PS7-C-Symp

Poster Symposium:
TIMSS and consequences drawn in Australia, Austria and Germany

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Discussant: Svein Sjøberg, University of Oslo, Norway

Contributions.

Peter Fensham, Monash University, Melbourne, Australia

What do the findings of TIMSS mean - science-wise and educationally?

Helmuth Kühnelt and Helga Stadler, University of Vienna, Austria

Assessing an assessment: Lessons from TIMSS/Pop3 in Austria

Gerhard Schaefer, University of Hamburg, Germany

Ways of reasoning in science education - a comparative German/Japanese study in view of TIMSS

Manfred Prenzel, IPN, Kiel, Germany

Increasing the efficiency of mathematics and science instruction: Report of a national quality program

Manfred Lehrke and Manfred Prenzel, IPN Kiel

A video study about differences in teaching and learning in science classes

On the intentions of the symposium.

The results of TIMSS, the Third International Mathematics and Science Study, have enjoyed much attention all over the world since they are available to the public. There is certainly no other study on results of science instruction that was so hotly debated so far. As Germany did not well (or to say it more cautious: not as well as expected) the reactions among those responsible for science instruction was overwhelmingly strong and controversial. Similar reactions occurred in other countries - especially when these did not so well.

The contributions of the symposium provide stimulation for discussion on the significance of the TIMSS results and on the best way to react to these results. Two contributions discuss TIMSS results in countries that did differently well, namely in Australia and Austria. Another contribution presents a study that compares students in Germany and Japan. The results show that Japanese students who did well in TIMSS (as compared to German students) show weaknesses in particular kinds of tasks. The last two contributions provide information on reactions in Germany. On the one hand a large project of developing science and mathematics instruction in school was started, on the other hand studies will be carried out to compare science instruction as taught in Germany with science instruction in other countries.

The contributors of the symposium agreed to chose the format of a poster symposium to allow much time for discussion of TIMSS and the consequences in general.

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What do the findings of TIMSS mean - science-wise and educationally?

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Abstract.

The initial findings of the Third International Mathematics and Science Study (TIMSS) have now been reported. More than 40 countries took part in one or more of its three school population studies - 9 year olds, 13 year olds and all students in the final year of secondary schooling. A very great deal of contextual and learning achievement data were collected. The findings reported so far are the direct analyses of these data. TIMSS encouraged countries to undertake complementary and subsequent studies that may add to their understanding of the findings as internationally reported. This paper describes three such studies in Australia that set out to gain insight into the meaning of the TIMSS findings, science-wise and educationally.

The publication in 1996 (Population 2), 1997 (Population 1) and 1998 (Population 3) of national and international reports of the initial analyses of the data from the Third International Mathematics and Science Study (TIMSS) has, as is inevitable, been selectively read as a series of "league tables" that rank the students in the participating countries on mathematics and science learning achievement. The very extensive contextual data about school systems, curriculum, teachers and students that was also reported has been hardly noticed, and their significance will have to wait until the more elaborate analyses are reported of how the contextual conditions in the TIMSS overall model influence these learnings.

The reporters of the achievement league tables have been careful to qualify the statistical meaning of the relative scores. Thus, the science achievements of the 13 year olds (Population 2) for the 41 countries were indicated in the Australian report in three blocks *-four countries with significantly higher achievements than the Australians, - fifteen countries, including Australia, with* not *significantly different achievements, — twenty two countries with significantly lower achievements.*

There are, however, another set of questions to ask about these testings and the analysis of the students' responses in them. These questions are about the meanings - science-wise and educationally - that can be attached to these TIMSS research findings. For example, we know that where test scores in science are, as in TIMSS, primarily derived from students' responses to multiple choice items there is a need to attend to distractor choices that are unusually popular because they unanticipated interpretation may have been ascribed to the item's wording. This particular issue of meaning was not acknowledged by the TIMSS project team, but it did recognise that its minority of short answer and free response items may need recognition beyond "correctness", and a two digit scoring system was devised and used for these items - one digit indicating correctness, and the other, the type of answer or explanation.

Investigation A Comparative Analyses of the 9 year old (Population 1).

Findings.

