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John Dewey and mathematics education in Sweden

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Abstract

International comparisons such as TIMSS and PISA have shown that the mathematical skills of Swedish students have declined notably in the last fifteen years. The Swedish government has implemented disciplinary efforts with an increasing amount of national tests, and grades in early years have been suggested. Yet, the results of Swedish school students have not improved. We suggest that this negative trend is not only the result of a lack of discipline in the classrooms, but is also the effect of a more recent didactic turn in mathematics education: the emphasis on verbal and meta-mathematical knowledge at “the expense” of numeracy skills. In this paper we discuss the state of mathematics education in Sweden using a distinction made by John Dewey between the psychological and logical aspects of a subject. To exemplify our argument we consider curriculum documents, national tests and evaluation material from the last 50 years.

Introduction

The results of Swedish students in international comparisons such as TIMSS and PISA have significantly weakened in the last fifteen years (National Agency for Education, 2012, p. 108). The same tendency can be noted in national tests: the amount of students in secondary education who fail mathematics has increased considerably in the past fifteen years. Some argue that this is due to the progressive ideals that have dominated Swedish pedagogy since at least the 1970’s, characterized by democratic classrooms, student participation and absence of homework and tests. As a reaction, the Swedish government has in the last decades implemented disciplinary efforts with an increasing amount of national tests. Grades in early years and grades for conduct have been suggested. Other efforts, such as financing research projects in mathematics education and special courses for mathematics teachers have also been arranged. Yet, the results of Swedish school students on TIMSS and PISA have not improved. We believe that this negative trend is not only the result of a lack of discipline in the classrooms, but perhaps also an effect of a more recent didactic turn in mathematics education: We suggest that during the past twenty years the emphasis on “verbal, meta-mathematical knowledge” has increased which may have affected the importance of numeracy skill in a negative way.

Here the expression “verbal, meta-mathematical knowledge” should be understood as the ability to describe mathematics and solutions to mathematical problems as well as to communicate mathematics with other people. A concrete example is when a student describes a strategy to solve a mathematical problem,
but the actual solution is not included. The expression refers to an ability to talk
about mathematics, that is a meta-mathematical knowledge. However, we would
like to point out that our suggestion should be viewed as a tentative explanation
regarding the negative trend of Swedish school students’ results on TIMSS and
PIŠA.

We will discuss the state of mathematics education in Sweden with the help
of the terminology of John Dewey, an American philosopher who had a
significant impact on the Swedish school system with its ideal of focusing on
student interest and student activity. With tools provided by Dewey we aim to
highlight the problem of separating verbal understanding and numeracy skills in
mathematics education. We have compared curricula, national tests and
evaluation material from the last 50 years in order to investigate the amount of
mathematical knowledge as well as verbal, meta-mathematical knowledge. Here
we will present two examples from our investigation, but first we will give a
short introduction to Dewey’s educational philosophy.

John Dewey’s progressivism

John Dewey was an American philosopher (1859-1952), known as one of the
main proponents of the American progressive movement in the beginning of the
1900's that tried to change the school from the highly authoritarian and
disciplinary institution that it had been in most countries during the 1800's. This
was a time when concepts such as student democracy, student motivation and
activation were introduced. These ideas became influential in the US in the 30's,
with the Lewin, Lippitt and White study, which concluded that groups led by
democratic leaders were more productive, efficient and cooperative and less
hostile and aggressive than groups with either autocratic leaders or totally
permissive leaders. The influence of this study was enormous, in a time when
people feared rising fascism and Nazism in Europe – it has been called one of
the most educationally influential studies ever launched (Raywid, p. 253). This
helped to boost the so called progressive ideals, and to spread the influence of
Dewey in the US and in other countries, such as Sweden.

