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Real uses of ICT in classrooms: Tensions and disturbances in mathematics teachers' activity

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This paper presents an extension of approaches of the teacher technology-based activity, articulating the Double Approach alongside with the Instrumental Approach within the overarching frame of Activity Theory. Tensions and disturbances are defined for analysing the dynamics of the teacher's activity when ICT tools are mediating both teacher's and students' activity. The approach is illustrated throughout a comparative study of two "ordinary" teachers using dynamic geometry. Various tensions related to the temporal, cognitive and pragmatic dimensions were observed, differently managed depending on personal, material and social determinants. Tensions are inherent to the dynamics of the situation. Together with disturbances, they are lenses contributing to a fine-grained analysis of teachers' activity.

Keywords: Teachers, technology, activity, tensions, disturbances, dynamic environment

Introduction

The activity of "ordinary" teachers integrating technology into teaching is constrained and depends on several determinants, namely personal, institutional and social. The work of researchers such as Ruthven (2009), Drijvers et al. (2010) and Abboud-Blanchard (2014) emphasize the need to study the practices of these teachers, often not technology experts and practicing in non-experimental conditions (i.e. ordinary practices). One of the aims of such studies is to better understand what happens in the classroom and thereby to address professional development issues (Clark-Wilson, 2014). The aim of the present paper is to contribute to this research line by introducing two new theoretical concepts, *tensions* and *disturbances*. These concepts were developed within a model of instrumented activities of teacher and students and were actually used as complementary resources within ICT teacher education programs.

We consider the teacher as managing an "open dynamic environment" (Rogalski, 2003), and we focus on both the relationship between the lesson preparation and its actual implementation (anticipation, adaptation); and also on the management of the inherent uncertainty within such an environment. Indeed, the use of technology adds a "pragmatic" dimension emphasizing the "open" character of the environment that constitutes the classroom activity. Monaghan (2004), stresses that this use leads to an increased complexity in teachers' practices and also that the uncertainties related to students' mathematical activities with technologies bring teachers to modify their objectives *during* the lesson in progress, leading them to focus on new "emergent goals". The concepts we introduce enable an

analysis of the impact of the dynamics of students' interactions with technology tools on the management of the planned (by the teacher) *cognitive route* (Robert & Rogalski, 2005), and the possible divergences from this during the lesson. In this paper, we provide an example of the comparative analysis of the activity of two "ordinary" teachers' uses of dynamic geometry with their (6th grade) students to describe the methodology and associated analytical tools and to highlight their usefulness. We selected this particular example from our research data as it is relatively easy to present in a short paper.

Theoretical and methodological approaches

The ergonomics theoretical perspective considers teaching as a case of dynamic management of the teaching environment (Rogalski, 2003). This environment is "open" as it contains many uncertainties due to the fact that the students' activity cannot be completely predicted and the teacher is often in an improvisation mode. The teacher's conceptions of the mathematical domain to be taught, and of the relation students have to it, are subjective determinants of his professional activity. These conceptions condition the "didactical process" he wants his students to follow i.e. the planned *cognitive route*, alongside the management of the processes developed during the lesson (Robert & Rogalski, 2005). Although the didactic scenario is familiar, the students' diversity and the specific context of the class introduce a factor of uncertainty. This uncertainty is exacerbated when students are working with a technological tool as the teacher may encounter difficulties to control the tool's feedback due to students' manipulations and to identify their emerging interpretations. Teachers often have to deal with tensions due to the presence of the tool and its role in the student's activity, and also its interaction with the mathematical knowledge at stake.

Following Rabardel's Instrumental Approach (2002), technological tools can be viewed from both the teacher's and the students' perspectives. In both cases, the subject-object interactions are mediated by the tool. As Rabardel states:

Beyond direct subject-object interactions (dS-O), many other interactions must be considered: interactions between the subject and the instrument (S-I), interactions between the instrument and the object on which it allows one to act (I-O), and finally subject-object interactions mediated by an instrument (S-O_m). Furthermore, this whole is thrown into an environment made up of all the conditions the subject must take into consideration in his/her finalized activity (Rabardel, 2002, p.42-43).

Nevertheless, the object of teacher's activity is the students' learning, whereas the object of the students' activity is the content of the task given by the teacher; their instruments based on the same tool are thus different. Figure 1, presents how these two instrumented activities are articulated within the dynamics of class preparation.

