ANALYSING TEACHERS’ CLASSROOM PRACTICE WITH NEW TECHNOLOGIES

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This paper presents an analysis of teachers’ practice in classrooms where new technologies are in use. An example of an analysis of data collected in mathematics classroom lessons in an upper secondary school is given. The analysis revealed how teachers structured the lessons and how the different tools were employed to achieve didactical and mathematical goals. The research contributed to research within the project “Teaching Better Mathematics” at the University of Agder1.

INTRODUCTION

Newer technologies2 are increasingly used in schools. In Norway the use of these technologies is now compulsory in all subjects and at all levels of schooling. It is argued therefore that it is important to learn more about how teachers integrate these tools into their classroom practice.

The classrooms studied were advanced mathematics classrooms in the second year of upper secondary school. In 2002 the school visited had initiated an internal ICT project. All students in advanced mathematics classes were issued with a laptop PC and classrooms were equipped with a screen and a projector. By the spring term of 2007 when the observations took place the classrooms had evolved to paperless classrooms; paper textbooks and notebooks were no longer in use. In the Norwegian context such classrooms were special but the project school was a normal school in that it operated in accordance with all formal regulations and guidelines. Practices described in this paper had evolved in a normal school environment with inherent functioning forces and tensions, not influenced by any external developmental project in mathematics education. I claim that this was an opportunity to observe and learn about ordinary teachers integrating new technology into their practice from the teachers’ perspective. Monaghan (2004) and others have seen a need for such research. This feature of the data is seen to be especially interesting given the generally limited success in the integration of digital tools into mathematics classrooms (Lagrange, Artigue, Laborde, & Trouche, 2001).

This paper addresses the following research question: “How do teachers structure mathematics lessons where newer technologies are in use and which technologies and tools are employed to achieve which didactical and mathematical goals”. An

1 The TBM project is supported by the Research Council of Norway
2 In official Norwegian documents the term ”digital tools ” is used
analysis technique was developed to analyse the classroom data. A detailed description of the technique is given before proceeding to the results of the analyses.

THEORETICAL FRAMEWORK

In the main study, the Instrumental Approach in Didactics provides the theoretical perspective. This approach combines elements from the Anthropological Theory of Didactic in mathematics education (Chevallard, 2005) and the Instrumental Approach from the field of cognitive ergonomy (Verillon & Rabardel, 1995). The approach is a middle range theory, domain specific to studying the use of newer technologies in mathematics education. Three main notions from the approach served to structure the analysis; praxeology and didactic process and instrumental genesis. In this brief paper I focus on the first two of these.

A praxeology is defined as the basic unit of human activity. This therefore includes mathematical activity and didactical activity. A praxeology is constituted of two inseparable parts, the praxis part and the logos part and each of these parts consists of two components (Chevallard, 2007, p. 133). The praxis block is formed by types of problems/tasks and by the techniques used to solve these tasks. The knowledge block, the so called discursive environment (logos) is structured in two levels: the technology (the discourse about the techniques used) and the theory that constitutes a deeper level of justification of practice (Barbé, Bosch, Espinoza, & Gascón, 2005, pp. 235-238). In studying teacher action in the classroom I use the term didactical praxeology to refer to teacher activity directed towards promoting the students mathematical activity.

The term didactic process is used to refer to the process directed towards the setting up of the mathematical praxeologies for the students. The process is claimed to be made up of six moments; the moment of first encounter, the moment of exploration, the technological theoretical moment, the technical moment, the institutionalisation moment and the evaluation moment (Barbé et al., 2005, p. 239). The analysis attempts to identify these moments in the classroom activity.

Two other notions used to structure the data analysis are didactical configuration and didactical exploitation mode (Drijvers et al., 2009; Trouche, 2004, 2005b). Drivjers et al. (2009) define these terms in the following way:

A didactical configuration is an arrangement of artefacts in the environment, or, in other words, a configuration of the teaching setting and the artefacts involved in it. These artefacts can be technological tools, but the tasks students work on are important artefacts as well. Task design is seen as part of setting up a didactical configuration.

An exploitation mode of a didactical configuration is the way the teacher decides to exploit it for the benefit of his didactical intentions. This includes decisions on the way a task is introduced and worked, on the possible roles of the artefacts to be played, and on
the schemes and techniques to be developed and established by the students (Drijvers et al., 2009, p. 2).

METHODODOLOGY

Data collection

Data was collected over a two week period, alternating between two parallel classes. Two researchers were present at each observation allowing for one researcher to video-record the lesson and the other to take comprehensive field notes.