Let’s have a look at Dewey’s educational philosophy. He argued that the
teacher shouldn’t be a dictator but someone who can activate and motivate the
students. The teacher should “psychologize” the subject, i.e., make it interesting
for the students through relating it to their experiences (Dewey, 1959, p. 105).
This is important because Dewey regards learning as an active undertaking,
something that the students have to participate in if they are really to learn
anything of value. If the motivation to learn is external to the subject
(punishments and rewards, as well as grades), the students only learn to meet the
requirements, to say and do what the teacher wants them to – or, rather, to seem
to meet the requirements, because what they really learn is unimportant as long
as it looks good in the eyes of the teacher (Dewey, 1966, p. 156). And since
competition rather than cooperation is encouraged in this kind of environment,
it fosters selfish and aggressive individuals who only care about their own
accomplishments. Instead, Dewey thinks, the motivation should come from the task itself, from a problem or difficulty that the student wants to solve. This encourages real understanding and learning, as well as cooperation. And if we want to foster democratic citizens, we should teach children not only to memorize data and follow orders, but to think critically about the information given so that they can form their own opinions. At the bottom lies an ethical ideal of democracy and the open society (Dewey, 1966, pp. 301, 356).

**Dewey in Sweden**

The so-called progressive ideals came to Sweden from different sources (for example via the German and Austrian Arbeitsschule). And even if Dewey had been translated into Swedish as early as 1902, his influence on the Swedish school dates most clearly to sometime after the Second World War. Here, too, the idea was to avoid the horrors of fascism and to instil democratic values in the students. A school commission was appointed by the government in 1946, with the purpose of investigating the possibility for a common, compulsory school for all children. Through one of the members, Alva Myrdal – who, with her husband Gunnar Myrdal, is known as one of the main driving forces in the creation of the Swedish welfare state – Dewey came to influence the formation of the Swedish school (Hartman, Lundgren & Hartman, p. 34). The Myrdals had recently stayed in the US and become very impressed with the progressive school movement there, and brought those ideas with them to Sweden. The recommendation that the commission wrote to the Swedish government stated: “In school, the individuality and personal capacities of each child must not only be paid attention to and respected, but be the actual starting point” (Myrdal, p. 115).

So the progressive, democratic ideals formed the modern Swedish school. But now the era of progressive ideals seems to be over, not only because of privatization of the schools and a bigger stress on individualism and market needs, but also because of bad Pisa results during many years. Many blame the progressive ideals of student democracy and participation, they argue that the teachers lack authority and that the impulses of the students set the agenda, rather than hard arguments and knowledge. And, allegedly, this is why Sweden is doing so poorly on international tests. In the last ten years or so the politicians have therefore been eager to increase disciplinary efforts, traditional teaching (with the teacher standing in front of the class talking rather than activating the students), more testing and earlier grading.

But these measures have not improved the results, on the contrary, they keep declining. And furthermore, the results on international mathematics tests didn’t actually start to decline until quite recently, in the 1990’s Sweden was still doing fairly well. So it seems that we can’t blame Dewey’s influence for the failure of school mathematics. And if we look at what Dewey actually said, it becomes clear that he did not undervalue knowledge in the way that is often thought. He thought of the “psychologization” of knowledge (relating the subject matter to
the experiences of the students and making them interested) as a starting point of education, not the end point (Dewey, 1959, p. 99).

According to Dewey you can view a subject, like mathematics, from two viewpoints, a psychological and a logical. To emphasise the psychological aspect is to stress student interest and experiences and to relate the subject matter to what the student is familiar with. To emphasise the logical aspect is instead to focus on the subject as it appears to the expert, as an abstract body of knowledge driven by its internal laws and rules. The teacher needs to be familiar with both of these aspects in order to be able to teach the students: The teacher of mathematics must master mathematics as an abstract body of knowledge, but also know how it can be made intelligible and interesting to the students. Dewey’s point is that these aspects cannot be separated, they are both part of a well functioning education. He says that the child’s interest (the psychological aspect) and the subject (the logical aspect) are two limits that define a single process: “Just as two points define a straight line, so the present standpoint of the child and the facts and truths of studies define instruction” (Dewey, 1959, p. 97).

This means that the teacher ideally starts from what interests the students, but that which gives direction to the instruction, the goal, is the “organized bodies of truth”—mathematics as abstract knowledge. Education, then, is what goes on in between these two defining points, the movement from student experience to abstract subject matter.