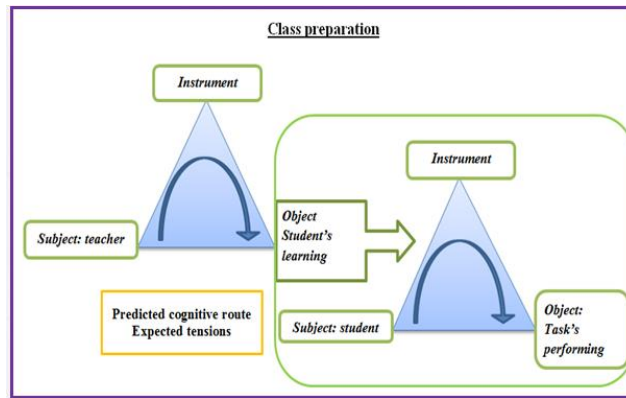


Figure 1. Teacher's and students' instrumented activities within the preparation phase

We now consider the classroom environment and present how the two instrumental situations are articulated within the dynamics of class management, indicating possible tensions and disturbances.

Tensions and disturbances

In our approach, we depart from the way Kaptelin & Nardi (2012) introduced the terms "tension" and "disturbance" when presenting the concept of contradiction central in Engeström's framework of analysis for how activity systems develop (Engeström, 2008). These terms appear in their familiar use; emphasis being put on the analysis of contradictions in activity systems as main learning sources.

We do not define tensions as conflicts or contradictions. In the teacher's activity *tensions* are manifestations of "struggles" between maintaining the intended cognitive route and adapting to phenomena linked to the dynamics of the class situation. Some of these tensions might be predicted by the teacher and so he/she plans how to manage them. Others are unexpected and constrain the teacher to make decisions, in situ, that direct his/her actual activity.

Disturbances are consequences of non-managed or ill-managed tensions that lead to an exit out of the intended cognitive route. Disturbances happen when a new issue emerges and is managed while the current issue is not completely treated or when the statement of a new issue is not part of the initial cognitive route.

We consider here only tensions and disturbances related to the local level of a class session; while some tensions are or might be managed at a more global level (i.e. over several sessions). Figure 2 illustrates how tensions can be related to different poles of the system of teacher-and-student activities; they can be shaped differently along three dimensions (previously introduced by Abboud-Blanchard (2014)): temporal, cognitive, and pragmatic.

Tensions related to the cognitive dimension appear in the gap between the mathematical knowledge the teacher anticipated would be used during task performance and the knowledge that is actually involved when students identify and interpret feedback from the instrument. Tensions related to both the pragmatic and cognitive dimensions are produced by the illusion that mathematical objects and operations implemented in the software are sufficiently close to those in the paper-and-pencil context

(we refer to Balacheff (1994) analysis of the “transposition informatique”). Tensions related to a temporal dimension are frequent in ICT environments and are linked to the discrepancy between the predicted duration of students' activity and the actual time needed to perform the task. Teachers are generally aware of such tensions; they often manage them by taking control of the situation, either by directly giving the expected answer or by manipulating the software themselves. Finally, a tension non-specific to ICT environment may concern the didactical contract: Students cannot identify the type of answer the teacher is expecting. ICT environments may amplify this type of tensions when students are uncertain of the goal of the activity i.e. is it about a mathematical object to manipulate with the software or about the use of the software itself.

