Anthropological Approach and Activity Theory: Culture, Communities and Institutions

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Activity Theoretical Approaches to Mathematics Classroom Practices with the Use of Technology – Part 2

The goal of this paper is to evaluate the contribution of the anthropological approach (AA) concurrently to Activity Theory (AT) in view of overarching questions about classroom use of technology for teaching and learning mathematics. I will do it first from a philosophical point of view, presenting the main notions of AA that have been used to address these questions, and then consider the conceptual roots and development of AA in comparison with those of AT. Then I will consider a particular research study for which a specific AT framework has been used, together with the AA notion of instrumented technique.

1 INTRODUCTION

As a didactical theory, the anthropological approach (AA) has been developed in a community around the French researcher Chevallard. From the mid-nineties, researchers experimenting with CAS calculators in the classroom outside this community became aware of AA's utility to address key questions relative to the integration of technology: What is the actual potential of technological tools? What do they precisely change in mathematics teaching and learning? Why is it so difficult for teachers to integrate technology? The notion of praxeology (tasks, techniques, theories) was especially helpful: praxeologies are crucial tools in teachers' hands to organise students' learning and technology introduces new techniques, concurrent to existing ones, and then, most often requires a reconsideration of existing praxeologies to create new praxeologies. Techniques, in the sense of AA, are then crucial when using technology (Lagrange, 2000). Artigue (2002) specified the roles of techniques, distinguishing between their pragmatic value and their epistemic value. Kieran and Drijvers (2006) confirmed the potential of AA, not only to analyse phenomenon, but also to help build and evaluate classroom situations with technology.

Recently, activity theory (AT) has also been used to address questions concerned with the complexity of technology enhanced learning situations and the changing roles and relationship to mathematics knowledge by learners and teachers. It is therefore important to examine whether AA and AT bring specific insight into these questions, and how AA deals with activity. While in AT (Leont'ev, 1979) an activity is composed of subject, object, actions and operations, for AA all human activity can be thought of as a praxeology, and praxeologies take place within institutions. The word 'institution' has to be understood in a very broad sense: among educational institutions, a whole country's educational system, a school, a class or even a single student are institutions in some sense. The "theory" level in praxeologies includes knowledge shared inside an institution, and also attitudes and beliefs. That is why teachers perceive "traditional" praxeologies not only as efficient tools to drive students' learning by building theoretical knowledge upon a reflection about tasks and techniques, but also as means to introduce them into a "mathematical culture". More or less explicitly, they think that this introduction is an important task assigned to them inside educational institutions.

AA tends to have the ambition to cover all aspects of mathematics teaching/learning and this "self-sufficient" ambition does not help to coordinate AA with other approaches. In order to make some progress, I propose to consider the respective conceptual roots of AA and AT. AA derives from a sociological framework initiated by the French anthropologist Mauss giving great emphasis to knowledge as a product of a human activity deeply rooted in society, seen via the lens of institutions. AT derives from Vytgovsky's socio-cultural psychology for which knowledge emerges and takes sense through collective artefact-mediated and goal oriented activity. In AA, institutions are the basic units. The main property assigned to institutions is "legitimacy" (Douglas 1989). Engeström (1987), an activity theorist, considers "activity systems" as the prime unit of analysis. Engeström notes that these activity systems have "historicity" - a property similar to "legitimacy" - but also assumes other characteristics that help to model how activity takes place inside these systems and how the systems develop. Nardi (1998) insists on internalisation/externalisation, a typical cognitive notion, emphasising that "internal activities cannot be understood if they are analysed separately, in isolation from external activities, because there are mutual transformations between these two kinds of activities."