Comparison 1

TIMSS	Local indicators
very high achievements in four states	poor quality in science learning
and above average in several others	general low standard of science teaching

Conclusion *The learnings being measured in TIMSS may not be primarily science ones.*

Comparison 2

	TIMSS tests	Two other contemporary tests	
multiple choice,	66%	28%	96%
short answer and free response		72%	4%

Conclusion *The science learnings emphasised are a matter of an authority's choice.*

***Comparison* 3**

TIMSS	One local test
Allows for five categories of performance response, and Australian students above science international average in all five	80% of items in two categories
36% require specific science knowledge 64% can be answered by reasoning	60% require recall of specific knowledge, 40% by reasoning

Conclusion *Australian students are willing to try to answer by reasoning/ metacognitive strategies, despite lack of specific knowledge of an item's science content.*

Investigation B: Interviews re Metacognitive Awareness of TIMSS Testing (Population 3).

Students were interviewed individually immediately on completing the TIMSS test booklet

Findings.

General inability to identify the science topic of which an item is an example. Correctness of response to multiple choice items no guarantee of meaning of the science.

Relevance of most school science beyond school not clear.

Affective response to items and topics restricted to "easy" and "difficult".

"Guessing" as the means of answering multiple choice items was in practice a range of strategies for using the alternative responses to answer the question. Preference for multiple choice items but awareness they did not test science understanding like free response ones did. More open school science could lead to improved affective and cognitive learning.

Investigation C Analysis of "Incorrectness" in Free Response Items (Population 3).

6 items were analysed, some of which had as almost 50% "incorrect" responses.

Findings.

In each case, a number of the "incorrect" responses had good grounds to be marked "correct".

In one case that included a diagram the question was What is wrong with the Figure? And there is a basis for suggesting that many of the "incorrect" responses should have been scored as "correct" and that some of these may indeed be the only "correct" response to the item as posed.

The items presented in an everyday context tended to evoke non-scientific but interesting responses.

Even within such a few items what was expected as an adequate "explanation" was so varied that it became clear the notion of "explanation" as central to the nature of science is quite confused, and confusing in school science education, even at its highest levels.

Comment.

Relatively simple additional studies of the science items and of the rich pool of data about them that TIMSS has provided for each participating country can add very considerably to what the crude rankings in the scaled score, "league tables" of achievement mean in terms of students' perceptions of science and of being participants in an educational measurement exercise.

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Assessing an Assessment: Lessons from TIMSS/Pop3 in Austria

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Abstract.

TIMSS was for the Austrian educational system the first external assessment of students' achievements in mathematics and science in an internatational context. This paper reports an in-depth study of the rather poor achievements of Austrian students at the pop3 (end of secondary education) level. In response to the TIMSS results the project IMST (Innovations in Mathematics and Science Teaching) was initiated by researchers in mathematics and science education and has been supported by the Austrian Ministry of Education. It aims at analysing:

- the validity of TIMSS in an Austrian context. A comparison between the curriculum underlying TIMSS and the intended curriculum in Austria as performed by teachers and by researchers,
- the strengths and weaknesses of pupils with respect to their achievements in Science Literacy and in Specialist Science,
- ways to use items from TIMSS for self-evaluation of schools and to develop a culture of assessment for educational improvement,
- other countries' measures to improve the quality of science education,
- favorable and unfavorable factors in Austrian science education in school,
- and at proposing changes with high expectations for improvement of achievement in science education.

Attention is also given to the comparatively even weaker achievement of females and to reasons specific to the kind of assessement and to teaching science in Austria. We find rather strong disagreement between teachers and researchers in science education about the quality of test items with respect to content and formulation as some of the first results of the study. We raise also critique concerning the understanding of fundamental physics concepts as it is exhibited in test items and sample answers. The statistical procedures preclude a detailed comparison of different branches of the system of higher education.

Synopsis.

