Applying Japanese Problem Solving Oriented Lesson Structure to Swedish Mathematics Classrooms

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Since the late 1990s, the ranking of Sweden in international surveys of education such as TIMSS, has dropped noticeably, especially in mathematics. The School Inspection points out (2010) the main reasons for the decline as follows: 1. Students are not being equipped to develop different skills such as problem solving and the ability to make mathematical connections, nor to reason and express themselves. 2. The teaching is largely characterized by students working individually in their text book. I believe one of the basic problems in mathematics education is to find ways to organise the classroom discourse to make the students active learners of mathematics, without losing the focus on the mathematical content. Problem solving centred teaching methods in Japan have been developed with an emphasis on just these issues. "The problem solving oriented" approach (here after PSO), which was developed by Kazuhiko Souma (1997) is one of the variations of Japanese teaching methods where teachers focus to enhance the students' attitude towards engaging in mathematical activities. The aim of this paper is to clarify how PSO could affect students' willingness to "reason and express themselves" by extracting its *didactical organisation* with the help of the anthropological theory of didactics (ATD), (Chevallard, 1999). ATD provides a framework for the analysis of how the didactic process relates to and transforms the mathematics taught where the didactic process is described as an organised collective work aiming to construct *mathematical praxeology (MO)*. A *praxeology* is described by structuring it into *tasks* and *techniques* (the *praxis*), together with its *technology* and *theory* (the *logos*). *A didactical organisation* (*DO*) is a praxeology developed by teachers to organise the work of establishing an appropriate *MO*.

Together with a teacher in a lower secondary school, I designed lesson plans according to PSO's basic lesson structure: 1. Show the problem, 2. Let students guess (a part of) the answer, 3. Give students opportunity to solve the problem and then discuss their solutions, 4. Summarise the lesson with references to the text book. In this presentation, I focus on an episode from a lesson with the topic "subtraction and multiplication with negative numbers". The students have been introduced to the positioning of positive and negative rational numbers on the number line and the interpretation of the absolute value as the distance from the origo. The question is to compare the value of following expressions: task A:

$(+6)-(+2)$, $(+6)-(-2)$, $(-6)-(+2)$, $(-6)-(-2)$, task B: $(+6)\cdot(+2)$, $(+6)\cdot(-2)$, $(-6)\cdot(+2)$, $(-6)\cdot(-2)$. The students' guesses for $(-6)-(-2)$ split into (-8) and (-4). They notice that the solution has something to do with the direction of the signs but it is difficult for them to explain clearly what. Student F points at the two minus signs and says "Minus times minus is plus, that why $-\ (-2)$ will be +2". Student M points out the position of (-6) on the number line and says, "Minus means going to the left, so $-(-2)$ may mean go to the left furthermore, so it is (-8)". Then the teacher asks the class, "What does the minus sign (in front of (-2)) actually express?" Student O says "It means to move from the current position to the opposite side – like in a mirror" and explains on the number line "It is supposed to go to the left side from (-6) by the subtraction, but because of the minus sign in (-2), conversely, it proceeds to the right". His description and method are accepted and used by many of his classmates when the class solves the next task in group B, $(-6)\cdot(-2)$.

The *techniques* are the simple arithmetic operations informed by visualisation on the number line, the *technology* consists of the interpretation of multiplication by (-1) as mirroring, the interpretation of addition by a number as translation left or right by the absolute value and the use of basic algebraic rules like the distributive law and associative law. The *theories* are those of basic arithmetic, the real or rational number system, and (largely implicit) the theory of one-dimensional vectors. The *didactical task* in the *DO* is to make the class start to absorb and for themselves construct this MO concerning negative numbers. The *didactical techniques* are: 1. Consideration of suitable ("rich") problems. 2. Encouraging initial guesses (in spite of the simple expressions, different guesses came out). 3. Techniques to steer and invigorate the whole class discussion. 4. Confirming and institutionalising by using the textbook. These techniques promote students' participation in the mathematical discourse. Without the *guessing* technique and other techniques of invigorating the class discussion, many students might just accept statements without actively participating in the construction of the MO. ATD is a macro theory, which views learning from an institutional perspective. The method of PSO is mostly motivated from a cognitive individual centred perspective, which emphasise students' motivation to participate in the discourse. But the MO provided in PSO fits the epistemological components of ATD.

References

Chevallard, Y. (1999). L'analyse des pratiques enseignantes en théorie anthropologique du didactique. *Recherches en Didactique des Mathématiques, 19*(2), 221-266.

Skolinspektionen (2010). *Rätten till kunskapen.* http://skolinspektionen.se/Documents/Kvalitetsgranskning/skolors-kompensatoriska/kvalgr-komp-slutrapport.pdf. Accessed, 2011/10/20.

Souma, K. (1997) *Sugakuka Mondaikaiketu no jugyou* [The problem solving oriented approach -The subject of mathematics]. Tokyo: Meijitosho.