The outcome is that AA and AT start from a common vision of knowledge as the product of a human activity in social and cultural contexts. AA tends to work with a limited number of concepts and puts emphasis on knowledge rather than on the subject. In contrast AT offers a wide variety of interrelated conceptual tools ever developing in several communities of researchers, and considers activity at various levels from big activity systems to cognitive processes. In AT, the emphasis on mediation by artefacts is particularly useful when teaching/learning is enhanced by way of technology. On the one hand, researchers in technology and mathematics education can take advantage of AT's wealth of conceptual tools. On the other hand, does this wealth give account of all aspects in a straightforward way, especially aspects relative to the mathematical knowledge? Does AA have a particular contribution to offer? I will try to investigate this question from a research study (Lagrange and Erdogan, 2009) aimed at characterising teachers' classroom activity using technology.

2 AN EMPIRICAL STUDY OF TEACHERS' CLASSROOM ACTIVITY

Investigating the questions mentioned in the introduction, I was brought to focus on the teacher using technology and especially on his (her) classroom activity, and to search for theoretical frames that could help. My hypothesis was that that an activity theory framework would help to elucidate the difficulties encountered by teachers using technology in the classroom. I assumed that teachers' practices in classroom use of technology are far from stable and I was looking for a framework that might give account of this instability. A particular AT framework, Saxe's cultural approach, could be useful because it considers individuals' activity in socio-cultural contexts as influenced by *emergent goals* challenging their knowledge.

Saxe's model centres on emergent goals under the influence of four parameters (explained below). Emergent goals are not necessarily conscious goals but are goals that arise from a problem in an activity and, once the problem is solved, the emergent goal usually vanishes. Saxe's model was conceived to explain mathematical practices in cultural transition (the Oksapmin tribe dealing with decimal money transactions) and is cultural-historical in its conception of artefact and interpersonal mediation in social practice.

Drawing from Monaghan (2004) I explain the four parameters, with hypotheses on how they are affected by technology use.

The *activity structures* parameter "consists of the general tasks that must be accomplished in the practice- and task-linked motives" (Saxe 1991, p.17). In mathematics lessons this parameter concerns tasks that the teacher sets and the lesson structure. The hypothesis is that, in contrast with ordinary lessons, tasks and cycles of the technology-based lessons vary considerably over the teachers and over time.

The *social interactions* parameter concerns relationships between participants, in this case between teachers and students in lessons. The hypothesis is that social interactions are affected by technology: for instances, teachers can spend much more time speaking to two or more students in technology lessons because of the computer room arrangement (as opposed to speaking to an individual or to the whole class).

The *conventions and artefacts* parameter consists of "the cultural forms that have emerged over the course of social history" (ibid p.18). In technology-based lessons the intervention of an artefact is obvious while it seems that the cultural meaning of practices associated with this artefact is fuzzy, in contrast with ordinary lessons where "paper/pencil" and associated practices are transparent, but deeply involved in mathematical culture.

The *prior understandings* parameter includes teachers' content, pedagogical and institutional knowledge, "the prior understandings that individuals bring to bear on cultural practices both constrain and enable the goals they construct in practices" (ibid p.18). While for ordinary lessons, this understanding has been constructed and /or transmitted via multiple professional confrontations to the classroom along years, for technology use we can expect that it consists mainly of beliefs influenced by various institutional or societal discourses.

A complementary hypothesis is that these parameters interact and impinge on practice-linked emergent goals. Beyond testing these hypotheses as a way to validate the usefulness of this AT framework, the question here is whether such a comprehensive AT framework is sufficient to take account of the difficulties met by teachers when trying to integrate technology, or if there is room for an AA approach. The empirical study will shed light on this question.

3 EMPIRICAL STUDY AND ANALYSIS

The context for the empirical study is the French curriculum for upper secondary non-scientific classes, intended for students more attracted by literature and arts than science and aiming at strengthening mathematical basic knowledge by favouring modelling, interpreting and criticizing various information sources using a spreadsheet. While it systematically proposes to put all the items into operation on a spreadsheet, it does not recommend the study of the spreadsheet for itself, but as means for exploring and solving problems. The methodology was to question and observe two teachers, with very different positions regarding the use of technology for learning mathematics, and to use the four parameters model to make sense both of these positions and of their class-room activity.

