

# MAKING BRIDGE BETWEEN MATHEMATICS AND REAL LIFE IN MASS HIGHER EDUCATION

© Nárcisz KULCSÁR  
(Széchenyi István University, Győr, Hungary)

[szicran@gmail.com](mailto:szicran@gmail.com)

*Nowadays all over Europe higher education faces the problems of mass education which is a new research topic in education science. The rapid growth of participation has a strong impact on tertiary education from the nano (individual) level to the supra (international) level.*

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## The changes with mass higher education

*Martin Throw* (1973), American sociologist, distinguished three quite different aspects of growth. These generate various problems therefore different methods are required to solve them. First is the *rate of growth*. Transition to mass higher education shows international tendencies but the process in different countries, areas appeared other times and with different intensity. However everywhere more decades were needed to grow the rate in higher education. In Hungary this kind of growth appeared in three big periods. In the 40<sup>th</sup> years expert shortages in the key sector, industry, started up the process, students' number doubled in 10 years. After education reforms in the 60<sup>th</sup> it run up again but the most dynamical transformation happened after the socio-political and economic changes in 1990. This is proved by the fact the number of students in higher education quadrupled in 15 years (Polónyi & Tímár, 2001). This expansion stopped in the 2005/06 school year. Second growth appears in *absolute size* both of systems and individual institutions. Finally third, growth means the changes in the *proportion of the relevant age grade enrolled in institutions*. Higher education tried to react to these changes with new organizational methods, curriculums, pedagogical and andragogical methods. In this paper I concentrate on the first manifestation of growth and its impacts.

It is a well-known problem that numerous disciplines and the connected labour market suffer from the lack of experts despite mass higher education. In the field of engineering and natural sciences especially physics, chemistry and mathematics faces the biggest problems, interest of students turns away from these sciences. In engineering education in higher education mathematics is a basic course in which students do not like immerse deeply. One of the biggest problems in mass higher education in contrast with elite higher education the relationship between professor and student became

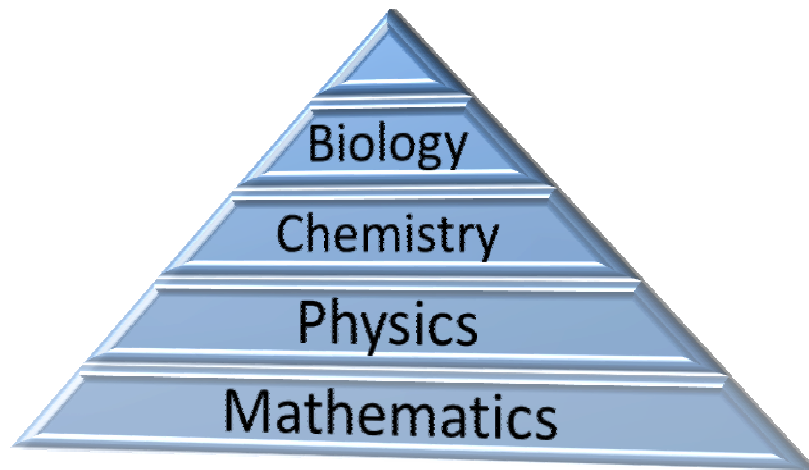
subordinated. New mediators appeared which can be technical devices, computers and internet. Although the number of students increased rapidly in higher education the number of teachers did not increase in parallel. In mass higher education it is not rare that more than 300 students study mathematics on lecture lesson at the same time and 70 students on practice lesson. Teachers struggle with this problem day by day and they think they do not have enough impact on students. Is there any way to recapture their interest in mathematics? A possible way could be teaching real-life problems which can complete traditional education.

### Advantages of real-life problems for engineers

Engineering students often criticize mathematics education because they think that they will not use higher mathematics in their profession later in real life. Occasionally some engineers confirm this dilemma because they do not use special mathematic knowledge in their daily work nevertheless some of them apply this knowledge day by day. University studies provide extensive knowledge in every area because later some students can use one part and other student another part of the acquired knowledge. While mathematics never changes (only new innovative methods appear) in other sciences knowledge can come obsolete after a time. That is why the basics of mathematics are the same in each university. After university studies some engineers complain they did not learn enough mathematics in the university so they have to develop their mathematics knowledge personally or they have to participate in costly trainings in their free time to solve some engineering problems without the help of mathematicians. In practice, all kind of knowledge that we gain in the university can not be used in real life in one job but we can not know in advance in which job we can use them. Acquire more knowledge ensure more flexibility on the labour market.

Teachers have great responsibility to present mathematics' application but not only general applications but also in the given field which is not easy at all. Applications can underline the importance of studying mathematics for all. Mathematics can not be taught separately from other subjects apart from other sciences. It can be supported by the science pyramid that Leon Lederman Nobel Laureate in Physics mentioned in one of his books. Science works in hierarchy which can be represented by a pyramid with mathematics on the base. Physics requires mathematics that is why it relies on the base of mathematics. Chemistry sits above physics using the results of mathematics and physics. Then comes biology which rests on these three former sciences. The rest of the pyramid can not be defined exactly (Lederman & Teresi, 2006). Based on Lederman theory mathematics can operate alone without the help of other sciences. Being as an applied science it is crucial in learning other natural sciences.