When the small child is asked to count three apples in a basket, and to count again after one apple has been removed, s/he is dealing with concrete, physical things. But at the same time the child is taught an abstract operation: 3-1. Here the instruction is psychologized, adapted to the child’s level and to his/her interest in colourful, eatable things. But learning won’t stop there, counting apples will make possible other, more abstract operations. During the years to come the instruction will become more and more abstract and move toward what Dewey calls the logical aspect of mathematics: toward mathematics as a goal in itself without a connection to practical interests. But it is important to keep in mind that these two aspects are interdependent. They are two sides of the same coin, impossible to categorically separate: the logical aspect, the part of mathematics that is driven forward by the internal development of the field rather than by the need of practical applications, would be unthinkable unless mathematics also played a practical role in human life. And the practical applications of mathematics (in for example technology) are dependent on the progress made in the theoretical field of mathematics research.

We think Dewey’s psychological perspective, where student interest and practicality are central, can be likened to a didactical perspective on mathematics, whereas the logical perspective includes the more abstract mathematical practices that are part of higher mathematics, such as for example calculus, algorithms and proofs. Ironically, the recent turn away from the progressive ideals in mathematics education in Sweden hasn’t resulted in the students
acquiring “real knowledge” instead of “only what the students are interested in”, as the proponents of these disciplinary measures claim, but rather, we argue, the opposite: As we will show there has recently been a tendency to downplay the importance of teaching students to calculate, and to think that they don’t need to learn algorithms and rules.

This is due to a recent research trend in which verbal, meta-mathematical skills are emphasized at the expense of numeracy skills in mathematics education, or, with Dewey’s terminology, to emphasise the psychological at the expense of the logical aspects of mathematics. This trend seems to be the result of a tendency to see numeracy as a potentially mechanical process, and therefore it is thought that the genuine mathematical understanding is best expressed verbally. We do not have the room to expand on the grounds for this view in the present paper, we can only note that the reasoning behind the calculus is viewed as separate from the calculus and therefore to be tested separately. This is why traditional math tests won’t do. Swedish students used to be able to complete a math test and get full points for using the correct mathematical methods and arriving at the right answer. This is not the case anymore, as we will show in the next section.

Two concrete examples

In this section we will consider two examples from our investigation of Swedish curricula and evaluation material from national tests in school mathematics.

Swedish curricula

In 1962 a reform took place within the Swedish school system. The old school form was replaced by the primary school (grundskolan) which was implemented during a ten year period (Prytz, 2010, p. 310). The first curriculum was published in 1962 and has been replaced by five new curricula published in the following years: 1969, 1980, 1994 and 2011. In our investigation we have compared these five curricula.

In general one can deduce that the amount of “everyday mathematics” and practical mathematics have increased over time, while the pure mathematical content has decreased. The recent curriculum stresses that mathematics not only consists of calculations and “learning rules by heart”, a large portion deals with the usage of mathematics as a tool, language and resource in order to solve practical problems related to private economy, social life, electronics, newspapers and medicine dosage (National Agency of Education, 2011).

We do not claim that it is wrong to focus on practical skills in mathematics, instead our point is that during the past fifty years the numeracy skill and practical skill have been separated and the latter seems to have been emphasized at “the expense” of the former. With Dewey’s terminology one could perhaps argue that the goal of mathematics education today is the psychological aspect of mathematics rather than the logical. We will return to this issue in the next Section where we consider national tests.
A related tendency within Swedish school mathematics is to emphasise the ability of communicating mathematics rather than the ability to calculate. It seems that verbal understanding has gained importance compared to previous years. A typical example is that the Swedish curricula from 1962, 1969 and 1980 are based on the different topics of school mathematics, for instance arithmetic, geometry, algebra and probability theory. Meanwhile, the two most recent curricula, from 1994 and 2011, are both based on general and verbal, meta-mathematical abilities that are the same for all school levels and every different topic of school mathematics. The abilities in the current curriculum from 2011, Läroplan för grundskolan, förskoleklassen och fritidshemmet (Lgr11), are the following:

1. Conceptual ability
2. Procedural ability
3. Problem solving ability
4. Modelling ability
5. Reasoning ability
6. Communication ability
7. Relevance ability

The commentary material to the 2011 curriculum of mathematics emphasises that students should learn to use “metacognitive reflections in order to think out loud, look for alternative solutions as well as discuss and evaluate solutions, methods, strategies and results” (National Agency for Education, 2011). This is related to “Bloom’s taxonomy” from the 1950’s where the aim was to achieve a system in order to categorize different levels of learning abstraction based on cognitive skills such as to describe, analyse, compare and evaluate (see Bloom et. al., 1956). (This will be further clarified in our next Section where we discuss national tests.)

The implementation of general and verbal, meta-mathematical abilities in Swedish curricula seems to be a result of an international trend within the research field of mathematics education. Over the past 20 years researchers have made efforts in order to understand what “mathematical skill” really means. One example is the American report “Adding it up” whose purpose was to describe mathematical knowledge by means of different competencies (Kilpatrick, et. al., 2001). A similar example is the Danish “KOM project” (Competencies and the Learning of Mathematics), initiated by the Danish Ministry of Education and led by Mogens Niss, whose aim was to describe mathematics curricula on the notion of mathematical competencies rather than on syllabi in the traditional sense of lists of topics (Niss, 1999; Niss & Höjgaard-Jensen, 2002). The competencies introduced in the “KOM project” are the following: Thinking mathematically, posing and solving mathematical problems, modelling mathematically, reasoning mathematically, representing mathematical entities, handling mathematical symbols and formalisms, communicating in, with and about mathematics, and finally making use of aids and tools (Niss & Höjgaard-Jensen, 2002).

As Helenius (2006) points out, our Swedish 1994 curriculum can be traced to the idea of competencies and we argue that the similarity becomes even clearer.
in the 2011 curriculum. Furthermore, we agree with Helenius that one of the advantages of using competencies is that it makes it easier to describe the progression in the curricula. But at the same time we believe that it is difficult to describe mathematical progression by means of general and verbal competencies (in a similar way as in Bloom’s taxonomy) since mathematics has an “internal” progression *between* its different topics as well as *within* each topic. The former means that you for example need a certain amount of arithmetic before you can learn algebra, while the latter can mean that you must acquire basic algebraic skills before you can learn more complex algebraic structures such as “groups” or “rings”.

We will now turn our attention to an additional problem; how do we measure general and verbal competencies in mathematics? We will investigate this issue by considering examples from evaluation materials of Swedish national tests.

**Swedish national tests and their evaluation material**

National tests were introduced in Sweden in the 1960s. During the years the tests have been given in various subjects and various grades. Today there are national tests in mathematics in grades 3, 6, 9 and at upper secondary school level. The tests are divided into different parts, for instance, during the last couple of years the national test in mathematics for grade 9 has consisted of four parts (A-D). Part A examines the student’s ability to verbally express and follow mathematical reasoning and the ability to comment on other students’ explanations and arguments. Part B consists of tasks that should be solved without digital tools or given formulas. Part C consists of a more comprehensive task of investigative nature where the solution should be clearly described. Finally, part D consists of tasks belonging to a certain theme (National Agency for Education, 2013).

<table>
<thead>
<tr>
<th>National tests grade 9</th>
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</thead>
<tbody>
<tr>
<td><strong>1977</strong></td>
</tr>
<tr>
<td>Part B: Estimate calculation</td>
</tr>
<tr>
<td>Part C: Percent</td>
</tr>
<tr>
<td>Part D: Algebra</td>
</tr>
<tr>
<td>Part E: Geometry</td>
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</tbody>
</table>
It is interesting to compare the current national tests with national tests from the 1970s, 1980s and the beginning of the 1990s. For instance, in 1977 the national test in mathematics for grade 9 consisted of five different parts; numeric calculation, estimate calculation, percentage, algebra and geometry (National test in mathematics, grade 9, 1977). If we compare these five parts with the four different parts of today’s national test (mentioned above) there is an essential difference. In 1977 the different parts were classified on the basis of different topics of mathematics, meanwhile, today the classification is based on more general aspects such as verbal reasoning, access to tools, problem solving, investigation and different themes (see Figure 1).