The Analysis Technique

Analysing classroom activity is recognised as complicated as the classroom is a complex environment with many people present and acting (Abboud-Blanchard, 2008; Barbé et al., 2005; Kendal & Stacey, 2001; Monaghan, 2004; Robert & Rogalski, 2005). In line with Robert and Rogalski (2005) my analysis focuses on teacher action rather than modelling the global system operating in the classroom.

The analysis technique involves four elements; organisation of space and time; the mathematical content; didactic episodes; and instances of instrumented activity. These elements are explained here.

1. Organisation of space and time. In this part of the analysis a detailed description of the physical environment and how this is organised is given. In addition, an overview of the time disposition in the lesson sequences is presented in table form.

2. The mathematical activity. In this part of the analysis the mathematical content of the lesson sequence is described by firstly presenting the relevant goals in the official syllabus and secondly identifying the four elements of the mathematical praxeologies; the tasks, techniques, discourse and theory. The mathematical problem and the techniques suggested by the teacher to solve the problem are identified and discussed. The main notions, concepts and mathematical notation employed in the lesson are presented. (Barbé et al., 2005, pp. 236-238)

3. Detailed analysis of didactic episodes with focus on tool use. In reviewing the data material it was noted that each lesson sequence was clearly divided into time periods signalled by the teacher comments, such as: “But now we are going to do something fun and this is something you have not done before” (My translation)

I decided to use these teacher made divisions in the analysis. I therefore define a didactic episode as a part of the lesson where the class engages in one primary activity as signalled by the teacher. For example: the first didactic episode in a lesson maybe an episode with recap of theory from the previous lesson; the second, correction of homework; the third, introducing new theory and so on. For each lesson sequence observed in the reported study a table, as shown below, was completed.
Table 1: Didactic episodes

The episodes are numbered and the time used on each episode is given. The teacher’s goal is the goal perceived by the observer to be the goal of the episode, for example; a recap of theory. This goal is interpreted in relation to the moments of the didactic process. In the third column the parts of the mathematical praxeology presented in the didactic episode are identified as: task, technique, discourse, theory. Under the heading Didactical configuration, two sub-headings are included: Working mode and Tools in use. Working mode describes how and when the teacher devolves the mathematical task to the students. Four physical/material tool sets were observed to be in use by the teacher: the blackboard, a digital textbook, PC+ program Derive, body gestures. Each of these was used in conjunction with the voice and assumingly schemas (cognitive apparatus). The column Didactical exploitation mode has two sub-headings: Tool use - didactical goal and Tool use- mathematical goal included to describe how the teacher exploits the tools and with which didactical and mathematical intentions. The tools were sometimes used together. Instances when the teacher appeared to favour one tool over another or moved between the available didactical tools are identified. This practice of moving between tools within a didactic episode is termed weaving (Billington, 2009).

4. Analysis of instrumented activity in relation to mathematical tasks

In this part of the analysis focus is on instances of instrumented activity in the lesson sequences (Guin & Trouche, 1999, p. 201; Verillon & Rabardel, 1995). In each lesson sequence a few exemplary episodes are chosen for presentation and the manner in which the teacher uses the digital tools to solve the didactical task and the associated mathematical task/s is described. The instrumented technique/s used or advocated is/are identified and discussed.

APPLICATION OF ANALYSIS TECHNIQUE

This section contains an illustration of the application of the analysis technique. This is done by presenting two elements of a particular lesson sequence with Teacher1: organisation of space and time and didactic episodes.

Illustration starts

Organisation of space and time

A large blackboard covered almost the entire front wall of the classroom. A screen was positioned on the right hand side in front of the blackboard covering part of the blackboard. A laser pointer was available. The teacher’s portable PC was placed on
the large raised desk directly in front of the blackboard and screen. Students had only their portable PC on the desk and perhaps a backpack on the floor. The class came quickly to order. Students were not observed to use pencil and paper. A picture of the classroom and a diagram of the student seating arrangement are shown below.

![Figure 1: Picture of classroom](image1.png)  
![Figure 2: Student seating](image2.png)

Time disposition was analysed as Table 2. In the fourth column the activity is interpreted in terms of the didactic process (Barbé et al., 2005).

