A STUDY OF JAPANESE PROBLEM CENTRED LESSON STRUCTURE IN SWEDISH ENVIRONMENT

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Abstract This paper presents my project analysing a problem centered lesson approach of Japanese origin and apply it into Swedish mathematical classrooms. The didactic method has the aim of motivate the students’ positive attitude toward mathematical learning and fostering mathematical thinking. As an analytical tool, the anthropological theory of didactics (ATD) will be applied.

INTRODUCTION

Teaching methods were developed in Japan in ways that are different from other industrialized countries. Hiebert et al. (1999) analysed, by studying videos from the material in the TIMSS study, differences in teaching methods and discourse between Japan, Germany and the United States. They argue that Japanese teachers as a goal for the lessons emphasize mathematical thinking rather than mathematical skills and choose problems starting the lesson that can be solved by varying methods developed during previous lessons. Students are also encouraged to develop methods themselves. The promotion of “mathematical thinking” means in particular the development of the pupils' attitudes toward and ability to communicate mathematics (Nagasaki, 2007). This goal is reached by letting the student discuss with their peers on the settlement options in the whole class. The Japanese teaching methods have also attracted considerable attention in Sweden lately. (Dagens Nyheter, 2010)

The “open approach method” (Nohda, 1991) is a proposed method to foster students’ mathematical thinking and to enable creative activities during the lessons. The open approach method is used and analysed by Japanese educators (Hino, 2007). The method often initiates the lecture by focusing on “open-ended problems” (Nohda, 1995) that ideally to lead to a many answers obtained by students during the problem solving process. Open ended problems usually starts with the task of formulating a mathematical model and will therefore naturally lead to a multitude of solutions and answers. The intent is to let students develop and express different approaches and to let them reflect on their own ideas by seeking to grasp those of their peers (Miyakawa and Winsløw, 2009).

Kazuhiko Souma is one of the pioneers who has both introduced and practiced classroom discourse in the same tradition. He calls his method “The problem solving centered (here after PSC)” approach (the author’s translation; “Mondaikaiketsu no jugyou”, in Japanese). In Japan, there is a tradition of practical books for mathematics teachers as the target group. It aims to present the ideas and lesson plans that connect to the different teaching methods (Souma, 1995, 1995 Kunimune & Koseki). Souma has written a number of such books and his method is actively and widely used by teachers in service in Japan, but has received little attention from the academic community.

The aim of my paper is twofold: First, to present the Souma’s approach, in relation to other Japanese lecture methods. Second, to discuss its practical application in a Japanese classroom.

ATD ANALYSIS OF THE PSC APPROACH

The PSC approach is a didactic technological-theory block based on theories about the psychological aspects of learning.
Dewey’s reflective thinking

In his book from 1997 (Souma, 1997), Souma declares that he is inspired by John Dewey’s theory of reflective thinking. Dewey (1933) presents five phases of reflective thinking when one attempts to solve a problem: 1. Recognize the problem. 2. Define the problem. 3. Generate hypotheses about the phenomena. 4. Use reasoning if the hypotheses are viable to solve the problem. 5. Test the most credible hypotheses. Souma evaluates Dewey’s five phases as a good pedagogical model. When it comes to mathematics education, he pays attention especially to the first three phases. He indicates that teachers usually hurry up to go to the fourth phase to “use reasoning”.

Dewey’s theory of reflective thinking can be compared to Chevallard’s description (Barbé, et al. 2005, p. 238) of the dynamics of didactic process. There are six moments; 1. the moment of the first encounter, 2. the exploratory moment, 3. the technical moment, 4. the technological–theoretical moment, 5. the institutionalisation moment, 6. the evaluation moment.

The first two phases of Dewey could correspond with the first encounter and the exploratory moment. Dewey’s third phase corresponds the technical moment, the fourth phase correspond the technological–theoretical moment. Dewey’s fifth phase is perhaps mainly aimed at empirical studies, although in mathematics it could correspond to Chevallard’s evaluation phase and the checking the validity of answers obtained.

