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ABSTRACT

Changes in mathematics instruction in vocational programs in Swedish upper secondary schools are intended to improve mathematics skills so students will perform better on national mathematics tests. Curriculum requires that all vocational students in Course A take 100 hours of mathematics instruction, but nearly 50% of them have been failing. Traditional mathematics instructors have been unable to link math concepts to vocational subjects to show students the relevance of mathematics skills, while vocational instructors who do not have mathematics backgrounds have been unable to teach compulsory mathematics satisfactorily. In the KAM Project, vocational and mathematics teachers worked together to integrate their expertise and develop mathematical models that were relevant and applicable to vocational students and that demonstrated the relevance of mathematics to their future careers. Results of a study in which one class was taught traditionally and another was taught with integrated methods suggest that the KAM Project will succeed in improving the success rate of vocational students on national mathematics tests. (Includes examples from a Swedish National Test Course A, 4 figures, and 5 references.) (MO)

The KAM-Project:
Structure of the Swedish Upper Secondary School

Lisbeth Lindberg
Göteborg University, Sweden

An Example

Leif Maerker
Bräcke Upper Secondary School, Sweden

Abstract

In Sweden vocational programs have been included in the upper secondary school since 1994. In these programs all students have to study mathematics approximately 100 hours. Nearly 50% of those students fail in the national mathematical tests in this course (Course A). That is after already 900 hours in the compulsory school system. The content for this session is from a development project funded by the Swedish National Agency for Education. Its main focus is on studying the relationship between mathematics and the vocational subjects. Part of this is to improve and develop mathematical models that are relevant and applicable. The outcomes stress changing the approach of learning and teaching and assessing with a focus on using integration while still keeping a door open to further education and to the more formal side of the subject. Since this project started the syllabus has changed in the same direction as this project, which of course is of great importance for our future work.

Structure of the Swedish Upper Secondary School

The Swedish upper-secondary school system is composed of national study programs consisting of different courses. The programs are of three years duration. Students can choose from sixteen national programs. Fourteen programs contain vocational subjects, and in these programs students spend at least fifteen weeks doing work experience at places of work outside school.

Mathematics Courses

Mathematics in upper secondary school consists of five units. The units are progressive, but can also be looked upon as a final course. Most pupils in the natural science program are taking all five courses. Course A has 100 points, Course B has 50 points, Course C has 50 points, Course D has 50 points, and Course E has 50 points. Course A is the lowest. Course A (100 hours), the only compulsory course in mathematics, is in most of the vocational programs.

About 65% of the mathematics lessons are the secondary school in course A, and half of them in the vocational programs. Course B is about 12%, course C about 13%, and course D and course E together about 12% (Grevholm, 1999).

The demands from society and the workplace are harder, and to meet some of those needs course A is compulsory in all programs. This means that it is the same content of Mathematics whichever program you study. Moreover, many students leaving year 9 do not have the mathematical knowledge that they are expected to have. But they might have a pass degree from the compulsory school. Mathematics in the compulsory school consists of 900 hours.

The Grading System

Grades in every course in the upper secondary school are awarded according to the following scale: Pass with special distinction (denoted by the letters MVG), Pass with distincion (VG), Pass (G), and Fail (IG).

New Curriculum, New Problems, New Opportunities

Currently a great number of the pupils who attended the vocational and trade stream at the upper secondary school failed mathematics and got the mark IG. Previously those pupils who had not achieved in mathematics or who were not motivated to learn it could choose not to study mathematics. However, this alternative does not exist according to the new curriculum, Lpf 94, as Course A in Mathematics is compulsory in all programs. For these pupils it is especially important that they are confronted with a kind of mathematics that starts on their own level, which in some cases may be a level corresponding to a year 5 level course. It is also important that the teaching of mathematics be given a new aim and direction so that it will be quite applicable in the vocational subjects and will support them in their vocational skills.

In England, problems with pupils in the preparatory vocational track of the upper secondary school are similar to the problems identified in Sweden (Steedman & Wolf, 1998).

In 1994 a new curriculum was introduced in Sweden, in fact two curricula, one for the first 9(10) years, i.e., Lpo 94, and Lpf 94 for the next 3 years. There is an emphasis on sharing and crossing borders in different areas.