<table>
<thead>
<tr>
<th>Time (m.)</th>
<th>Time %</th>
<th>Activity</th>
<th>Moment of didactic process</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>18</td>
<td>Recap of theory and homework</td>
<td>Institutionalisation moment</td>
</tr>
<tr>
<td>14</td>
<td>18</td>
<td>Introducing new task</td>
<td>Moment of first encounter + exploratory moment</td>
</tr>
<tr>
<td>11</td>
<td>14</td>
<td>Students draw graph (Derive)</td>
<td>Technical moment</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>Trying example together</td>
<td>Technological-theoretical+technical moment</td>
</tr>
<tr>
<td>34</td>
<td>43</td>
<td>Students work with problems: teacher goes around</td>
<td>Institutionalisation moment</td>
</tr>
<tr>
<td>Tot. 79</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Time/activity analysis

**Didactic episodes**

A table showing the analysis into didactic episodes was completed. A section of the table is given in appendix 1. The completed table showed that there were fourteen shifts in activity ranging from one to seventeen minutes in the duration of the lesson sequence. The lesson sequence could be divided into three main parts. In the first part: introduction with homework correction and recap of previous work (episodes 1-4: 15 min.) the digital textbook was the main or preferred tool used by the teacher. These episodes are interpreted as representing the institutionalisation moment of the mathematical organisation from the previous lesson. In part two, the new mathematical problem and the new techniques to solve the problem (episodes 5-9: 26 min.) were introduced using both the program Derive and the blackboard. The phenomenon of weaving was observed in episode 9. Episode 5 of 5 minutes duration
encapsulated both the moment of first encounter and the exploratory moment. The technical-theoretical moment and the technical moment were contained in episodes 6 to 9. In final part of the lesson sequence, students worked individually or in small groups with the teacher assisting individual students in applying the new techniques (episodes 10-14: 29 min.). These episodes are interpreted as the institutionalisation moment of the didactic process.

In seven of the fourteen episodes the teacher used the digital textbook. It was used as a pre-written blackboard to display the formal mathematical theory and completed and uncompleted exercises. The data indicates that the tool occupies a strategic place in the classroom praxeologies of this teacher. The digital textbook provided support with exercises and formal presentation of the mathematical theory.

The work mode descriptions indicate that the teacher clearly steered the lesson, presenting and explaining the mathematical concepts, tasks and techniques carefully without posing many questions to students. Questions posed required short answers. Student work was not displayed to the whole class. Students engaged actively in the discussion when the mathematical problem was posed in contextual terms. The mathematical tasks were only devolved to the students in the final part of the lesson which involved working on problems.

Conclusion of illustration

DISCUSSION OF RESULTS

All observed lesson sequences were analysed in the manner as described above and then compared. In this section I will discuss some of the results of the full analysis with respect to the research question presented earlier: “How do teachers structure mathematics lessons where newer technologies are in use and which technologies and tools are employed to achieve which didactical and mathematical goals”. The full analysis revealed that the teachers had actively taken in use the new technologies and had developed similar patterns of practice and usage in the classroom.

The physical environment and time allocation

The physical classrooms in use were traditional in design except for the rather haphazard installation of a projector, a screen and a large number of electrical contact points. Individual teachers may not have much say in such issues but the seating arrangement could be altered easily by the teacher. The seating allocation observed and described above lends itself to an expository mode of teaching as all desks were directed towards the teacher. The arrangement also made discussion between students difficult. The screen was visible to all students and this allowed the teachers to demonstrate techniques instrumented on the PC. This was observed constantly. It was also possible for students to present their work to the rest of the class by coming forward connecting their PC to the screen. This was not observed.
A comparison of the time allocation tables revealed an apparent lesson script of: teacher review; teacher leads to formula/technique; practice. This script is documented in research as a standard lesson script (Jacobs & Morita, 2002; Jacobs, Yoshida, Stigler, & Fernandez, 1997). The introduction of the new technologies had seemingly not altered the traditional lesson script. The further division of the lessons into didactic episodes showed that there were a large number of teacher initiated shifts, varying from eight to fourteen shifts, in activity in the observed lessons. The effect of so many changes in activity on student learning may warrant further investigation. Further analysis is also required to ascertain if these shifts were caused or stimulated by the availability of the digital tools.

**The didactic process**

The moments the didactic process were identified within the didactic episode divisions. The analysis revealed that generally only a few minutes in each lesson sequence were given to the *moment of first encounter*, that is introducing the mathematical tasks and that the blackboard was the preferred tool when introducing the mathematical problem. In some of the documented lessons the students indicated that they did not really understand the problem with such comments as: “What is it actually that we calculate, because I don’t understand?”