3.1 The teachers

Lagrange and Erdogan (2009) called one teacher Mrs P_{SCEP} and the other Mrs P_{EX}. Mrs P_{SCEP} is "sceptical" about the educational use of technology and Mrs P_{EX} is "experienced" in this use. Mrs P_{SCEP} taught for 35 years at upper secondary level and her first acquaintance with the spreadsheet was 15 years ago in a professional development course. When the curriculum changed, she had to adapt her teaching although she considered this curriculum less interesting and lacking mathematical rigour. She did not use technology in other classes and she justified this by saying that it would have required significant efforts which she was not sure would contribute to learning. Mrs P_{EX} taught for 30 years at different levels. She has tried to integrate technology in her teaching since the eighties and participated in research projects. She volunteered to teach this course after the curriculum change. She tries to use technology as much as possible in other classes.

3.2 Parameters

I use here the parameters to characterise the respective positions of Mrs P_{SCEP} and Mrs P_{EX} towards the use of technology in this curriculum.

- *Activity Structures:* The course was for two hours per week, one hour with the whole class and the other hour (duplicated) with a half class. Teachers had to decide how to use the time. Mrs P_{SCEP} taught the whole class in an ordinary classroom and the half class in a computer room. Whole class sessions were devoted to the presentation of the mathematical content and half class sessions to "applications" with the spreadsheet. Mrs P_{SCEP}'s students worked individually following a worksheet. Mrs P_{EX} adopted another organisation. She had the whole class hour in a computer room: Students worked in teams with a computer at their disposal. She devoted the half class hour to a report on the teamwork and to a synthesis. Teams reporting their work could use a computer linked to a video projector and to a network.

-*Conventions - artefacts:* We consider here the spreadsheet whose use is compulsory in this course and the written material that teachers prepared for the students. In the whole class hour Mrs P_{SCEP}'s students had to work with paper-pencil. In the half-classes it was clear that they had to work on the spreadsheet: Mrs P_{SCEP}'s worksheets were very specific about this use, referring to cells and formulas. In Mrs P_{EX}'s lessons, the students had the spreadsheet and paper/pencil always at their disposal and the worksheets gave no instruction to use either of the two artefacts.

- *Social Interactions:* Mrs P_{SCEP}'s interactions with students were similar in the computer and in the ordinary room. These interactions were very frequent and generally between herself and a single student. In contrast, in Mrs P_{EX}'s classroom these schemes were not the same in the whole and half classes. In the whole class, students interacted in teams and Mrs P_{EX} spoke infrequently and generally to encourage students to work as a team. In the half classes, during the report of teamwork, Mrs P_{EX} spoke much more, questioning the team and prompting the rest of the class for their reaction.

- *Prior Understandings:* In Mrs P_{SCEP}'s view, technology was introduced in this course in order that the students learn about spreadsheets. For her, beside the use of technology, the mathematical content was not different from the previous curriculum. She thought that technology does not make a very concrete contribution, but has a positive effect on the behaviour of her students that she considered weak and not interested in mathematics. Changing students' image of mathematics was Mrs P_{EX}'s goal when using technology in this class. She was happy with the new curriculum because the use of technology that she tried to promote, often without much success, among colleagues and parents was now compulsory. She explained that a majority of her students failed in mathematics, and thus her priority was to create a different entry into mathematics. She understood the activities about mathematical progressions indicated by the curriculum as very important for her students' learning.

3.3 Teachers' classroom activity

In spite of these dissimilarities, both teachers chose similar tasks for students during the first week: the "birthday" task (Figure 1**)** is an example. I discuss the techniques that can be activated in this task, before reporting on fragments of the two teachers' classroom activity while students did this task.

The "birthday" task

Sabine has just been born. Her grandmother opens a credit account for her, makes a first 100 € deposit and decides to make each year a new deposit of the same amount plus the double of Sabine's age. How much does her grandmother deposit into her account each year?