Guessing and applying “well presented” problems

The PSC approach holds that it is important to infuse momentum into the didactic process by motivating and engage the students in the classroom (Souma, 1997). The students will gain motivation when they first encounter and explore the task if this encounter entails guessing and the exploration entails variability of techniques. According to Souma’s actual example (Souma, 1995), it is common that a Japanese mathematics lesson starts with a teacher giving a task (often a rather challenging one), for instance; “Show that the difference of the squares of two integers that follow each other is equals to the sum of the two numbers (5^2 – 4^2 = 9 = 5+4, 24^2 – 23^2 = 24+23 and so on).” The students try to solve the task, the teacher lets some students who has solved the task write their answers on the blackboard and/or lets the students explain orally their solution. The didactical technology (Bosch, M., & Gascón, 2006) here is that by using variables to express the phenomena, the students will understand and train the skills, with the aim that they will master the expansion of the square (a + b)^2.

Souma wonders (pp. 103-104) if the students feel a necessity to reflect upon the problem; several students might not to get any ideas to solve the task.

Instead, PSC approach proposes the following didactic technique: The teacher (in this case was Souma himself) writes down several expressions on the blackboard without any comments;

\[ 5^2 – 4^2 = 9, \quad 24^2 – 23^2 = 47, \quad (– 9)^2 – (– 10)^2 = − 19 \]

and asks the students what can they observe from these expressions. The students answer “It becomes a odd numbers”, “The differences equals to the sum of the integers”, “The differences equals the first integer times two minus one”, “The last integer times two plus one”. Then the teacher controls the all proposals are correct on the blackboard and says; “Now we try to prove each of the assumption”. This first encounter with the task and the second moment of exploratory moment to let the students discover the patterns by themselves brings curiosity to tackle with the tasks.

Souma says that Dewey’s reflective thinking tells us that we should have an aim to what we solve and to know why we solve it. By committing to make a guess, especially in the social context of the class, the student will have a stronger motivation to study the problem. This focus on motivation
at the first moment, the encounter, is perhaps the point that set Souma’s method apart from other Japanese didactic technologies in the same vein.

As a technique, several students use the formula of the square with a variable $x$;

$$x^2 - (x - 1)^2 = 2x - 1$$

$$= x + (x - 1)$$

or, using $x$ to the first integer and $y$ for the second integer;

$$x^2 - y^2 = (x + y)(x - y).$$

Cause $x - y = 1$, thus;

$$= x + y$$

This type of lesson allows the students to use and discuss several techniques on a well defined content. Therefore, the students’ construct mathematical praxeologies that are at least local praxeologies (García, et al., 2006).

The teacher then leads the class on to discuss the reason behind each method and lets the students determine which of the techniques they have used and why. In this way, the students contemplate the techniques not as something to memorise, but to find out and compare. It is thus a discourse on technology which leads to the theoretical discourse. After this, the PSC approach often lets the students to reflect upon the mathematical theory. The teacher can point out what they have learned today by having a student read out explanations of the theory relevant for the lessons.

Problem solving activities are, according to Bochet al.’s (2007) study, often introduced at schools without any connection to a specific content or discipline. They state that this type of didactic technology, suffers the risk of leading to the study of very localised mathematical organisations, since this what students are trained to study. Introducing specific open-ended problems may lead to the construction of mathematical praxeologies of a point character. “Students usually evolve in a mathematical world made of disconnected and isolated point-praxeologies (or at most local ones) and it is not easy for them to acquire the necessary means—and not even the necessity—to connect and contextualise the problems they study” (Rodríguez et al., 2008, p. 297).

Souma (Personal Communication, 2010) agrees with this type of assessment, when he judges open approach method as a something that can not be used in everyday school mathematics. Nohda also notifies that “We do the teaching as open-approach once a month as a rule” (Nohda, 1991, p. 34) Souma states that lessons applying too open-ended tasks might be isolated from ordinary lessons that, for instance, aim to train students’ basic mathematical skills. He names the type of tasks a teacher should try to present, when applied in the PSC approach as “open-closed” tasks (Souma, 1987). It means that the problem should, ideally, lead to multiple methods of solution and stimulate a discourse on theory and technology. At the same time, the discourse should stay somewhat focused on the well-defined subject that the teacher aims to cover.