> Development in professional life implies that you need to cross the borders between different areas of different professions, which is a big challenge for planning how to work at school. (Lpf 94)

In the vocational programs the learners are taught mathematics by an academically trained teacher and sometimes in the vocational course by an autodidact. This fact might be a problem. The mathematics teacher does not know what kind of mathematical content the student needs in the vocational course and the vocational teacher has very little and limited knowledge of mathematics and didactics of mathematics. The vocational teacher has never been trained to teach mathematics. (Mathematics is taught according to the content in course A.) The mathematics teacher does not know the content or very little of the vocational subjects and the vocational teacher does not help the learner to link the content that is taught/learned to the course where it could/would be applied.

Upper Secondary School for Everyone

Nearly 100% of the population between 16 and 19 years in Sweden is studying at the upper secondary school. Today all communities in Sweden are by law obliged to offer all students that have completed the compulsory school a place in the upper secondary school. The Swedish upper secondary school will give basic knowledge for professional and social life.

Below are examples of tasks from a national test for Course A. This is to give you an idea of the content and the demands for grade pass in course A. The test has three parts with different characteristics. The examples below are from part 1, a "numbers sense type test" with no help of a calculator and a time limit of 25 minutes. Only an answer is required.

Some Examples From a Swedish National Test Course A.

Write three hundredths in decimal form.

How much is the half of $\frac{1}{4}$?

Mia shall dilute cordial. How much squash will she gets if she follows the instruction on the bottle.

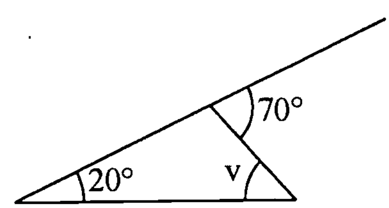
Which of the following expressions can be written as x^3 ?

$3x \qquad x \cdot x \cdot x \qquad \frac{x^6}{x^2} \qquad x + x + x \qquad x^2 + x$

Solve the equation $7(x-4) = 49$.

Calculate the value of $5 \cdot 10^4 + 2 \cdot 10^3 =$

How many degrees is angle v?



A hair is growing 0.4 mm per day.
How many days will it take for theto grow 1 cm?

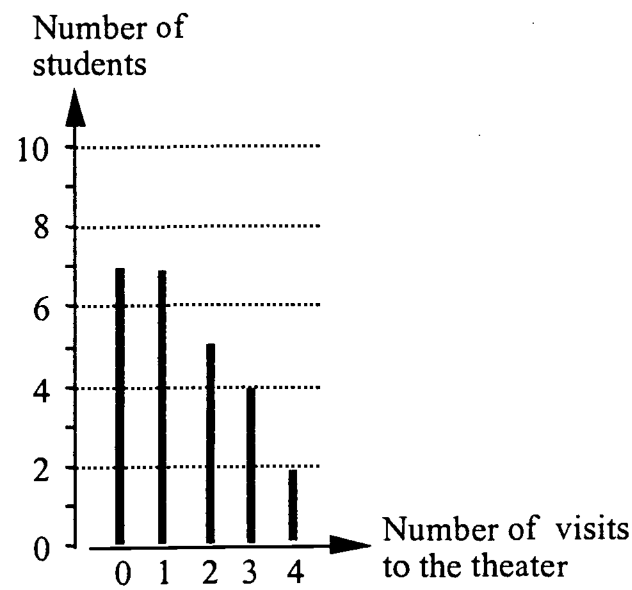
Which of following **calculations** give the highest result ?

$\frac{32}{1,8} \qquad \frac{32}{18} \qquad \frac{3,2}{1,8} \qquad \frac{3,2}{18}$

What's the value of 6 x + 8 y
if
3 x + 4y = 17 ?

A car drives 9 km in 10 minutes.
Calculate the average speed in km/h.

The diagram shows how many times the students in a class visit the theater during a month.