Figure 1 The Birthday Task

The yearly deposit is a linear progression. Computing the deposit for a given year by hand or mentally is not difficult. Using a spreadsheet, one has to make a column for the years (column A), then enter a formula like =100+2*A2 into an adjacent cell like B2 and fill down this formula. At a first view, spreadsheet software is designed to help a user to efficiently reach a solution and then the value of spreadsheet techniques should be mostly pragmatic. Here paradoxically, this pragmatic value does not exist; compared to the relatively easy mental calculations, making columns of numbers and formulas is a tedious process for students who do not know how to use this tool efficiently. The formula and the technique of filling down, in accordance with the curriculum's epistemology of the connection between spreadsheet and mathematics, has an epistemic value as a way to express algebraically a relationship.

Mrs P_{SCEP}'s classroom activity

In accordance with Mrs P_{SCEP}'s activity format, this session was in a computer room and followed a whole class lesson without computers during which Mrs P_{SCEP} introduced the mathematical notion of a sequence. The objective of the half class session was to "apply" this knowledge by using a spreadsheet. The tasks presented to students came directly from a textbook. The task was presented in a worksheet:

Starting with u_0 = 100, compute *by hand* the amount that Sabine's grandmother will deposit on the account at year 1: u_1 =… at year2: u_2 =… at year 3: u_3 =… at year 4: u_4 =… at year 5: u_5 =…. . Then decide between three formulas = B2 + 2*A3, = B2 +2 = B2+ 2*A3, which one will make the spreadsheet calculate the values, and write a formula giving the deposit at the year *n*: u_n=…

Student 1: (*showing her sheet*) Am I right ?

Mrs P_{SCEP}: (*reading the values*) Yes…(*she realizes that the correct values were entered and not calculated)…*And how do you proceed?
Student 1: I calculate
Mrs P_{SCEP}: no, you must not calculate, the spreadsheet must calculate!
Student 1: but it is quicker than with the computer
Mrs P_{SCEP}: but go until 200 years like that?
Student 1: but this poor girl will never be 200 years old!

Figure 2: Mrs P_{SCEP}' management of an emergent goal

Mrs P_{EX} 's classroom activity

In the previous session, Mrs P_{EX}'s had presented the birthday problem, a first task being to compute the money that Sabine's grandmother will deposit in the account each year up to Sabine's 18^{th} birthday. In the observed session, Mrs P_{EX} asked a team of students to present their work to the class and told them that they were free to choose an environment (spreadsheet or blackboard). The team started to present its work to the class without the spreadsheet. Actually the team had only a small understanding of the situation and had much difficulty to explain how they proceeded. Mrs P_{EX} asked them to redo and write the calculations on the chalkboard.

$$100 + 2 \times 2 = 104, 100+ 2 \times 3 = 106, 100+ 2 \times 4 = 108.$$

At this moment, she became aware that continuing like that, students could approach a formula for the deposit at the year *n*, without using the spreadsheet. Then a goal emerged: to make the students use the spreadsheet. This goal was important for her because, in her understanding of the course, students' use of the spreadsheet was a means for them to access the notions. It was unexpected because her idea was that students would prefer to use the tool rather than calculate by hand. She achieved this goal, by way of a dialog with the class, insisting on the "modern" aspect of technology in contradiction with her position on the role of artefacts.

Observation

Overlooking the worksheet's task, a majority of students directly launched into the spreadsheet and started to fill in the sheet. Most students entered the amounts of the deposits in column B that they easily calculated mentally (as in the interaction below). Mrs P_{SCEP} was surprised by this behaviour. She prompted individually the students to enter and fill down formulas, typically an emergent goal (Figure 2).

Mrs P_{EX}: What there now? You are waiting for what? You do all calculations by hand? There is a more modern means to do that? There is a more modern means to do that, you make by hand?
Students: technology tool
Mrs P_{EX}: that is?
Students: the spreadsheet
Mrs P_{EX}: the spreadsheet, then go ahead.