Figure 1. Science pyramid



Engineers use primarily physics to solve mechanical (static, dynamical), acoustical, vibration problems hence mathematics is the basic of their studies. If we mathematics teachers would like to present some real-life problems we need to find some problems in the area of physics in which higher mathematics supports the seemingly simple physical problems. Teachers often fall into the trap they develop students' algorithmic thinking but the heuristic thinking not. Through real-life problems not only algorithmic thinking but heuristic thinking can be improved as well which is more useful to solve technical problems.

### Problems with the implementation of real-life problems

We can see easily there are many advantages of showing real-life problems in education. Beyond the necessity of them, look at those circumstances and questions which make teaching them more complicated for mathematics teachers.

- Real-life problems are always word problems that students reject immediately.
- The hardest thing about solving word problems is understanding the problem and translating them into mathematics.
- Real-life problems in engineering are complex so many kinds of knowledge from different disciplines (mostly physics) are needed.
- Because of problems' complexity the solving process needs a lot of time.
- Mathematics lessons are in the first three semesters at the beginning of the university. Real-life engineering problems often need such kind of knowing from other subjects that students study in later semesters. That is why the best real-life problems are those which can be understood easily and do not need unknown rules and context.
- Due to mass education in mathematics lessons several types of engineers (mechanical, electrical, transport, civil engineer) learn together. What type of problems can be used in a mixed group that everybody can mostly understand?
- Whose responsibility is to show real-life problems to students? Teacher of a particular subject or mathematics teacher? Is mathematics teacher obliged to know physics in higher level than he

learnt in secondary school? Do mathematics teachers have adequate competences to present such kind of problems?

### Real-life problems in word problems in practice

Despite the difficulties I would like to share some examples that can be used in mathematics lessons. Before going in to details, we need to make it clear what kinds of word problems are distinguished.

Word problems can be classified in several ways.

- Determinative or proving (Pólya, 1985)
- Qualitative or quantitative
- To prepare for a concept or to use a concept
- Complete, incomplete or overdetermined
- Open ended or closed
- Theoretical or practical

I would like to discuss the theoretical and practical classes in more details. The former is drawn in the language of mathematics, it contains only mathematical concepts. The latter can be divided into three more subclasses based on the realism of the problems: fiction, lifelike and real-life problems.

See some examples that can be presented in mathematics lessons for different kind of engineer students.

- A military thread crossed over a bridge during keeping pace. The bridge collapsed. What happened?  
Mathematical topic: Differential equations  
Word problems' class: practical - real-life
- Determine the deflection ( $y$ ) of a given types of rail to the effect of wheel load ( $Q$ )!  
Determine the maximum bending moment ( $M$ ) in the rail!  
Determine the displacement ( $U$ ) of the elastic embedded rail ( $k$ ) during  $\Delta t$  temperature change!  
Mathematical topic: Differential equations  
Word problems' class: practical – real-life
- A piece of metal 10 centimetres by 24 centimetres is used to construct an open box. Squares of sides  $x$  are cut out of each corner to fold and make the box. What is the value of  $x$  that makes the box's volume maximum?  
Mathematical topic: Local extremes  
Word problems' class: practical - lifelike
- In an electronic circuit (in order:  $E$ ,  $r$ ,  $R$ ) the voltage ( $E$ ) and resistance ( $r$ ) are constant.  $R$  is the resistance of a load. The electric current ( $i$ ) is given by  $i = E/(r+R)$  and the power ( $P$ ) delivered to the load is given by  $P = Ri^2$ . Resistance and load are positive. What is the value of the load ( $R$ ) when the power delivered to the load is maximum?  
Mathematical topic: Local extremes  
Word problems' class: practical - lifelike
- Robin Hood shoots with bow on a round target which radius is 30 centimetres. What is the probability he shoots less than 1 centimetre far from the middle point?  
Mathematical topic: Geometric probability  
Word problems' class: fiction
- What is the maximum volume cylinder inscribed in a sphere with radius  $r$ ?

Mathematical topic: Local extremes  
Word problems' class: theoretical

### Summary

Mass education brought a lot of changes in higher education. Despite mass education the labour market looks for loads of well-trained engineers. As engineers solve real-life problems in their daily work their education should be practice-oriented full of real-life problems. It is undisputed fact that mathematics teachers have responsibility to make relations between an abstract science and real word and present some applications of their subject. Best applications are those problems which can connect mathematics and real-life. Sometimes it is not easy to find such kind of real-life problems that fits to the current student group and to the teacher as well. To find adequate problems teachers from different fields need to cooperate. To reach the goals with real-life problems teachers have to find the appropriate target group in suitable time.

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