

TWO-TIER EXAMS AS A WAY TO LET TECHNOLOGY IN

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Introduction

When talking to teachers about the use of technology, we generally encounter two groups. One group is made up of teachers who prefer to use the most powerful calculators, such as the TI-89/92, in the belief that students should focus on solving problems. The other group consists of the teachers who oppose the use of these calculators, because the scientific calculators “made our students lose most of their manual calculation skills” and the more powerful calculators are likely to cause students to have even more deficiencies.

Each of these groups represents an extreme position on the two main teaching goals we (should) have: *mental training & problem solving*. Every activity in mathematics teaching possesses both qualities in varying proportions, much like everything in the cosmos possesses the elementary qualities Yin and Yang.

Mental Training

I borrow an analogy from physical activities: Most people in the industrialized nations don't use their muscles any more to earn a living. But, unused muscles degenerate. Hence we do (physical) sports such as jogging and playing tennis or soccer so that we stay physically fit and healthy.

Due to a massive increase of (computer) automation over the past years, many of our intellectual skills are in jeopardy. In the past we needed to memorize phone numbers – today we use memory keys. In the past we had

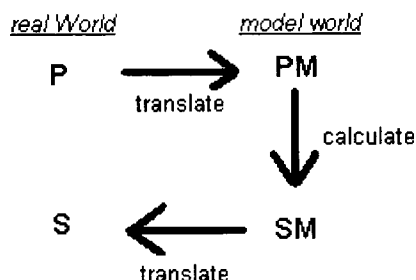
to memorize how to program a video recorder – today we swipe a bar code reader over the TV program. It goes without saying that all this makes life so much more comfortable, BUT it leads us to losing what I call *mental wellness and fitness*. Many school teachers complain about students' lack of concentration' and their weak memories. These are typical symptoms of a diminishing mental wellness.

Physicians use definitions of what a healthy person must be able to do physically. After a heart attack, for example, a patient must learn to walk a certain distance and to climb a certain number stairs before being released to home care. We need something similar for our mental capabilities, i.e. a definition of what a person who has a healthy mind must be able to do in terms of, for example, memorization and mental calculation. (An attempt to give such a definition for mathematics teaching is [Herget et al 2000].)

We introduced *sports* into our schools in order to fight a further deterioration of physical fitness. We need to take similar steps regarding our mental capabilities; we need a subject *mental sports* (or *mental training*) in our schools. I believe that this subject should be part of mathematics teaching.

Problem solving

In mathematics I consider problem solving to be the ability to use mathematical tools for solving real world technical problems. Characteristic of problem solving are the three steps shown in the following graphic



Today, problem solving is treated at school only half-heartedly. The main emphasis is put on the second step, calculation, and its execution with paper and pencil. We treat at most three optimization problems in an hour using 80% of the time for (hand) calculations and only 20% for modeling and translating. Hence, most problem solving exercises turn into exercises for practicing calculation skills. Since translation rarely is taught explicitly, it is understandable that a majority of students don't develop this ability. Hence, they are afraid of exercises requiring the translation to and from the real world. With the use of technology for the calculation step, we can dedicate time to teach the choice of models and how to translate results. We may be able to treat ten or more optimization problems in an hour spending 80% of the time on modeling and translation and only 20% on calculations.

Mathematics = Mental Training + Problem Solving Training

Curricula should aim at educating students in the disciplines of *mental training* and *problem solving*. The goals of mental training are the building of a healthy and fit mind and a preparation for problem solving. It goes without saying that at most technology should be a training tool ("mathematical home trainer") and must not be used when testing mental abilities. The goal of problem solving is the ability to use the appropriate tools for solving problems. The use of technology should be welcomed here.

Employing an analogy, problem solving compares with a moving problem, such as "tomorrow noon I need to be in London". It is unimportant what transportation means I use to get there, it only matters that I be there at the given time. Mental training is comparable to a jogger who runs along a track in order to gain physical fitness. Only the jogging counts, it is unimportant where the track is or where it leads to. Transferred to mathematics this means the following: In problem solving only the

appropriate result counts, it is irrelevant how the calculations were performed. In intellectual sports only performing the calculation counts, while the result is unimportant.

Balance

The magic word is *balance*. Good mathematics teaching includes both qualities in a well-balanced manner. Since assessment is an important pedagogical instrument, it must reflect this balance also.

A logical solution is a two-tiered exam: When assessing mental fitness, no tools are allowed. This includes even a simple four-function calculator. When assessing problem-solving capabilities, all tools are allowed (better: solicited). This includes graphing and algebraic calculators. If the split is not manageable within a single exam, one should assess the two disciplines at different times. I draw a parallel with ice skating: Mental training compares with the compulsory exercise, in which the athlete demonstrates a mastery of the basic required techniques. Problem solving compares with the voluntary exercise (freestyle), in which the athlete demonstrates the ability to combine the basic techniques into choreographed presentation. The total score depends on the scores of both the compulsory and the voluntary part.

Concluding remarks

Two-tiered exams would be a well-balanced compromise meeting both the desires of technology supporters and the reservations of those who are concerned about the use of technology in the classroom. Hence, they are a way to let technology in.

References

- Herget W, Heugl H, Kutzler B, Lehmann E, 2000: Indispensable Manual Calculation Skills in a CAS Environment, (in this book)