Whereas satisfactory achievements in the Third Mathematics and Science Study (TIMSS), i.e. a ranking amongst the top quarter of participating nations, had been reported for Austrian pupils in populations 1 and 2, respectively, publication of the achievement of population 3 brought an unpleasant revelation to the educational authorities and the public, because the achievements were very weak (Mullis & Martin, 1998). Up to now, external evaluation has been an idea foreign to Austrian schools. Presently and in the past a rather detailed curriculum has been considered sufficient to insure quality of the outcomes of mathematics and science instruction as well as public trust in teachers' efforts to reach the aims of the national curriculum. There are still no entrance examinations at Austrian universities, instead a positive result of the final examination ("matura") opens the doors to nearly all branches of tertiary education.

With nations' increasing competition for inducing global players in industry to invest and to produce in their respective countries indicators for quality of the educational system are often thought to help in such decision processes. Also, the government policy of giving more responsibility to schools - not only in financial terms but also in defining their goals of education - adds to the trend for increased evaluation, especially external evaluation. An in-depth critique of such trends as opposed to an organic development of science education, especially a comparison between the aims and outcomes of the TIMS study with the OECD study "Changing the Subject: Innovations in Science, Mathematics and Technology Education" (Black & Atkin 1996) has been given recently by Atkin and Black (1997). Therefore, participation in TIMSS has brought to light a conflict between different cultures of assessment. Of course, one of the main questions raised immediately in Austria has been how our pupils can deal with a form of assessment which they are not really used to. An other explanation by teachers and administrators of unfavorable results points out different aims in science education as expressed by the Austrian curriculum and by the curriculum underlying TIMSS. A further unwelcome result of TIMSS highlights gender differences in achievement which are especially pronounced in Middle Europe. They need a deeper investigation.

Planning, realization and first statistical analysis had been done with intense cooperation with the Austrian Center for Educational Achievement at Salzburg University, i.e. researchers in general education with a strong interest in quantitative assessment studies, schools and the school authorities, but without contact to researchers in science education. No detailed analysis has been published so far to complement e.g. the descriptive analysis of TIMSS in Germany (Baumert & Lehmann, 1997; Baumert, Bos, & Watermann, 1998).

The research project IMST (Innovations in Mathematics and Science Teaching) has been triggered by the results of TIMSS, especially of population 3 (end of secondary education), and is performed by a team of researchers in mathematics and science education supported by teachers active in pre- and in-service teacher education in close cooperation with the Austrian Center for Educational Achievement and utilizing the wealth of original data available. The paper will deal only with the science part (science literacy and advanced physics) of TIMSS and of IMST and concentrate mostly on population 3 with occasional reference to achievements, research questions, etc. for population 2 (age 13-14 years) where appropriate. The paper will concentrate on the research questions which play major roles in IMST, among them are:

- To what extent is the Austrian curriculum covered by TIMSS items with respect to content, required knowledge, skills and understanding?
- What is the quality of items with respect to understandibility, to correctness in scientific terms, relevance to everyday life or to science education?
- Pupils' conceptions as they become apparent in their responses. An interesting comparison becomes possible through the published tables of item responses by country.
- Which level of abstract reasoning is achieved by students at the end of

secondary education? There is the wealth of data concerning those non-specialists who participated only in the science literacy test.

- How do pupils deal with situations when they do not know the "right" answer? Can they utilize common sense to answer multiple choice questions?
- Does the performance of girls in TIMSS reflect their performance in school science? Why are gender differences especially high in Austria (as a part of Middle Europe)?
- What is the teachers' view of TIMSS and of the problems uncovered by it? How do they view legal regulations as playing a big role in science education?
- The public opinion holds that schools outside large cities are more efficient. To what extent can such a prejudice be tested in TIMSS? Is the data base sufficient to make statements differentiating types of schools or regions in Austria?

The importance to understand the research questions above is underlined by the fact that the OECD-PISA study will be forthcoming already in year 2000. The paper will raise the question whether a paper and pencil test can at all inform about a branch of science which claims to draw its inspirations from observation, careful experimentation and model/theory building. We will also argue that - as far as TIMSS is concerned - students' understanding of fundamental concepts is marginal (and very often not to be distinguishable from pure guessing; s. Rühting, 1998) even in countries whose specialists score high in tasks related to "problem solving". Furthermore, an analysis from a physicist's point of view reveals surprising deficencies in test item formulations and in sample answers (for an example see Mullis, Martin 1998, p. 215).

References.

