Managerial Perspective to Mathematics Education Research

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Background. The public reputation of *Teaching Mathematics* is very bad. If there had ever been an enterprise named *Teaching Mathematics*, it would probably already have crashed and *Mathematics* would disappear from most schools like it was the case with the Latin language. Mathematics teachers and enthusiasts should therefore ask themselves: *Can we prevent Mathematics to become a follower of Latin?*

The authors see the usage of managerial terminology as a helpful one for clarifying the subject of our discussion. When people speak about "bad reputation of *Mathematics*", their criticism may address either science itself or its teaching in schools. In our opinion, only the latter is correct. Those who deal with Mathematics as professionals know about its importance. The critics are predominantly coming from people who have had only a limited contact with mathematics during their school education. Despite the fact that throughout their adult lives they have a little to do with it, their bad feelings and attitude persist. So, improving the perception of Mathematics in classrooms could substantially improve a population's life-long appreciation.

From a managerial point of view, *Mathematics* is in the position of the parent company; *Teaching Mathematics* is its daughter. The verification is quite obvious. If there would not be *Mathematics*, there would be no *Teaching Mathematics*. (If there would be no car producers, car dealers would not exist.) Usually, their interdependence is reciprocal. Car dealers cannot exist without car production, but car production becomes meaningless if no cars are sold. Similarly, there would be no mathematics education without mathematics but mathematics would face the extinction without (some form of) teaching it. Compare the situation with *Latin*. It is still taught at a limited scale sufficient for "keeping it alive". Similarly, Teaching Mathematics will unlikely fade away entirely but it might be limited to the level necessary for its survival.

For that reason, our questions do not address teaching "*Mathematics for enthusiasts*". In this form, it will survive anyway. What we do face is a danger of extinction of teaching "*Mathematics for others*". Our Latin (managerial) lesson says: "To prevent its disappearance, concentrate on creating demand. The higher public demand increases, the probability of extermination decreases." Here, we have to prioritize *Mathematics for others*. Success in this "market segment" is more important as this is the group of "potential troublemakers". If we win their endorsement, the danger vanishes.

The problem is that the group is specified by exclusion, it is not a homogenous body. Consequently, a single strategy will hardly work – the strategy described in our paper should be considered as an example and a call for alternative strategies. Their combination could lead to a better image of Mathematics education in eyes of public.

Aims and methods. In this contribution to trig discussion, we consider Teaching Mathematics as a (virtual) company and try finding answers to two subquestions: *What's wrong with Teaching Mathematics that makes its reputation so negative? What business principles can propose ways out?* We concentrate on methods which could improve the image of mathematics teaching among general audience. Instead of talking about internal problems of mathematics, we discuss the issue as a managerial problem. We use an analogy: *What has to be done if Teaching Mathematics would be an enterprise with a similarly bad reputation?* Based on the parallel, we propose long-term

solutions and later exemplify them. As shown, the most of them requires substantial changes in mathematicians' minds and in their approach to their teaching methodologies.

Results. We suggest taking the following measures to be involved in educational research:
(1) Each "market segment" has its own expectations. Thus, we should set up relevant priorities for different groups of pupils/students.
(2) As "the customer is always right", we should make Mathematics more "edible and digestible" for each segment i.e. closer to their environment and cultural values.
(3) Research in Mathematics Education should concentrate on specifying these particular needs and expectations and combine systematic planning with "minimalist" instruction.

Setting up Priorities

In order to maximize benefits for both mother and daughter and to minimize unnecessary overlapping between them, we ask: *Does Teaching Mathematics distinguish itself enough from its mother - Mathematics*? It helps us to form the "flesh and spirit" of the new body (bodies).
Tasks of this sort are solved during the strategic planning – the function each company must regularly execute every few years. So, even if Teaching Mathematics exists for centuries, its aims and methods should be revised and redesigned at regular intervals.
First, the target groups of *Mathematics for enthusiasts* and *Mathematics for others* radically differ. The former one is formed of professional mathematicians and active users of Mathematics (engineers, designers, physicists, biologists, and other specialists) who need new or improved methods for solving their problems. The latter one is aimed to general audience. When we want to demonstrate the usefulness of Mathematics to them, we can redefine the traditional method "Repeat what mathematicians do and you will (hopefully) start understanding Math". High skills in algebraic manipulations and geometric constructions are not the best way to understanding Mathematics to this target group. To attract them, we should simulate the work of mathematicians in a more realistic manner: formulating real-life problems, forming hypotheses about their solutions, making estimations and verifying their correctness. We should release students from drill as much as possible and give them opportunity to appreciate the core of mathematics in a very individual way whenever possible designed directly for them. Computer Algebra Systems and Dynamic Geometry can play an important role in this relief.