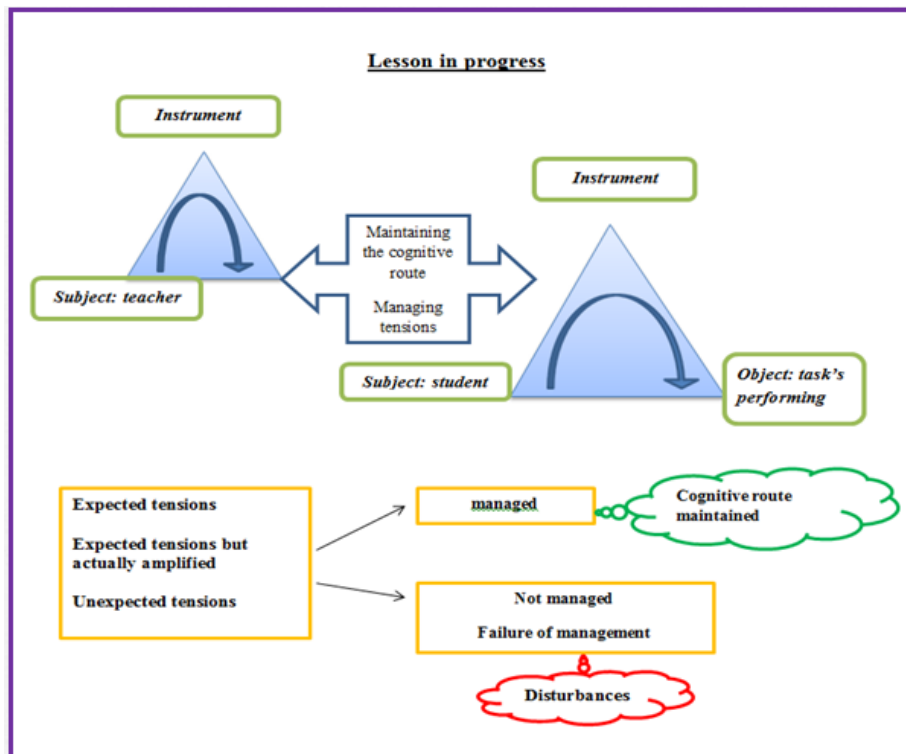


Figure 2. Tensions and disturbances within the dynamics of class management

Illustrating the theoretical approaches through a comparative case study

We present how tensions and possible disturbances appear in the case of two teachers, Alan and Colin, using dynamic geometry software (Geoplan) with 6th grade students to introduce the notion of perpendicular-bisector. They are both “ordinary” teachers who use technological tools occasionally, and willingly, in ways that are in line with the institutional expectations, that is to introduce students to an experimental approach. The two teachers designed the same cognitive route based on the succession of two tasks: moving several points (eight) on Geoplan screen in order to place each of them at the same distance from two fixed points, M & N, (ICT task) and then similarly drawing 8 points with the same condition in a paper-and-pencil context (p&p task). Each teacher’s final goal was to: give the definition of the perpendicular-bisector as a set of points equidistant from two given points; and establish an efficient associated construction method using compasses. Alan’s school is

in a low-income socio-economic zone, while Colin is in a middle-class zone. Their working environments are different: Alan had access to a traditional classroom and a computer room that lacked either a video projection device or a black board, while Colin worked in a classroom equipped with laptops.

The sessions included in our analysis were video recorded by the teachers themselves. Our choice of data collection approach is to reduce as far as possible the impact of researchers on the teacher's and students' activity in the class. The analysis of the teachers' preparation documents and deferred interviews enable the identification of some personal and social determinants. We then compare the observed succession of episodes in the video alongside the planned cognitive route, to enable us to detect tensions and disturbances.

Results

A somewhat surprising result is that both Alan and Colin managed the session without temporal tensions despite a number of “unfavourable” material and social determinants. In Alan's case, these could have resulted in strong tensions, e.g. the time needed to move from classroom to computer room and students' prior cognitive difficulties. In fact, Alan took into account the social determinants of his class and the material constraints by anticipating and avoiding tensions that could have produced disturbances through a threefold organisation: temporal, pragmatic and cognitive. Indeed, Alan closely supervised his students and organised their activity by structuring the cognitive route as a succession of well-defined sub-tasks. This mode of guidance has been identified previously as a common approach that teachers use to manage such experimental approach in order to avoid students' erratic behaviour (Abboud-Blanchard, 2014). The rhythm of sub-task completion is also strictly planned and guided. This is probably linked to Alan's personal determinants that led him to establish strong routines to discipline students in all moments. Indeed, not all teachers with this type of students are able to establish such routines and to be at ease when implementing them. Colin avoided temporal tensions in quite different ways. He started by presenting the task both with ICT and p&p. During the session, he used the IWB for sharing elements of the task outcomes with the whole class. He particularly drew students' attention to where they should look on the screen, and by doing so, avoided some pragmatic and cognitive tensions. Colin's open attitude may be related to a personal determinant of “compliance” inherent in his relationship with his students.