Figure 3 Mrs P_{EX}' management of an emergent goal

The student who was presenting launched the spreadsheet but he used it as a way to display the results previously calculated mentally, entering each value individually. He took care of using a monetary layout for the deposit and to arrange titles in the worksheet. Mrs P_{EX} was not happy with that and insisted on using formulas and the fill down functionality first for entering a list of years and then the corresponding list of deposits. With different parameters, she encountered the same emergent goal as Mrs P_{SCEP}'s: to make students use a technique based upon spreadsheet formula to get the sequence values.

3.4 The productivity of an AT model

How the two teachers managed this emergent goal and other goals emerging more or less concurrently during the lesson, and the influence of teachers' own parameters has been analysed by Lagrange and Erdogan (2009). This analysis brought deep insight on the two teachers' activities and their potential for evolving, an evidence of the productivity of Saxe's model. I have reflected about this, realizing that there should be something in common between our teachers and the Oksapmin from which Saxe built the model. This should be that both had to deal with a new artefact involving deep cultural representations. This comparison brought me to consider cultural systems involved in classroom use of technology. Students saw the spreadsheet as a means to neatly display data. It is consistent with the social representations of technological tools. People are generally not aware of the real power of the computer, which is the possibility of doing controlled automatic calculation on a data set. In contrast, the teachers saw the spreadsheet as a mathematical tool. They were disconcerted because they were not conscious of the existence of other representations. Clearly, Saxe's approach helped to widen the reflection about the impact of cultural views associated to computer artefacts upon classroom phenomena.

4 INSTRUMENTED TECHNIQUES IN COMMUNITIES, CULTURES AND INSTITUTIONS

Beyond this "socio-cultural" analysis, the way both teachers justified the spreadsheet technique to students, insisting on a supposed pragmatic value sheds light on the difficult management by teachers of the instrumented techniques. As mathematics teachers, Mrs P_{SCEP} and Mrs P_{EX} knew more or less consciously the potential epistemic value of those techniques, but seemed to have difficulty opening a dialog with the students about the values associated with the techniques. From a community oriented AT point of view, Mrs P_{SCEP} and Mrs P_{EX} belong to specific communities with different cultures. Mrs P_{SCEP} uses mainly textbooks as a resource and she shares the average teacher's view of technology promoted by the institution because of the importance of ICT in social life. In this culture, the epistemic value of a spreadsheet technique is overlooked. Mrs P_{EX} belongs to the community of teachers who believe that technology has a potential to help students learn mathematics. The epistemic value of a spreadsheet technique value is present, although this teacher privileges a supposed pragmatic value when dealing with the emergent goal of making students use the spreadsheet.

The way the two teachers consider instrumented techniques seems then to be deeply involved in their teaching culture. The two teachers obviously have distinctive teaching beliefs, especially with regard to technology. However they share a common belief of the spreadsheet as an automatic calculation tool and a common norm about how it should be used to solve tasks in the mathematics classroom. This belief and this norm are implicit, which explains why both teachers are surprised by the students' behaviour, and have difficulty opening a dialog. This belief and this norm are parts of a mathematics culture which associates computer and calculation tool. The two teachers belong to a secondary school mathematics institution marked by this culture and a poor reflection on instrumented techniques. It means that, beyond specific communities and cultures in the sense of AT, the institution, in the sense of AA, plays a deep role in how teachers behave in technology enhanced classroom settings.

5 CONCLUSION

In the introduction I said that AA and AT share a common view of knowledge as a product of a human activity. While in communities, in the sense of AT, knowledge evolves generally in the short or mid-term in relatively explicit processes, institutions function by way of norms and beliefs resulting from long term mainly inexplicit processes and deeply interiorized by the subjects. In some sense, the contribution of AA is in making the reasons for these norms and beliefs more explicit. Because institutions play a big role in how we act in society, this particular contribution is one that should not be missed.

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