Making Mathematics More User-friendly, Edible and Digestible

In our Discussion Group we show a cavalcade of examples how to:
• show the human character of mathematicians, who also make mistakes sometimes,
• utilize modern progressive technology to visualize abstract objects and assign meaning to them,
• formulate the problems in order to raise pupils/students' interest in solving them,
• make imperfect calculations for our imperfect world,
• underline contradictions between naïve and formal solutions,
• provide realistic models, including non-linear ones,
• demonstrate a limited application of some models.
Our main aim is to invite students into "microworlds" in which they will understand the meaning of the problem and become interested in getting its solution. We see their curiosity as a crucial motivational factor.

Finding research-based pedagogical framework to combine systematic planning of self-determined learning environments within minimalist instruction

As said above, we see CAS and DG as one of potential carriers of such an approach. The focus has been shifted from a technology-oriented viewpoint to a humanistic view, stressing cognitive, affective and social variables involved in the learning process. Mathematics educators should be aware of the way citizens use technology in modern society and how this affects those variables. The second author's ClassPad project's findings indicate that there is a positive answer to the

question "*Can learning of Mathematics move from the classroom into leisure time?"* As a result, the role of the school needs a thorough re-consideration. There are many features of minimalism in our every-day life. They should be taken into account when designing and preparing teacher manuals and learning materials. The learners should not be overloaded by concepts, facts and rules. Often, allowing them to discover alternative methods and tools on their own is the best method not only for learning but also for growing their self-esteem. Their confidence in their ability to solve mathematical problems is needed for their better appreciation of the subject. This kind of learning paradigm means recalling heuristic strategies that have been successful throughout the centuries of human history. Their "heureka" moments may highlight their appreciation of mathematics for all years to come. This does not, however, exclude the application of more traditional systematic models that help the teachers and educators in planning, problem posing and assessment (see [14]).

Conclusions

The results of mathematical education in this present structure are quite sad. Even excellent students do not understand why mathematics is taught. Their picture of a "mathematician" is either "teacher of Mathematics" or "researcher solving mathematical problems". They can hardly imagine a mathematician helping to solve economical, medical or engineering problems because they have never been told that some mathematicians do that. As long as the public is not convinced about its usefulness, the picture of mathematics and of the role of mathematicians in society will remain distorted. Non-mathematicians will hardly invite mathematicians to participate in solving their problems' unless they believe that they can help them. Consequently, we are loosing plenty opportunities for mathematically-oriented jobs because top managers do not see reasons to invite mathematicians into their teams.

Mathematics is not here for the pleasure of mathematicians. Its elements were discovered and developed to solve practical problems around us. Contemporary advanced software tools are much better in performing calculations, formula manipulation and construction of geometric bodies than most people (including highly qualified specialists) are. If mathematicians are compared solely with them, Mathematics education will be removed from schools quite soon and follow the destiny of Latin. Whilst Latin was a vivid language (at least inside the community of highly educated individuals), it was also a flourishing school subject. Our lesson from its decline must be plain – *Mathematics* will continue as a general subject as long as people value it as a vivid, vital and no-nonsense subject.

For this reason, the change of its appreciation is a critically important "managerial" problem of *Teaching Mathematics*. We have to:

- Frequently demonstrate that mathematical problems relate to our daily life;
- Show alternative methods of solving the same problem and discuss their advantages and disadvantages – see for example [11];
- Stress that for common users it is more important to find one "sufficiently correct" solution than memorizing a variety of them;
- Train our learners to interpret their outcomes and to discuss to what degree they are in a good correspondence with their daily experience.

In the full presentation in DG 10, we will indicate several ways of doing so.

At the same time, such attempts cannot be isolated. We should be looking for a variety of alternative methods fitting to different "market segments". Attempts have already been made – see for example [12] – but there is no feeling of urgency which would wake up our community to act. We will have to make many experiments to understand which methods work and which do not. We should have the same pleasure from our experiments as our pupils. Mathematics is not always fun but often can – and could – be. It is not always fully understandable but our students should have a feeling that they understand a reasonable part of it. We should also do "marketing research" that will reflect their attitudes and level of comprehension [13]. *Teaching Mathematics* can learn a lot from managerial disciplines – and it should do it.

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