Another difference between the national tests from the 1970’s, 1980’s and the beginning of the 1990’s compared with recent national tests is the evaluation material. For instance, in 1977 the evaluation material consisted of an answer key of 1-2 pages for each part of the test. Meanwhile, today there are around 20 pages of evaluation material for each part of the test, that is, around 100 pages for the whole test. Clearly, the amount of evaluation material has increased over time, and we believe that the main reason for this is the difficulty of measuring general and verbal, meta-mathematical abilities compared to numeracy skills. In fact, today’s national tests in mathematics are based on the general abilities from the 2011 mathematics curriculum (which were enumerated in our previous Section). In order to understand the complexity of evaluating today’s national tests let us consider the evaluation material to the test given in grade 9.

In Sweden the grading scale is A-F where A is the highest grade, E is the lowest passing grade and F stands for “failed”. In the students’ test paper for grade 9 the maximal score at each assignment is denoted on the basis of the different grades, for instance, an assignment with the notation (3/2/1) means that the maximal score is 6 where 1 point is at the E-level, 2 points at the C-level and 1 point at the A-level (observe that this notation always refers to the A-, C-, and E-levels). In the teachers’ evaluation material the points are not only connected to different grades, they are also connected to the different abilities (which were enumerated in the previous Section). Here the abilities are denoted C (Concept), PR (Procedure), P (Problem solving), M (Modelling), R (Reasoning) and K (Communication). In the evaluation material the notations $E_p$ and $A_R$ should be interpreted as one “problem solving point at E-level” and one “reasoning point at A-level” respectively.

In Figure 2 an example of an “evaluation table” for part A of the national test in mathematics for grade 9 is given. Part A is an oral exam carried out in groups of three to four students. The test consists of one assignment, in this case the problem deals with a water tank that is pumping out water and a graph that shows the change in water level over time. In Figure 2 the vertical axis consists of the abilities evaluated in this test; problem solving (P), concept (C), reasoning (R), and communication (K). On the horizontal axis the grades A, C and E are
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given. The maximal score of this assignment is 15 points distributed in the following way: a maximum of 3 points for problem solving ability (the upper row in Figure 2), 3 points for concept ability (the second row in Figure 2), 3+3 points for reasoning ability (rows three and four in Figure 2) and 3 points for ability to communicate (the bottom row in Figure 2).

<table>
<thead>
<tr>
<th>Problem solving and method (P)</th>
<th>Concepts (C)</th>
<th>Reasoning 1 (R)</th>
<th>Reasoning 2 (R)</th>
<th>Communication (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower E</td>
<td>Middle C</td>
<td>Higher A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reads the graph or draws simple conclusions (E_P)</td>
<td>Interprets the relationship between the variables and describes how the graph shows change over time (C_P)</td>
<td>Draws correct conclusions from the graph (A_P)</td>
<td></td>
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</tr>
<tr>
<td>Shows basic knowledge of the gradation of the axes in the diagram (E_C)</td>
<td>Expresses knowledge of how the inclination of the graph shows the change of the water level or that the structure of the graph is connected to the geometric form of the tank (C_C)</td>
<td>Reasons correctly about how the form of the tank or about the proportions between its parts or about the structure of the graph with respect to volume/ time (A_C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shows simple reasoning skills with respect to the graph or the gradation of the axes (E_R)</td>
<td>Reasons about the structure of the graph and its connection to the form of the tank (C_R)</td>
<td>Shows well developed reasoning skills with respect to the form of the tank or the proportions of its parts or about the structure of the graph in relation to volume/ time (A_R)</td>
<td>Takes part in the argumentation of other students and develops and expands their reasoning (A_R)</td>
<td></td>
</tr>
<tr>
<td>Contributes with a question or comment that to some extent advances the reasoning of other students (E_K)</td>
<td>Contributes with ideas and explanations that advance the reasoning of other students (C_K)</td>
<td>Expresses her/ himself with certainty and consistently uses the relevant and correct mathematical language (A_K)</td>
<td>Expresses her/ himself simply and the train of thought is easy to follow (E_K)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. Evaluation table for part A of the national test in mathematics, grade 9. (PRIM-gruppen).