Atkin J.M. & Black P.(1997). Policy Perils of International Comparisons. *Phi Delta Kappan* (September 1997), 22-28.

Baumert J., Bos W., & Watermann R. (1998). TIMSS/III: Schülerleistungen in Mathematik und den Naturwissenschaften am Ende der Sekundarstufe II im internationalen Vergleich, Zusammenfassung deskriptiver Ergebnisse (unpubl.).

Baumert J. & Lehmann R. et al. (1997). *TIMSS: Mathematisch-Naturwissenschaftlicher Unterricht im internationalen Vergleich - Deskriptive Befunde.* Berlin: Max-Planck-Institut.

Black P. & Atkin J.P. (1996). *Changing the Subject: Innovations in Science, Mathematics and Technology Education.* London and Paris: Routhledge and OECD.

Hagemeister V. (1998). Was wurde von TIMSS erhoben? [What did TIMSS measure?], submitted to *Die Deutsche Schule*

Mullis I.V.S. & Martin M.O. et al. (1998). *Mathematics and Science Achievement in the Final Year of Secondary School (TIMSS).* Chestnut Hill, MA: Boston College

Rüthing G.A. (1998). Analyse der TIMSS Physik-Items aus fachlicher und fachdidaktischer Sicht [Analysis of TIMSS items from a physics and an educational point of view]. !. Staasexamensarbeit für das höhere Lehramt [Master thesis]. Kiel: IPN.

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Ways of Thinking in Science Education - a Comparative German/Japanese Study in View of TIMSS

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Abstract. In the TIMS study, German and American students showed poor results in science and mathematics, as compared with East Asian students. A parallel, independent investigation with German and Japanese students in the age of 17 to 19, however, revealed some opposite results with respect to a deeper understanding of basic scientific concepts like Chemistry, Information and Environment. Using 5 different methods of concept research, and adding the results gained with Me(Ego) as a fourth concept, it was possible to discover striking differences in ways of thinking between German and Japanese students. They will be interpreted as a possibly better disposition of German upper grade students for creative scientific work, i.e. for scientific literacy on the process side.

Topic of research. Parallel to, and independent of TIMSS, a comparative German/Japanese investigation was carried out by a group of 4 German and 4 Japanese researchers on geographically different samples of upper grade students (totals of 6oo to 800 students in each country). The group analyzed polarities of thinking in the classroom and checked commonalities as well as differences in the way how German and Japanese students treated 4 selected concepts of global importance: Chemistry, Information, Environment, and Me (Ego). These concepts were chosen because their scientific meaning and designation are almost alike in Germany and Japan, and thus no special semantic problems had to be expected in word tests. Furthermore, among these four concepts there are two pairs being in some kind of polarity relation (Chemistry/ Information, Environment/Me), and their test results can be used to complement and control each other. The hypothesis prevailing in previous TIMSS discussions is that Japanese students, due to a more classical way of teaching, yield better results in memorizing facts, rules and methods of problem-solving than, for instance, German students who are being educated in a more open (possibly too open) way of teaching. Thus criticism is repeatedly expressed in the German educational system that there were too little repetition (accumulation) on one side, and practical application to everyday problems on the other in German schools. In general, TIMSS discussions so far centre mainly around methods of storage and application of knowledge. The hypothesis underlying this study is that Japanese students are used to a more exclusive, stereotype and static, German students, however, to a more inclusive, variable and dynamic way of thinking, and that these differences influence considerably the way how knowledge is stored and actualized. The hypothesis was born by multiple-choice tasks on the concepts of Chemistry and Information (which can be regarded as basic concepts of science): they were solved, contrary to the expectations drawn from TIMSS, much bet ter by German students than Japanese.

