Chapter 4.2

POSSIBILITIES FOR, AND OBSTACLES TO TEACHING APPLICATIONS AND MODELLING IN THE LOWER SECONDARY LEVELS

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Abstract: Reports on teaching applications and modelling in eight countries dealt with similar arguments regarding obstacles, each with a different emphasis. The following four obstacles are seem to be common across eight countries in which applications and modelling are located within the national curriculum; "Teachers' perceptions of mathematics", "Teachers' understanding of modelling", "A lack of adequate textbooks and curricular modelling tasks", "A lack of adequate assessment, and of modelling tasks in central examinations".

1. INTRODUCTION

Many issues emerge in the context of applications and modelling at the lower secondary level. For example, reasons for teaching applications and modelling; approaches to teaching applications and modeling; obstacles to teaching applications and modelling. Because of space restrictions, this document focuses on the issue of obstacles.

It seems there exist a variety of obstacles to teaching applications and modelling in different countries around the world. This document samples experiences within eight countries that exemplify general aspects of the issue of obstacles, and summarizes some general features of the reports from these countries.

2. EIGHT CASE STUDIES

Obstacles to teaching applications and modelling in the eight countries are described as follows.

2.1 Gabriele Kaiser (Germany)

Being able to apply mathematics competently is an accepted overall aim of German mathematics teaching. The question as to why applications and modelling examples do not gain the same importance in other domains as they have within didactic discussions, can be approached from various points of view:

(1) The system: Mathematics teaching is dominated by a subject-based understanding of theory, and this implies a partial and predominantly subject-based implicit didactic. The lesson structure follows the subject structure, which means, if put into concrete terms, that the lessons start from general concepts and phrases and then continue with general conclusions.

(2) The teacher: Empirical research has made it clear that the perceptions of mathematics, held by mathematics teachers, are dominated by an understanding of mathematics as a logical and consistent construction of thinking. The notions of usefulness and applications of mathematics play a minor role in the perceptions of mathematics and in the learning of mathematics as well.

(3) The student: Empirical studies have demonstrated that the mathematical beliefs of most students are dominated by an understanding of mathematics as an accumulation of knowledge. The higher the age-group, the lower the importance of application-based mathematical beliefs.

2.2 Hugh Burkhardt (England)

In England, everyone talks of the importance of being able to use mathematics. However, in most lower secondary school classroooms, few applications are actually taught, and there is no modelling.

Reasons for this include: (1) An inward-looking view of mathematics on the part of specialist mathematics teachers, focussing on the concepts and procedural skills of pure mathematics. Applications, where they exist, are mainly seen as concept reinforcement. (2) The political emphasis on 'basic skills' for weak students and schools. While the recent focus on "functional mathematics" may change this, it could again degenerate into just 'basic skills'. (3) The belief that you have to learn skills before you can apply them leads to indefinite postponement of work on solving non-routine problems of any kind. Change will be difficult because many teachers have no experience of the teaching skills needed, and regard non-routine problems as 'unfair'. (4) The 1989 National Curriculum for mathematics and its tests introduced a view of mathematics as a checklist of narrowly-defined skills. (5) 'High stakes' testing at ages 7, 11, 14, 16 and 18 affects the future of every teacher and student. It leads to teaching that focusses on those fragments of mathematical performance that are tested – you cannot do applications, let alone modelling, this way. (6) TIMSS has focussed on pure mathematics – this may be mitigated by PISA.

All of these factors reflect a traditional approach, nationally and internationally. Indeed, over the last 20 years, things have become worse, rather than better, in England.

2.3 Florence Mihaela Singer (Romania)

The most pre-eminent obstacle is the theoretical orientation of the teacher training pre-service and in-service programs. Their content is focused on a highly theoretical level of mathematics, with a very low emphasis on aspects connected with teaching methodology, and even lower on applications and modelling.

With regard to learning, there is a discontinuity at the transition from primary to lower secondary education. This discontinuity is generated, on the one hand, by different teaching expectations: the primary teachers teach a number of subjects, while the lower secondary teachers teach only mathematics. On the other hand, it is compromised by the dual system of initial teacher training: primary teachers are trained in colleges/high schools and are more pedagogically oriented than subject oriented; while the lower secondary teachers graduate at university level, with a very low emphasis on the psychological and sociological aspects of teaching and learning.

This discontinuity is also manifested at the level of curriculum interpretation. While the written curriculum recommends a progressive development following a unifying system of objectives, content, and learning activities, the teaching practice lags far behind this; due to insufficient training programs being provided to support the curriculum reform process.

2.4 Christine Suurtamm (Canada)

In Canada, although each province is responsible for its own educational system, there are many similarities in the mathematics curricula. Most provinces have a curriculum and curriculum resources that would support applications and modelling in the lower secondary level. Mathematics educators in Canada realize that students at this age level often need to see the relevance of mathematics and mathematical modelling helps them to make connections.

Teachers are encouraged to present students with a mathematical problem first and then to develop mathematical ideas through the process of problem solving. However, in practice, many teachers tend to use applications, modelling, and problem solving as examples of uses of mathematics once the mathematical concepts are taught. Some of the obstacles to full implementation of mathematical modelling are teachers' understandings of modelling, their view of mathematics, and their inexperience in doing mathematical modelling themselves. However, teachers are moving along the continuum as further professional development engages teachers in mathematical modelling activities.