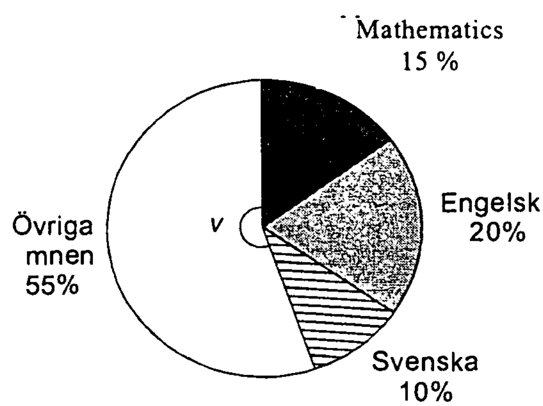


What is the median value for the number of visits to the theater?

Write the following parts in order.

4 ‰ 70 ppm 0,3 %

200 students



How many math students are there?

The KAM Project: An Example

Project Background

Too many of our students in vocational education fail in mathematics. As I started to teach mathematics in vocational education I joined the students in some of their vocational classes. Their vocational teacher complained to me about the students' low performance in basic calculations. The students' attitude can be summarized in the following lines from Hill:

> In the vocational subject even the parts that were theoretical they felt motivated most of the time. In the core subjects they said, a bit surprised, that they recognized most of it. The content, the methods and...the boredom. (translated from Hill, 1999)

Today nearly all Swedish students go to upper secondary school where course A in mathematics is compulsory, but many of the teachers are trained to teach in the old form where the task was to give all the students a more formal mathematics. Old traditions are still alive in a changing upper secondary school. Teachers are lacking support through in-service training.

Official statistics show that nearly 50% of the students in vocational education fail in the national test but half of these students get the "pass" mark anyway. In combination with other reports this can be seen as a trend which for the students is a dangerous development in the long run. Instead of changing teaching methods, some teachers produce their own criteria to give the grade "pass" to a course. As we will show later the students have the intellectual skills to really pass course A but they lack motivation. We know from experience that the teachers want to change their teaching due to their concern for their students, but they need help from in-service training and textbooks.

An Example: The Gearbox

The first foundation course that students in the Transport Program study is "Coach Work," a course studied by the students in the Vehicle Engineering Program. The following model was in one textbook (Brogård & Kristersson, 1989).

Gear ratio; $u = \dfrac{z_2 \cdot z_4}{z_1 \cdot z_3}$ where z_1 stands for the number of teeth on the gearwheel on shaft A in the gearbox and z_4 for the number of teeth on the gearwheel on shaft B (figure beneath); z_2 and z_3 stand for the number of teeth on the gearwheels on the common shaft.

The gearbox works like this: The wheel with 12 teeth (shaft A) drives the wheel with 48 teeth. And the 25-teeth wheel sits on the same shaft as the wheel with 20 teeth, which in turn drives the wheel with 40 teeth. This means that the number of revolutions of shaft B is less than the number of revolutions of shaft A.

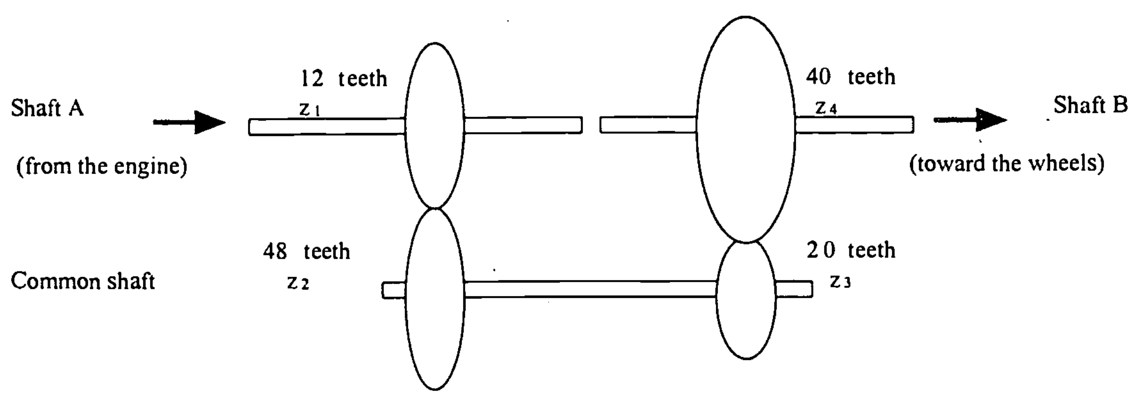


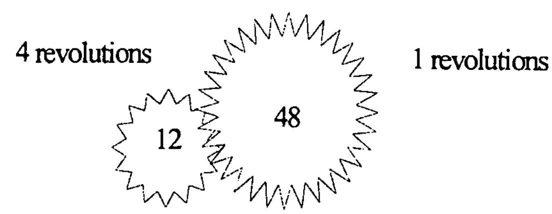
Figure 1

Fractions

From this formula we get a new formula, $u = \frac{n_1}{n_2}$ where n_1 and n_2 stand for the number of revolutions of shaft A and shaft B respectively.