According to Souma, it is desirable that the PSC approach is applied, with the same basic form, during most lessons. Familiarity with the situation makes the students to feel more secure in participating actively in the discourse, so that the students and the teacher construct a didactic contract (Brousseau, 1996), keeping the discourse on keel. Souma also states firmly that studies in mathematics should be organised and based on a good textbook. The textbook allows the students to recognize the theory and explain more fully what has been discussed during the lesson. It is also a good instrument for students to repeat previous subjects in order to build a more whole picture.

Following the PSC approach, the teacher should present problems that will lead to more local praxeologies, exemplified by the standard problems in the ordinary textbooks of mathematics. Souma emphasise the importance of problem construction; the teacher should thus aim for “fertile problems” as Chevallard put it (Garcia, et. al., 2006). The teacher needs to modify parts of the tasks
or change the way of giving the questions as in the example we saw. If the problem is carefully constructed, it can lead to conjectures, tasks and techniques that connect the local mathematical organisation covered with more global mathematical praxeologies and inspire to technological and theoretical discourse that even further connects to higher level mathematical organisations.

A MATHEMATICAL PROBLEM ORIENTED CLASS IN SWEDEN

Method

I have done a pilot study at an upper secondary school in Sweden where the teacher practices an adapted version of PSC-approach. I videotaped four 150 minutes lessons in two parallel class with the same teacher with one video camera. I focus on the teacher’s acts and what was written on the blackboard. The collected data about the lesson are: the video recording, notes from the classroom observation, notes from an interview with the teacher and the student, the teacher’s didactic planning notes as well as textbook and syllabus.

I intend to make a study using the same method at lower secondary school grade 7 (age 13 to 14) from the beginning of their semester during at least half a year. I will interview teachers and students, at the beginning, end, and in the midpoint of the study. The focus will be about the students’ attitudes towards mathematics lessons and how the feel about communicating mathematics during the lesson.

Result from the pilot study

Here I briefly present a summary of the results from my pilot study:

- Students now present their solutions to the class without hesitation.
- Students are now more likely to join the discussion and their curiosity seem to be more aroused.
- By the interview, the most of the students told that they were positive to listen to other students reasoning.

I am still looking for suggestions on how to use the video-filmed lessons in order to measure students’ activity, communication skills, etc. I can not make a decision which variables are suitable yet.

PRELIMINARY CONCLUSIONS

I think what Soumas approach shares with many writers in the ATD tradition, is that it takes the organisation of the mathematical content of the study process seriously. Like Chevallard, Souma emphasize the need to construct central fertile problems that connects to mathematical knowledge studied both forward and backward in time.

When Garcia et. al. (2006) give three necessary criteria for which questions are successfully studied, namely cultural, mathematical and functional legitimacy. However, they leave out the individual level; if a question is perfectly legitimate from such aspects, it is still needed that the students are not alienated from it. Therefore, I think that such an institution based analysis need to be complemented with a more tactic analysis centered on the students actual study process inside and outside the classroom.

The focus of the PSC approach is to propose, like many other Japanese teaching methods, a specific didactic technology based on whole class problem solving and discussion of “open-closed” or “fertile” problems, where making conjectures which stimulates the students’ didactical process.
conjectural motivational technique and the emphasis on how the problem is presented is perhaps that which set the PSC approach apart from many other Japanese teaching methods. The motivation is pedagogical and based on Dewey's model for the “Reflective Thinker”. Dewey's theory focuses on the individual student rather than the institution, which is the fundamental unit for analysis in ATD. However, I think that the didactic process of Chevallard is a description of learning that, as well as Dewey's, can be used to motivate the didactic technologies proposed by PSC approach. The problem with individual motivation is also implicit in Garcia's et al.'s (2006) description of the problem with the “monumentalisation” of mathematical organisations in education; that students are invited to visit the mathematical organisation but not to construct them.
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