation of meanings, by the constant division of tasks and by the accountability in achieving the goals that were jointly defined in the learning scenario. Students have done that and had that opportunity because teachers gave them legitimacy to do so. These aspects led to opportunities to use different styles of doing things and for the use of different artifacts that helped define the competencies

of participants, that is, the definition of the community's 'regime of competence'. School practices with those features provide learning opportunities for all involved, in which the errors and conflicts are taken as natural and can be recovered as special situations for learning to occur.

In school practices of a more 'traditional' nature, competence is often conceptualized as being good in making/producing something and little emphasis is placed upon the way that it is done and the relationships that have developed between people when they are doing it. As we have discussed, being competent is closely linked with what is recognized individually and collectively as competence in a particular practice, revealing the accountability within the joint enterprises. It implies not only being recognized as competent but also having legitimacy to participate meaningfully in the constant negotiation and definition of what we want to achieve.

What is defined as 'regime of competence' at the macro-level by the Portuguese Minister of Education is defined in a document named "competencies book". That document defines which competencies must be developed at school and what kind of experiences teachers must provide to their students in order to develop those competencies (such as projects). The way teachers recontextualize this document to their practices is quite different for each one of them and in the most cases they conceptualize competence as being a good student, having good classifications in the exams and being good in following the school's norms. By assuming that, teachers don't give legitimacy to their students to be able to make their own choices, negotiate their identities and choose in which practices they can be more accountable for.

NOTES

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