Design and procedure. In the study 5 different polarities of thinking were examined: exclusive/inclusive, static/ dynamic, linear/ complex, stereotype/variable, and materialistic/structuralistic thinking. The approach is basing on a general theory of a polarity of life (Schaefer 1987, 1992, 1998) which describes life as a continuous balancing process between several contradicting needs, and thinking, regarded as a product of evolution, as the same balancing process on a cognitive, neuronal level. According to this theory thinking, as long as it is life-like and life-promoting, has to move between order and chaos, opening and closing, variation and unification, syntactic and semantic view, and all the others of about 11 polarities. Other theories of thinking are included in this synoptic approach (e.g.de Bono, Dör- ner, Guilford, Piaget,). 5 test instruments were used to study ways of thinking in the classroom: multiple-choice tests (MC), semantic differentials (SD), aspectizing tests (AT), free definitions (FD), and free association tests (FA). The partly simultaneous use and comparative evaluation of these tests allowed a fairly objective judgment of test results. The substrate of thinking used for testing were the above mentioned four concepts (chemistry / information, environment /me). Although all tests used here throw light upon the way of thinking about the four concepts, and of thinking in general, a precise, quantitative analysis of thinking polarities has been based on the MC data alone. For this purpose all MC items were valued, and weighted, in view of the 5 polarities mentioned above. The weighted scores were added over all items and expressed as percentage of the maximal possible sum. So the relativated numbers were comparable. In the end, the concept-bound results were integrated to one concept-transceding number which may, in first approximation, represent a general way of thinking in the population under study.

Results. Results obtained with MC tests on Chemistry and Information show that the general picture drawn by the TIMS study has, at least partly, to be modified: In the understanding of such basic concepts of science the investigated Japanese students were weaker than the corresponding German students. Apart from a general low interest expressed for chemistry in both countries, the interest is clearly lowest in Japan. And the rating of right answers is also lowest, and of wrong answers highest in this country. Furthermore, German students seem to differentiate better in matters of chemistry acting on health, whereas the Japanese tend more to simplifications. Also the body/mind interactions through chemical substances apparently caused problems of understanding for the Japanese students, but not so for the Germans. While this positive result of German boys and girls could possibly be explained with the fact that Germany is a traditional chemistry nation since 200 years and Japan obviously a modern information nation leading in information technology, the MC results on the concept of Information contradict this explanation: Also this MC revealed a lot of uncertainty about the concept in both nations, and - surprising enough - again the German students achieved better results than the Japanese when reflecting Information in the context of matter, structure, order, meaning, news, entropy, conservation law, etc. The concepts of Environment and Me do not reveal such clear differences because they are highly complex concepts, and the students in both nations reacted with much uncertainty. However, some items showed again a stronger disposition for rational differentiation and the courage to separate phenomena in German students than in Japanese. The latter tended to a more undifferentiated, tentative, perhaps modest reaction. Slight, but interesting differences could also be observed between the concepts (chemistry dropped out of the general trend to a surprising extent), and between genders, types of school, and East and West Germany. However, neglecting these sub-variances here the quan-tifying analysis of MC data in toto demonstrated that the German students apparently have a greater capacity than the Japanese for the following ways of thinking:

- *variability thinking* (even the opposite pole, stereotype thinking, seems better developed. But variable thinking dominates by far in German students).
- *complexity thinking* (in both countries complex thinking dominates over linear thinking, but in Germany differences are much greater).
- *dynamic thinking* (change vs. constancy; in both countries clearly concept-bound, e.g. chemistry less, information stronger dynamic; in the average, predominance of dynamic over static thinking in both countries, German students on top).
- *inclusive thinking* (open borders vs. closed borders, open-minded vs. closed-minded; with the exception of chemistry again, in both countries inclusive dominates over exclusive thinking, German students leading in either variant).
- *substrate thinking* (substrate vs.structure, content vs. form, materialistic vs. structuralistic; German students, gender-independent, more substrate-oriented, except for information. In Japan remarkable gender effect: girls more structure-oriented, boys more substrate-oriented; in toto slight predominance of the latter. Another striking difference between the countries: Chemistry notion in Germany strongly materialistic, in Japan more structuralistic).

The MC analysis is well confirmed by SD and FD tests. These, and also all associative tests used in this study (FA, AT), proved that apparently there are national differences in the way of thinking between German and Japanese students which manifest themselves considerably in science-relevant concepts in such a way that - contrary to the TIMSS results - the general capacity for scientific work possibly has to be seen greater in German students than in Japanese.