Doing calculations using the formula above causes difficulties for most of our students. The students have difficulty understanding the formulas and calculations. Our problem is to help students meet the mathematical prerequisites of Course A, but on the other hand it is also to have them understand at the same time the function of the gearbox. The teacher has to coordinate instruction in these topics with instruction in topics such as multiplication and division of rational numbers in connection with percentages and scale. An important principle in our work is, in the first phase, to get rid of irrelevant mathematics from the gearbox model above.

We can look at the problem in two ways: either in terms of the number of teeth of the cogwheels that show changes in revolutions or in terms of the gear ratios. These are in fact inverses of each other.



$\frac{12}{48} \Leftrightarrow \frac{1}{4}$

Gear ratio = 4:1

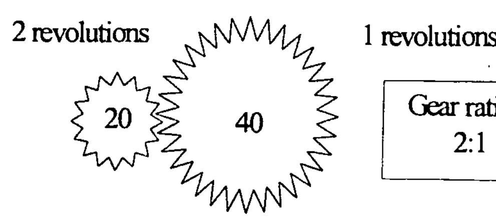


Figure 2

Gear ratio = 2:1

$\frac{20}{40} \Leftrightarrow \frac{1}{2}$

The pinion with the 12 cogs is engaged to the pinion with the 48 cogs. As the 12-cog wheel rotates one revolution the big pinion rotates ¼ revolution. The process is repeated once more. The number of revolutions from the engine shaft is reduced in the gearbox and the increase in momentum (gear ratio) is thus inverse to the increase.

Gear ratio = 4:1 & Gear ratio = 2:1

⇓

Gear ratio = 8:1

Four times and two times bigger
=
eight times bigger

The large 48-tooth wheel is on the same shaft as the 20-tooth wheel, hence we can combine the ratios to find the overall effect.

To understand the gearbox we think it is easier to first look at the number of teeth (the circumference) to understand what happens in the gearbox and then via exercises show that the ratio between revolutions (teeth) and the gear ratio (momentum) are inverses of each other.

For the vocational students we need to connect the function of the gearbox with the momentum and we will do this with the help of a balance. In the garage, as an application of this, you take a lever and the function of the moment keys and the bolt to show this.

To explain the role of the transmission of power and the relation of the power to the number of revolutions, in the garage they use a 10-speed bicycle that has been disassembled and set up for demonstration. At this demonstration station, there can be many activities to give the students concrete experience with power, revolutions, and moment. The students then proceed through a station where they work with starter motors, and finally to the gearbox station.

Results

After this the vocational teachers work with the mathematical material and the mathematics teachers work with vocational material. The different lessons are then joined together in an appropriate structure. Both the core teachers and the vocational teacher assess Joint tasks.

The project is running with just one class. This is because of timetable constraints and the teachers' opportunity to actively take part in the project. Thus we chose class A as the experiment group. In order to find the control group we tested all classes in ratio and percentages. We chose class T1A, which had almost the same result as the experiment group.

The two classes chosen were taught in mathematics as well as in the Vehicle/basic course. A teacher who had not actively taken part in the development of the model and the material taught the control group. The difference in the teaching was that the experimental group had more time studying the gearbox and had also specially designed teaching material for fractions and percentages. At this stage we were interested in looking at whether the students' knowledge and thinking about these sections of mathematics had changed, i.e., if we had any success in our teaching strategy.

Written Test

Results from the written test in Mathematics (max 32 points) are shown in the diagram below. The number of students in each class is written in brackets. Test 1 was a pre-test in Mathematics before teaching the concept of ratio. Test 2 was given the students after ratios had been taught. TS1C is the control group and G1A is the project group.

