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How to Teach Advanced Highly Motivated Students: Teaching Strategy of Iosif Yakovlevich Verebeichik

Olga Kosheleva and Vladik Kreinovich

Abstract The paper describes and explains the teaching strategy of Iosif Yakovlevich Verebeichik, a successful mathematics teacher at special mathematical high schools – schools for students interested in and skilled in mathematics. The resulting strategy seems counterintuitive and contrary to all the pedagogical advice. Our explanation is not complete: it worked well for this teacher, but others who tried to follow seemingly the same strategy did not succeed. How he made it work, how can others make it work – this is still not clear. In the words of Verebeichik himself, while mathematics itself is a science, teaching mathematics is an art, which cannot be reduced to a few recommendations.

1 Introduction

Who was Vereberichik. Iosif Yakovlevich Verebeichik was a teacher of mathematics in St. Petersburg, Russia, who taught in special *mathematical high schools* where a special emphasis was made on mathematics, most of the time in School No. 30, where one of the authors (VK) studied under his guidance. Among mathematics teachers from such schools, he was one of the most successful – his students regularly won prizes at local and national olympiads for high school students, and after graduation, were regularly accepted into highly competitive university programs; see, e.g., [1].

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Not only he was successful in teaching students mathematics, he also managed to make them feel good. Most of his students adored him – although not everybody. For most of his students, he was their favorite teacher.

What was the secret of his success? Many folks – his students, other teachers, journalists – often asked him the same question: what is the secret of his success as a teacher? How can other teachers become more successful? Vebereichik was willing to help others, he gladly allowed interested teachers to attend his classes – and many teachers benefited from this experience. However, he was not able to formulate what exactly he is doing differently.

In replies to such a question, he always emphasized that teaching is an art – just as it is difficult to explain why some music affects us and some does not, it is not easy to explain why some teaching ideas work better. As a result, in contrast to many other successful teachers, he did not leave a description of his teaching strategy.

But why? Now that many of his students became teachers themselves – in schools, in universities, etc. – our minds go back to Verebeichik's success. We all ask ourselves the same questions: What was his secret? How can we use his teaching techniques in our own teaching?

Why now? This year, we celebrated the 100th anniversary of Verebeichik's birth. Many of his students shared their memories about him. Naturally, the question of why was raised again and again.

We think we found some explanation – at least the explanation for some of the features of his teaching that we all remember. In this paper, we tried to provide this explanation.

This is a first attempt, maybe others can dig deeper and find other explanations of these and other features of his teaching – we would welcome that.

2 How mathematics (and other disciplines) is usually taught: a brief reminder

Why do we need this reminder. In order to understand what Verebeichik did, let us recall how mathematics (and other high school disciplines) is usually taught.

Classwork and homework. Most material is studied in class. Usually, for each topic:

- the teacher describes the main ideas,
- then the teacher shows, in detail, how to solve typical problems,
- after that, the teacher asks students to solve similar problems in class.

After that, other similar problems are assigned as homeworks. The amount of assigned homework is reasonable, so that students can maintain a healthy work-life balance.

There is usually a textbook that describes all this in detail. So, if something is not clear, students can always look into the textbook and clarify their understanding.

Tests and quizzes. To gauge the student knowledge, students take several tests and quizzes. Usually, the problems given on these tests and quizzes are similar to what the students saw in class and on the homeworks.

How homeworks, tests, and quizzes are graded. Usually, if a student worked reasonably hard, this student gets a perfect grade (A in the US system, which corresponds to 5 in the Russian grading system). Students who do not work as hard as required get corresponding lower grades.

Praise, praise, and praise. In accordance with pedagogical advice, students are always praised for what they have done, criticisms are limited to a necessary minimum and packaged in the most nice way – e.g., “sandwiched” better two positive statements.

3 What Verebeichik wanted and what he therefore did

Specifics of Verebeichik’s students. The above-described traditional approach to teaching works well for many students. However, the students in mathematical school are different from the average students: they clearly have better abilities to do mathematics. In their previous schools, they easily got As in math without making too much effort.

What Verebeichik wanted. The main objective of Verebeichik – and of other math teachers in the mathematical school – was to motivate the students to work harder, to unveil their full potential in math. Not all the students became professional mathematicians, but all the students learned much more in this high school than their friends in regular schools.