In particular, a comparison of free associations (FA) and free definitions (FD) exposes a fact which may be regarded as significant for future research in science and technology in the two countries: Free reactions to given key-words, including Me (Ego), demonstrate a striking homogeneity in the Japanese and inhomogeneity in the German population. Homogeneity in education may be good for solving standard tasks of science and mathematics (see TIMSS), but may be bad for the development of creativity which is a pre-condition of research and future progress.

General interest. The question is raised in pedagogical discussions today which kind of knowledge will be needed for a general scientific literacy of the citizens in the coming century. A triangle of scientific literacy has to be discussed stretching out between three extreme (and each one certainly wrong) positions: purely knowledge-centred, purely process-centred, and purely humanities-centred approaches. Although the TIMSS inquiry, according to the presently existing curricula in the world, moved correctly between the knowledge and the process positions, it has to be carefully reflected on the basis of the present study, whether the existing curricula are suited for 2000+.

References.

Schaefer,G. (1987). Twelve Principles of Life as a Basis for a Positive Concept of Health. In Kelly,P.J. & Lewis,J.L.(ed.), *Education and Health*. Pergamon, Oxford etc., 19-26.

Schaefer,G. (1992). A Theory of Human Needs on the Basis of Universal Principles of Life. In Schaefer,G.(ed.), *Basic Human Needs*. Peter Lang, Frankfurt etc., 15-29

Schaefer,G. (1998) *Balanceakt Gesundheit* [Health a delicate balance]. Wiss.Buchges. Darmstadt

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Increasing the efficiency of mathematics and science instruction: Report on a national quality development program

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Abstract.

As a reaction to the insufficient results of German students in the TIMS studies a nation-wide program to increase the efficiency of mathematics and science teaching started in the autumn of 1998. The goal of the program is to stimulate, promote and scientifically guide processes ensuring quality and optimizing teaching and learning in mathematics and science in an interstate network of schools. The conception of the program is based on an expertise worked out by a national group of science and mathematics educators on the one hand and educational psychologists on the other hand. The science part of the program is directed by the Institute for Science Education in Kiel. 30 pilot schools, connected with another 150 network schools, will work on selected modules which concern key problem areas in mathematics and science teaching as identified by the expertise. The paper reports on means being used to co-ordinate and stabilize quality development in the pilot and network schools involved. The accompanying research concept for this program is also presented.

Expertise on key problem areas in German science and mathematics education.

German students did not do well in the TIMS studies. Their results in science and mathematics were just mediocre. What was even more worrying, however, was the fact that relatively large numbers of German students had problems solving the more demanding tasks, especially those requiring conceptual understanding. The heterogenity of achievement is unusually high. From a longitudinal point of view there are relatively limited increases in competency in the course of compulsory education in Germany. These results clearly indicate that science and mathematics education in Germany is far less successful than expected and necessary to guarantee a minimum of scientific and mathematic literacy. The deficiencies of German students have been hotly debated not only among the educational specialists and those responsible for science and mathematics education in the ministries of education but also by the broader public. The ground then was prepared for actions to increase the quality of science and mathematics instruction in Germany.

An expertise was developed by a group of experts directed by Jürgen Baumert (Max-Planck-Institute for Educational Studies in Berlin) who identified and described the following main problem areas in mathematics and science teaching in Germany: The science content taught at different grade levels is only loosely connected, and there are only rather limited connections between the different school subjects. Typical for German lessons is the following very limited interplay of teachers' questions and students' answers. Usually, the teacher directs the students' answers towards one single correct answer. In this way emphasis is given to routines and short-term retrieval achievement. The limited cumulative instruction in mathematics and the sciences hinders students in experiencing growth in competency and disturbs the development of subject-oriented learning motivation and interest. The systematic introduction of scientific work and argumentation patterns as well as the consequent use of the potential offered by scientific experiments are further issues that are seldom given sufficient attention. The main problem areas identified by the expert group were summarized in the following eleven modules:

(1) Further development of the task culture in science education.

(2) Towards more adequate views of scientific work and experiments.

(3) Learning from mistakes - Towards admitting that mistakes are not just impediments of learning.

(4) Towards securing basic knowledge - meaningful learning at different levels.

(5) Making students aware of their increase of competence - cumulative learning.