The *exploratory moment* was allocated more time but the teacher always led the explorations with demonstrations. These demonstrations were enriched by the facility of the digital tools to reify the mathematical objects and relations. The technological-theoretical moment, that is the moment where the techniques are justified in reference to theory, tended to merge with the technical moment where techniques are practiced. These two moments together were given the largest time allocation in the public part of the lesson sequences. All techniques were instrumented through the digital tools. The largest relative percentage of time in lessons was given to the students solving exercises. Both the *institutionalisation moment* and the *evaluation moments* were realised through short public summaries by the teachers and through the longer periods of students working alone or individually on exercises. The analysis showed that teachers favoured an expository teaching mode; giving explanations, demonstrating, with elicitation of answers from students followed by students working alone.

**Teacher tool use**

The blackboard appeared to be the preferred tool when the teachers presented the mathematical task, gave an overview, illustrated notation; presented and/or discussed contextual examples and gave responses to spontaneous questions. A subjective observation was that the teachers were livelier when using the blackboard: moving around, using arm movements, tracing over important features of a curve with the chalk and so on. In contrast to its use in classrooms without PC and screen, the
blackboard was used in a rough way for sketching out problems and solutions. The blackboard seemed to acquire the status of conceptual sketch pad.

The formal mathematical knowledge; both theory and the argumentation in worked exercises was presented pre-prepared through the digital textbook. This practice required extensive planning and preparation. The students thus did observe the teacher mathematician actually conducting, carrying through a mathematical argumentation. The teachers clearly appreciated the word processing facilities offered by the digital tools as expressed in the following quotation.

Teacher1: Now everyone has the possibility to work down, now it is the mathematical, it is the logic that causes a stop; it is not all the writing that causes problems. (My translation from SM_070212)

The CAS program was employed in exploring the properties of mathematical objects in the exploratory moment and to demonstrate and justify techniques to solve the mathematical problems in the technological-theoretical and technical moments. Teachers planned for the technological-theoretical moment with the production and preparation of the interactive illustrations and demonstrations. All problems were solved with techniques instrumented through the CAS program although some of these techniques represented simulations of paper and pencil techniques.

A phenomenon, which I term weaving, was often observed whereby the teacher moved between the available tools of the blackboard and the digital toolkit when holding public discourse.

CONCLUSIONS AND FURTHER RESEARCH

It could appear that the new technology was used to strengthen rather than alter existing practice as has been found in other research (Cuban, Kirkpatrick, & Peck, 2001). The lesson observations were discussed with teachers informally and in a more formal meeting and these discussions provided insight into the logos behind some of seemingly unchanged practices.

Regarding the analysis technique, one strength of the technique, as I see it, is that it divides the lessons according to the teacher determined shifts in activity. The imposition of the theoretical notions on the data may perhaps restrict the interpretation. I would like to further develop and adapt the analysis technique to analyse lessons other than mathematics lessons with a goal to identify commonalities and differences in practice.

REFERENCES


<table>
<thead>
<tr>
<th>Ep. (min)</th>
<th>Teacher’s goal – Moment of did. process</th>
<th>Mathematical Organisation MO</th>
<th>Didactical configuration</th>
<th>Didactical exploitation mode</th>
</tr>
</thead>
</table>
| **1 (5)** | Introd. researchers, prepares for lesson | *MO Finding rate of growth linear function.* \[
\frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x}
\] Use of f(x) instead of y, focus on “rate of growth” & new notation | Whole class lecture | Digital textbook: theory page + examp. | Pre-written blackboard/public textbook | Presents formal mathematical knowledge |
| **2 (3)** | Recap of concepts from previous lesson | *Instit. moment M₅* Use of f(x) instead of y, focus on “rate of growth” & new notation | Whole class lecture: no questions to/or response from students | Digital textbook: theory page Laser pointer + hands: gesticulate “how fast” | Pre-written blackboard/public textbook | Presents formal mathematical knowledge Mathematical notation. |
| **3 (5)** | Correct homework: testing application of knowledge Tech. moment M₄ | *Tech: using formula to calculate rate of change of linear function. Tech: fractions and sign change with arith. operations involving negative numbers T₂* | Whole class lecture: short questions and response to individual students | Digital textbook: worked examples | Pre-written blackboard/public textbook | Presents formal mathematical argumentation + mathematical notation. |
| **4 (2)** | Recap/ application prior know. Instit. moment M₅ | *Tech. Rate of growth linear func. \[
\frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x}

Table 3. Didactic episodes extract