From the viewpoint of this objective, let us look again at how classes are usually taught, and let us analyze what needs to be changed to better motivate the students in mathematical school. Interestingly, we arrive at exactly the techniques that Verebeichik used.

Classwork. In a regular class, when explaining a new material, the teacher explains, in detail, how to solve several typical problems. To make students think harder, instead of explaining the solution to such a problem, a natural idea is to have students come up with a solution – Socratic way, with a series of hints.

Another trick is: once the main ideas are clear, instead of explaining all the details to the class, let the students themselves come up with these details on their own – as a result, practically no solution was explained in detail in class (but of course, a detailed solution is required on the homeworks!).

Homeworks. In a regular class, the amount of homework is reasonable, to maintain the work-life balance. Of course, for students who have special math abilities,

this “reasonable” amount is larger than for a general student. But how larger? All students in the class have higher math skills, but in this, they are not equal:

- some of them are future (or even past) winners of national olympiads,
- some are simply somewhat better in math than an average high school student.

If we set up the amount of homework based on the students who are somewhat better, then the best students would not reveal their full potential. No matter where we place the threshold, if there are students who can easily do this amount of homework, these students will not reveal their full potential.

A natural solution – which, without the above explanation, sounds very counter-intuitive – is to assign an *unreasonable* amount of homework, so that no student will be able to do all of it.

Do we need a textbook? Following a textbook makes studying easier. So, a way to make students work harder is to follow some unusual path to each topic, a path which is not reflected in any well-designed textbooks.

Tests and quizzes. In traditional pedagogy, tests and quizzes contain:

- a reasonably small number of problems, and
- these problems are similar to what was studied in class and what was done in the homework.

To make it more challenging, natural ideas are:

- to give a high number of problems, and
- to make sure that these problems are somewhat different from what was previously studied.

Comment. Of course, when we drastically increase the number of problems, the time needed for grading also increases – or, if it is an oral exam, the time for asking questions and listening for the answers also increases. For grading written exams and for asking questions on oral exams, students from a higher class (or alumni) who have already studied this topic are asked to help.

They help willingly, first, because they were similarly helped by other students, and two, because this way, they recall this material and learn it better.

How homeworks, tests, and quizzes are graded. In the usual teaching practice, a student who works reasonably hard gets an excellent (A) grade. Of course, in a mathematical school, where students’ abilities are higher, the threshold for A should be higher. But here we encounter the same problem as with determining the amount of homeworks to assign: whatever threshold we set, students who can easily solve that many problems on the text will not reveal their full potential.

A solution is the same as with homework: make this threshold unrealistically high, so that most (or even all) students will get at most B (which is 4 in the Russian system).

Comment. Of course, it is desirable not to ruin the students’ Grade Point Average (GPA) – which is important for admission to universities, etc. So, this tough grading

is only done in the beginning; after that, students already get in the habit of working hard.

Praise? In the traditional teaching practice, a teacher tries to praise the students as much as possible. One of the reasons for this is that praise provides an additional motivation for students – in addition to grades.

The problem with this is that once a student is praised for his/her achievement, this student is less motivated to do better. To avoid this slow-down, and to make sure that all the students work as hard as they can, praise is minimized, and criticisms become more bare.

4 Let us summarize

Summary. According to our analysis, the best strategy for a teacher in mathematical school is as follows:

- instead of explaining the topic, use Socratic method: give hints so that the students themselves come up with the ideas;
- for all examples, provide the main ideas, but never all the details;
- assign an unreasonably large amount of homeworks, so that no student will be able to do all of them;
- select a way of presenting each topic which is not described in detail in any textbook;
- on each test and quiz, assign many problems, and make sure that they are somewhat different from the types of the problems the students had earlier;
- grade the homeworks, tests, and quizzes in such a way that practically no one gets a perfect grade.

Are we serious? When formulated this way, what we have described is a monster teacher who violates all known pedagogical principles. Based on this description, students should hate this teacher, and the school principal should fire him/her on the spot. And still we loved Vereberichik – and, by the way, hated some teachers who tried to follow seemingly the same approach. Why?

The only answer we can give here is to repeat Vebereichik's statement that teaching is largely art: there was something in Vereberichik's personality that allowed us to accept his teaching style – while other teachers who lacked this “something” were not that successful. What is this “something” – maybe someone can find out.

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