(6) Making students aware of the limited view of a particular science subject - towards integrative features in biology, chemistry and physics instruction.

(7) Promoting girls and boys - towards gender equity in science teaching.

(8) Towards co-operative learning in science.

(9) Strengthening students' responsibility for their learning.

(10) Assessment: Measuring and feedback of progress of competencies.

(11) Quality development within and across schools.

The program to increase the efficiency of science and mathematics instruction.

A large program funded by "Bund-Länder-Kommission" (an interstate commission to improve education in Germany) started in autumn 1998 to address key limitations of science and mathematics education as elaborated by the above expert group. The set of eleven modules has provided the framework for the work in 30 pilot schools and the network of another 150 schools connected to the pilot schools. Working groups focus on a certain selection of modules, i.e., they work on means to address the deficiencies identified. The project is school based. Input to support the teachers' work is provided by the institutions responsible for the project. The IPN serves as co-ordinator for science education, the "Staatsinstitut für Schulpädagogik und Bildungsforschung" (The Bavarian institute for teacher education and curriculum development) in Munich in co-operation with the mathematics educator Prof. Dr. Peter Baptist (University of Bayreuth) co-ordinates the work in mathematics education. The input provided includes seminars to introduce teachers the philosophy of the program and to make them familiar with the above modules and papers summarizing major findings of research concerning the particular modules as well as ideas to improve the situation. These materials are available to all participants of the program on an internet server.

Co-operation among teachers is a fundamental principle of work in the program. The teachers have to document their work plans and the goals achieved to make the information available to their co-operation partners. The teaching ideas developed are tested in the individual schools and school networks and evaluated by the teachers. In order to allow for compensation for the considerable amount of extra work, the teachers involved give fewer lessons. The work in the schools is co-ordinated and supported locally, regionally and supra regionally.

The program aims at a long-term, a continuous, and - finally - a professional process of optimizing mathematics and science education using stimulation and support by providing the actual state of research on teaching and learning. This process may be described as a cycle of the following three stages which will usually be closely linked:

Stage 1: Identification and description of a problem

Stage 2: Generation of solutions

Stage 3: Setting solutions into practice, evaluation of the effects

Research about implementation and evaluation.

The processes and conditions of professional reflection and quality development are the focal points of research on the impact of the program. The documentations, evaluations and co-operation reports at the school level serve as the data basis. These are supplemented by targeted and theory guided questionnaires, interviews and observations. Research on implementation and evaluation will be closely linked to other research programs, as, for instance, studies within the OECD/PISA program and a large program funded by the German Science Foundation on improving learning science and mathematics.

A video study about differences in teaching and learning in science classes

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Abstract.

One component of the Third International Mathematics and Science Study (TIMSS) was the Videotape Classroom Study carried out in 8th grade mathematics classes in Germany, Japan, and the USA. Based on this study we learned about fundamental differences in teaching patterns in the countries involved.

This part of TIMSS plays a major role when dealing with the results of the study in Germany. Thus it demonstrates the potential benefits of a videotape study. On the other hand it shows certain limitations with respect to its explanatory power, and the question is left open to what extent the findings from the math classes are valid for science classes as well. For that reasons we are planning a similar comparative study in science classes combining data from observations and from questionnaires. It is theoretically more ambitious and it is hoped to gain greater practical relevance as well.

We are planning a comparative video study about science education in Germany and at least in one more European country. Switzerland is among others one of the countries which seem to be especially appropriate for comparisons with respect to what is known about features of its science classes (Moser et al., 1997). The goal is to identify different qualities of learning in the classroom that are influenced by teaching patterns.

On the one hand, the study is supposed to tie into the videotape study run in connection with the "Third International Mathematics and Science Study (TIMSS)" (Stigler et al., 1998); yet on the other hand, it is markedly to go beyond it with regard to the theoretical orientation (e.g. Reusser, Reusser-Weyeneth, 1994; Schommer, 1993). The TIMSS Videotape Study is currently playing a main role in the discussion about interpreting the TIMSS results (Baumert et al., 1997). The reason for this is that it allows the identification of typical patterns ("scripts") of mathematics lessons in various countries - without categorizing them as "good" or "bad" lessons. These patterns are obviously connected to varying, divergent conceptions of learning and teaching (epistemological believes) within a school or teaching culture. As it is known, similar differences are to be expected to a certain extent also in different school types and in different regions within Germany.