Regarding tensions related to the cognitive dimension, an important result is the shared illusion of transparency: Implicitly, Alan and Colin took for granted that after completing the ICT task, all students *would* have detected the existence of a straight line on which all equidistant points are situated. This was clearly not the case. This tension was not managed as indicated by the absence of any collective comment concerning the point of transition between the ICT task and the p&p one. For some students, this fact led to a divergence from the intended cognitive route: a “local” disturbance. These students persisted conscientiously throughout the whole session to draw equidistant points without appreciating the notion of a straight line as the set of such points. A tension related to the

didactical contract was also observed in both classrooms when, during the p&p task, some students tried to place the 8 points at the same positions they occupied on the screen. What may have triggered this students' interpretation of the task differs for the two teachers. Alan had introduced the p&p task, by saying “now we will do the same task but without the computer”. However, for Colin, the computers were not shut down and thus students may have continued to refer to what they saw on the screen. During the session, both teachers succeeded in managing this tension by explaining the differences of the two situations.

Finally, a pragmatic tension that was not managed was an implementation issue that could be related to a shared belief among teachers that students are skilled with technology using a trial and improvement approach. At the beginning of the ICT task, for any given point (P) on the screen, the students *could* read the relative distances to the point M and N and, when moving this variable point, they *could* observe the numerical changes. However, dragging the point P to maintain the equality involved two degrees of freedom on the plane. Therefore, an efficient approach relied on both students' awareness of this constraint and their development of an adequate concept-based strategy to “maintain a constant dimension when moving along the other” or “anticipate the curve on which the point is moving” (as shown in Abboud-Blanchard, 2015). In Colin's class, some students continued to drag points without any strategy even when the teacher asked them to engage in the p&p task. As a consequence, they could not easily be aware of the efficiency of using compasses instead of rulers when switching to the p&p context. For Alan's students, we can infer that some of them succeeded to place only few points with limited opportunities to notice their alignment.

Overall, we have identified a set of tensions in the activity of two ordinary teachers use of dynamic geometry and have illustrated the dimensions they may affect. By predicting many tensions, these teachers avoided some of these tensions by anticipating and organising the students' activity relative to the temporal, cognitive and pragmatic dimensions. The teachers managed others *in situ* mainly via individual interactions with, and support for the students. Their approach to classroom management depends on personal, material and social determinants. Nevertheless, the analysis also shows that even though they succeeded to maintain the essence of their intended cognitive goal, some unrecognised or ill-managed tensions led some students to diverge from the planned cognitive route.

Discussion and conclusion

In this paper, we have presented how and why we developed the notions of tensions and disturbances to analyse the dynamics of teachers' activity in ordinary contexts when they are using ICT in line with the institutional demands. We first schematised how ICT occupies two different positions as an instrumental tool for the teacher and for the students. The first schema is based on the postulate that there exists a crucial difference in the object of activity of the teacher (e.g. students' understanding/learning of the mathematical content involved in the task), and of the students, which is essentially to complete the task. Within the second schema, we added and defined several types of

tensions that may appear within the teacher's activity along three dimensions: temporal, cognitive, and pragmatic, and at the level of the didactical contract. The cases of Alan and Colin are examples of ordinary, experienced teachers investigated within a larger study, who use technology regularly. In addition, they are convinced that dynamic geometry enables students to make pertinent observations through the immediate feedback (this belief is widely shared by teachers). We identified a set of tensions: some of which were managed through anticipation; others in real-time (depending on different personal and social determinants); some were not detected or detected and not managed by the teachers. If teachers are able to identify and manage tensions, they can maintain the intended cognitive route for students or, when disturbances occur, modify this route to different effect. Several issues remain open for further research. First, the present study focused on the “local level” - an analysis of a specific classroom session. It will be necessary to extend our concepts and methodological tools to analyse tensions and disturbances at the more global level of a sequences of tasks on particular mathematical topics. Secondly, we analysed cases with “simple” ICT-based students’ tasks; other cognitive and pragmatic tensions could appear when the tasks involve objects and operations that are more deeply modified by the “transposition informatique”. Finally, at the deeper level considered in Artigue (2007), what different kinds of tensions would teachers encounter when students are engaged in mathematical activity involving mathematical objects (an epistemic orientation) compared with more specific computer-based tasks (a pragmatic orientation). Finally, we consider that the concepts of tensions and disturbances have enriched the range of theoretical tools to study teachers' instrumental activity, in particular for the identification and analysis of critical aspects of the dynamics of this activity. We conjecture that this could also inform approaches to teacher education.

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