Let us consider the reasoning ability in the evaluation table in Figure 2. In order to get one point at the E-level (that is \(E_R\)) the student must “contribute with a question or a comment” to the group’s discussion. To achieve the higher grades in the reasoning ability category, \(C_R\) and \(A_R\), the student must be able to “contribute with ideas and explanations that advance the reasoning of other students” and “develop and expand the reasoning of other students”. Note that the mathematical content is not mentioned, neither is the volume, graph or the velocity of the water. Clearly, within the “reasoning category” the focus is on verbal understanding rather than any numeracy skill.

The same tendency appears in other categories as well, for instance, in order to get the grade \(E_K\) within the “communication category” the student must be able to “express her/himself simply and the train of thought should be easy to
Moreover, to get the highest grade $A_k$ in the same category the student must be able to “express her/himself with certainty and consistently use the relevant and correct mathematical language”. That is, to get the highest grade in mathematics in grade 9 one must not only be able to use a correct mathematical language, one is also required to express this language with certainty. Consequently, a student who is shy or introvert may find it difficult to get the highest grade in mathematics, regardless of her/his ability to solve mathematical problems.

Final remarks

On the basis of our two examples we can conclude that in mathematics education in Sweden today it is not sufficient to give the correct solution to the mathematical problems – the students must also be able to reflect, discuss and evaluate their solutions, methods and results. This would not necessarily have to be problematic, but taking the evaluation material into account, it seems that the verbal, meta-mathematical abilities are emphasized at “the expense” of the numeracy skills. One could perhaps say, with Dewey, that in Sweden the logical aspect of mathematics has been separated from the psychological. A typical example of this is the structure of the evaluation material discussed above; the problem solving ability (which can be viewed as a logical aspect of mathematics) and the ability to communicate (which can be viewed as a psychological aspect of mathematics) are measured separately.

A potential risk of this separation is that the requirement of verbal ability becomes an obstacle for those having numeracy skills but a weak self-confidence or verbal ability. Another potential problem with a tendency that emphasises verbal, meta-mathematical abilities at “the expense” of numeracy skills is that our future teachers prefer to discuss mathematics rather than solving mathematical problems, since they have not practiced enough numeracy during their teacher training. If the teachers have been taught mathematics from a meta-perspective without first having learned to calculate properly, it will be difficult to manage the declining TIMSS- and PISA results in Sweden.

In this paper we have focused on mathematics education in Sweden, but one should have in mind that Sweden is not the only country where verbal, meta-mathematical knowledge have gained much greater importance in the curriculum compared to numeracy skills over the last 20 years. An interesting next step within our project would be to consider the curricula and TIMSS results in Sweden’s neighbouring countries Finland and Norway. The results of the latest TIMSS tests in Finland have been much better compared to Sweden’s results. However, they have recently (two years ago) implemented a new curriculum which effects we cannot draw any conclusions of yet. Moreover, Norway has improved their TIMSS results both in 2003 and 2011 (see Yang Hansen, Ed., 2014). An interesting future project would be to investigate the design of the
curricula in Finland and Norway with particular attention on verbal, meta-
mathematical abilities.

Just like Dewey, we think that the logical and psychological aspects of
mathematics go hand in hand: These two should not be separated in teaching or
in testing mathematical understanding. If you think of the psychological aspect
as freestanding and independent, you might very well think of the ability to
reason about and to discuss mathematics from an external perspective as the
important part, and the calculating, which can look mechanical, as unimportant.
But then you end up with students who don’t know how to solve mathematical
problems correctly, which has been shown to be the case with Swedish students
in international as well as historical comparisons. This prompts the question
whether they really have the needed mathematical understanding.

We can conclude that the progressive ideals of John Dewey are not to blame
for the declining mathematical skills of Swedish students. Rather, if understood
correctly, his views could provide us with the solution.

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