In the planned study, the quality of learning is mainly defined by the extent to which the teacher succeeds in motivating and leading as many students as possible to actively come to terms with the subject being taught and to goal-oriented mental activities directed towards understanding. Thus, the question is how does the teacher make the individual students become active learners. This goal implies that the teacher's attention is directed towards the individual learning processes and towards the heterogenity within the classroom with regard to learning pre-requisites. One of the main research questions in this study is, therefore, whether and how the teacher acquires the information about his/her students' learning processes that he/she requires to guide, test, and support these processes. Categories for analyzing the teaching and learning behavior to be observed will be taken from recent developments in cognitive educational psychology and will include features like metacognition, motivation, and self-directedness. (Although such teaching and learning processes necessarily occur within the subjects and with concrete teaching contents - the only way possible -, they simultaneously aim at cross-curricular competencies.)

We assume that a number of behavior patterns that guide or indicate the mental activities in the classroom can be recorded by observation. This may also include behavior that occurs sub-consiously. On the other hand, the observations allow only limited interpretation when they are not supplemented by additionally acquired information (from students and teachers) by questionnaires, interviews, and other sources. The TIMS Videotape Study shows deficiencies in this area. Neither are we sure to what extent the results of the studies about mathematics education can be applied to teaching in the natural sciences, the area we are especially interested in.

A crucial requirement for effective analysis of video material is digitalization and the use of special, only recently developed software. With that aid our intent is to combine data from different sources and perspectives: from teachers as well as students, teacher judgements on own lessons and on lessons of others, intended and realized behavior.

Single lessons are not the object of the study, but rather two to three period units showing different phases of learning. One of the criteria for inclusion in the study is the topic being taught. Lessons in at least two science subjects (physics and biology) are to be analyzed and compared in the course of the project.

As a result of TIMSS and from other sources we have clues about which countries would be especially interesting to compare with regard to the research questions already described. The good results in TIMSS were not the only reason for dealing with a country like e. g. Switzerland. Knowing where the relative strengths and weaknesses lie, what the priorities are in teaching, which conceptions teachers and students have in connection with teaching and learning are almost more important. Switzerland evidently sets different priorities than Germany does as we know from curricula, current syllabus work and teacher questionings. What is completely unclear is how these points and ideas are realized in actual teaching, in actual teacher actions.

One of the advantages of video data is that they can be analyzed according to various aspects again and again. (Necessary is of course, as mentioned above, a special technical support by digitalized pictures and appropriate software.) It is conceivable and it could be economic, therefore, to include several research questions, maybe also quite limited ones, in the planned videostudy and work at them simultaneously. It would, however, then be necessary to think of the additionally required information (from teachers and students) in time.

The project is divided into two descriptive/explanative phases (video analyses in two subjects) and a prescriptive phase (theory guided use of the video material in teacher in-service training).

References.

Baumert, J., Lehmann, R., Lehrke, M., Schmitz, B., Clausen, M., Hosenfeld, I., Köller, O. & Neubrand, J. (1997). TIMSS – Mathematisch naturwissenschaftlicher Unterricht im internationalen Vergleich. Deskriptive Befunde. Opladen: Leske+Budrich.

Moser, U., Ramseier, E., Keller, C. & Huber, M. (1997). Schule auf dem Prüfstand. Eine Evaluation der Sekundarstufe I auf der Grundlage der „Third International Mathematics and Science Study". Zürich: Rüegger.

Reusser, K., Reusser-Weyeneth, M. (1994). Verstehen als psychologischer Prozess und als didaktische Aufgabe. In K. Reusser & M. Reusser-Weyeneth (Hrsg.), Verstehen. Bern: Huber.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. Journal of Educational Psychology, 85, 406-411.

Stigler, J.W., Gonzales, P., Kawanaka, T., Knoll, S. & Serrano, A. (1998). Methods and findings of the TIMSS Videotape Classroom Study. Washington, DC: U.S. Government Printing Office.