During the test the students were not constrained by time but no calculators were allowed. At the end of the school year both groups took the test again. We were also interested to see whether the quality of the thinking had been affected as a result of the special teaching. For that reason eight students were interviewed after both the initial and the final tests.

Most of the students in these programs have not been successful in understanding mathematics. Part of the reason for this is that the content has not seemed relevant to them. The thinking procedures they have constructed do not enable them to apply their mathematics. In order for the students to change their thinking modes, the prerequisite is that they recognize this problem. They need to be exposed to an intellectual conflict (Piaget). This will not happen if the teaching methods and contents are no different from the previous ones.

Results written test (max 32 p)

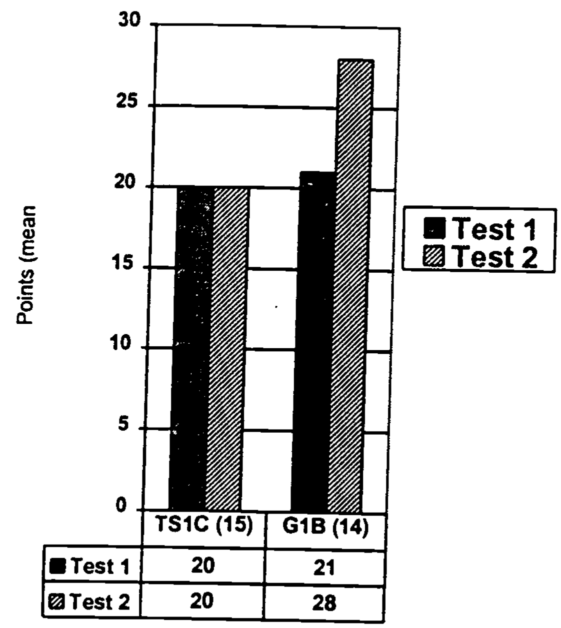


Figure 4

The control group has had traditional upper secondary teaching by another teacher who assumed that the students have the basic prerequisites in mathematics from the compulsory school. The traditional approach includes a lot of repetition and, since the prerequisites have not been questioned, it reinforces unproductive thinking modes. Through practical activity related to their future vocation the experimental group has been forced to question, giving them reason to change their former thinking modes. These new thinking modes are strengthened and deepened through the program in the mathematics class.

In the Swedish version of this report (Skolverket, 1999) all the answers to the questions given in the math test are analyzed, but as this is a concentrated version we know that many of the students in the test group have changed the thinking modes.

Attitudes

An important part of this project is to give the students a positive attitude toward mathematics. Data about experiences of mathematics and attitudes toward mathematics were collected through open questions in semi-structured interviews close to each of the two tests. This allows study of attitude change.

Some of the questions and responses by the students:

- What do you think of the subject of mathematics?
  "As boring, but it has become easier."
- Do you think that you need mathematics in the education here at this school?
  "No"
  This was the answer given by over half of the students prior to the gear ratio course and none afterwards.
- How do you think you will do in the mathematics course A?
  "I will fail the course."
  25% thought this before the course and none afterwards.

The students' self-confidence strengthened and they became more motivated in their study of mathematics because of the relevance of the subject.

Discussion

The teachers from both the mathematics and vocational teachers' education programs have gained from this project. Both groups also feel they have participated on equal terms with no inferiority involved. All have gained a broader perspective on their role as teachers.

For teachers who come from different traditions and, because of long experience, may be firmly set in their ways, negotiation for change and the changing of working methods is difficult.

For the mathematics teachers it is new to take some responsibility for the use of the mathematics they teach in the vocational subjects. The vocational teachers in the past have not had to think about the origin of the mathematics they teach. Often the mathematics used in the vocational subjects has been presented as isolated and rigid facts and formulas. In order for these two groups to work together productively the approach had to be open, allowing critique and questioning from both groups.

The evaluation of the project indicates that we are on the right track. However there are still many questions to be answered:

- Does the knowledge of vocational subjects also improve?
- Is there any linkage to other sections of the course?
- How do the students find this approach?
- Would students' outcomes be improved if the fraction content had been repeated after the gearbox work?
- Does this improve the students' long-term learning?

We hope to get resources to continue this project and to tackle these questions and others during the next years of this project.

Acknowledgments

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