2.5 Jarmila Novotná (Czech Republic)

The main reason for using applications and modelling in mathematics education in my country is always teaching mathematics, not teaching applications and modelling only. Two problematic issues are as follows.

Difficulties in choosing appropriate problems

Characteristics of problems suitable for applications and modelling at the lower secondary level include: (1) Minimal mathematical background required. (2) Tasks should stimulate both manual and intellectual activities. (3) Tasks need to provide for the modelling of situations either in reality or in the minds of the students. (4) Tasks should challenge students to create their own models or introduce new interesting situations to be solved.

Difficulties with the language appropriate for applications and modelling

There is still much work to be done to better understand the role of language in the theoretical-experimental domain of modelling for identifying epistemological obstacles. For example, relations between language and point of view, and between mathematical language and change of strategy.

2.6 Pauline Vos (Mozambique)

In Mozambique (as in many other countries, especially in lesser developed countries) applications and modelling are not perceived as an important part of the mathematics curriculum. The first obstacle is the existing curriculum, which has a strong enforcing role on what is taught in Mozambican mathematics education. Secondly, the national exams (at the end of grades 5, 7, 10, and 12) are an obstacle, as they do not contain any applications or modelling items. Another obstacle is the predominantly deductive approach used in mathematics education, whereby students are trained to memorize definitions and algorithms, resulting in little understanding, short-term retention, and low motivation. A further obstacle is the large number of un(der)qualified teachers. More than 80% of the mathematics teachers are un(der)qualified, and their insecurity makes them hold firmly to old routines.

From a political perspective, a general belief seems to be that if students know the definitions and can carry out the algorithms, they will be able to apply them. There are some thoughts on making the curriculum more practical, but few people have an idea as to what this means, and what the curriculum would consequently look like.

2.7 Koeno Gravemeijer (Netherlands)

Experiences in the Netherlands suggest that a lack of adequate teacher enhancement, textbooks, and assessment can be a serious obstacle, even if applications and modeling are mandated, and exemplary tasks are developed. Applications and – to some lesser extent – modelling were central traits of the curriculum reform of the early 1990's. However, the government did not facilitate much in-service teacher enhancement, and as a consequence, teachers seem to have developed a rather limited image of the innovation. The adage, 'learning mathematics by doing mathematics', seems to have been translated into, 'independently working on textbook problems'. In addition, the new textbooks were not innovative enough to alter this view. In such a setting, challenging problems interrupt the smooth flow of the lessons, so textbook authors started to make those tasks less demanding at the request of teachers. This eventually has resulted in textbooks full of contextual problems that are divided into a series of simple sub questions that in fact obscure the intended applications or modelling for the students. In addition, our conjecture is that the individual help that teachers offer tends to adjust to the expressed needs of the students, who ask for instrumental directions – a tendency that seems to be in tune with the instrumental character of customary forms of assessment.

2.8 Toshikazu Ikeda (Japan)

Most teachers use applications and modelling as examples of uses of mathematics once mathematical concepts have been taught. More process-oriented modelling tasks need to be developed, and mandated for implementation in classroom teaching.

In terms of practice, there seem to be three dominant obstacles. First is the influence of entrance examinations, in which modelling tasks hardly appear. The second is concerned with the development of modelling tasks and the use of technology – there are still too few modelling tasks that students really want to attempt to solve, and technology is not popular in Japan. The third is concerned with the belief and confidence of teachers. Modelling makes teaching more open and complex, and teachers have little experience in modelling. Further, principals of schools don't encourage teachers to undertake modelling in their classroom teaching, and therefore, teachers don't want to tackle modelling and applications.

3. SUMMARY

All of the eight reports raised similar issues regarding obstacles, with different emphases. Focussing on the treatment of obstacles to applications and modelling in mathematics curriculum, three situations can be identified. First is that applications and modelling are not perceived as an important part of the mathematics curriculum. For example in Mozambique, the following belief was expressed, "a general thought seems to be: if students know the definitions and can carry out the algorithms, they will be able to apply these."

Second is the opposite situation in which applications and modelling are (officially) a central attribute of a curriculum. Canada and the Netherlands (curriculum reform of the early 1990's) seem to belong to this category. However it is suggested that implementation falls somewhat short of the intention for a variety of reasons associated principally with teacher practices and priorities. Reports from other countries suggest a third (intermediate) category, in which applications and modelling are located in the national curriculum, but their role is not central. Within the latter two categories, the following four obstacles seem to be common.

1. Teachers' perceptions of mathematics. 2.Teachers' understanding of modelling. 3. A lack of adequate textbooks, and adequate modelling tasks. 4. A lack of adequate assessment methods, and modelling tasks suitable for central examinations.

The following suggestion from the Netherlands is especially meaningful. "Experiences in the Netherlands suggest that a lack of adequate teacher enhancement, textbooks, and assessment can be a serious obstacle, even if applications and modeling are mandated, and exemplary tasks are developed." Teacher education appears to be the central, and most commonly recognized, issue to address in the future.