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TWO LEVELS OF SEQUENCING IN GERM LEARNING: COURSE AND TASK LEVELS

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Abstract
A university course of practicals has been redesigned with the aid of fundamental principles we call germ learning. Models for knowledge construction guide the sequence of learning. The objective of the course is to learn a generality concerning the way new knowledge (including skills) is constructed and validated. The generality is introduced in a domain of prior knowledge, practised in a new domain and applied in another domain (transfer). In each domain new skills (measurements, calculations) are constructed, elements of which are provided. The results and the learning processes of good, moderate and weak students have been evaluated. It turns out that weak students fail in the last domain in which transfer is required.

Introduction to the problem
The models we use for knowledge construction in germ learning include a concept model, a development model and a validation model. From these models a sequence of learning has been derived on two levels. On a global level (the course as a whole) the sequence of learning to acquire and validate knowledge can be designated to consist of three parts: introduction (orientation), development (practise, integration), application (transfer). On a session level the students have moreover to construct new measurements and calculations. On this level we distinguish: homework (theory, lab-guides and assessment questions), preparatory tasks, (confronting) measurement tasks, open ended problems. Our question was what kind of influence this sequencing has on results and learning processes.

Theoretical framework
Germ learning (Vos, 1991) combines the ideas of Ausubel about a true advance organizer with those of Davydov (1968) about a genetic germ. A germ of learning in our sense is a cognitive structure, part of the student's mind, that has to be found and developed by the student. Teaching with the aid of models helps to accentuate this cognitive structure. The level of thinking is raised by special tasks to reconcile contradictions inherent in the models. Specification of different problem situations helps to differentiate problem solving actions for constructing

the missing conceptual knowledge. Integration of actions is aimed at by the requirement of validated knowledge and by open (ill structured) problem solving tasks.

Method

The experiment consisted of a redesign of a university course of practicals implemented in 1986/87. This course consists of nine sessions of 3.5 hours, partitioned in three parts of three sessions each: Introductory measurements, time domain, frequency domain. In the introductory part students learn how to measure, how to calculate and how to validate knowledge in a domain of prior knowledge. In the time domain the students practise what they have learned. Finally in the frequency domain the students apply what they have learned to a new domain.
The content and objectives of the course remained unchanged. In the first session, in which an entrance test and remedial exercises were introduced, prior knowledge is needed. This prior knowledge is summarized in a short description and pictural representation of the functions of the apparatus. A reading task and a confronting task in handling the measuring apparatus have to be fulfilled.
The tasks of sessions two to six have been analyzed and more clearly separated according to function. Homework tasks intend to teach the students to acquire and assess information they need. This information involves knowledge about concepts and skills, as well as knowledge about the validation of knowledge. We inform the students that measurements and calculations have to "fit" and we provide them with a "method of inquiry" containing about 50 action elements grouped into the headings: problem analysis, acquiring information, selecting a hypothesis, experimental validation, conclusions, reporting.
Preparatory tasks teach the student to construct new skills (constructions, measurements, calculations) for the determination of a quantity. Measuring tasks intend to compare measurements and calculations of a given quantity, and to validate the outcome. These tasks are the main objective of the course. Open investigation tasks leave the students the choice for the quantity to be determined, as well as for the method to be used. These tasks enable the students to practise above the final level required.
The tasks in the last part (sessions seven to nine) remained the same in order to monitor transfer.
During the sessions the students learn to make logbooks: they have to write down what they think, what they do (calculations and measurements, handling apparatus) and what comes out of it (their results). These logbooks are assessed by the teaching-assistants after every third session of the course. The logbook of each part is marked. Final marks are mainly based on the last two logbooks.
In 1990/91 an intensive evaluation of our course was carried out, including a comparison with earlier data. The years before 1987 provided quantitative data with respect to the marks of the students, and qualitative data with respect to the instruction and learning process. In order to get quantitative data concerning the learning process questionnaires were used after each session in 1990/91 to evaluate homework and laboratory activities of the students. The teaching-assistants used scoring-lists along with their own assessment lists. The scoring can be considered a content-analysis of the written work of the students. We did observations to check our data.

Our study can be considered as a time-series-design. The situation before and after the implementation were compared. The students were divided into three groups (good, moderate, weak) and the data for these groups analyzed. In order to check how these students behave in other courses, we analyzed correlations and factors in the marks for the first years courses.

Results

Overall failure rates dropped from 52 % to 21 % (average of the four years before 1987 and after 1987 respectively). Marks are rather independent of the assistant grading the logbooks. Marks correlate better with marks in other courses than before. The time used for homework did not increase. Student interaction is large, both in the old and in the new situation. Student interaction is effective in most groups in the new situation. About half of the students fails just as previously in one group with rather few good students. Students get remarkably less assistance in the new situation.

Scores rise from the first to the second logbook, and are generally lower for the third one. No complaints about the handling of apparatus have been found in the new situation. Students find it difficult to use the "method of inquiry". In the unchanged last part of the course some students are still complaining as before that they have to apply new not yet fully treated concepts in the laboratory, but most of them now are able to fulfil their tasks.

The marks for the logbooks show that good students perform usually best. With respect to measuring tasks they show a rise in performance in the second part and a decrease in the third one. Moderate students get nearly level with the good ones, starting at a lower level. They also show a decrease in the last part with respect to measuring skills, but are steadily improving their performance on study skills. The weak students fail in the last part, although their second logbook scored higher than the first one. Good and moderate students show better performance in selecting the difficult, relevant homework questions and they use much more time for these questions. Good students ask more often short help of the teaching assistants, weak students least.

Observations gave supplementary results only.

Conclusions

Prior knowledge needed has been activated satisfactorily in the first session, and has been upgraded. This is considered to be development and integration of a germ after partial knowledge has been acquired.

The results of the students improved satisfactorily. In groups with strong interaction it is probably of importance that the group contains not too few good students.

Tasks showed more variation and included more difficult ones. Therefore mastery learning cannot be the explanation of our results.

Most students have learned to acquire by themselves the information needed in the unchanged last part of the course, in which transfer to a new domain is needed. They have also learned to compare results of measurements with results of calculations. Therefore it is concluded that on the global level, most students have learned how to acquire and validate knowledge (to apply the required knowledge construction).

Weak students fail in the last part of the course. Weak students have learned something in the first and second part. The conclusion is that our course selects on transfer. This is considered an indication that a germ has been accentuated and developed by most students.
Most students pass the course. Thus students learn more than before, more students learn it and in less time. Our education has shifted from remedial teaching (reparation of lacking skills afterwards) to preventive teaching (giving students the opportunity to prepare themselves effectively and efficient).

Discussion

The teaching-assistants give during the sessions minimal help (in the new situation). Superficially viewed we would say, as students and staff do, that assistants should take more initiative for help. A better conclusion is that the behaviour of the assistants contributes to learning to acquire information. This seems to be a confrontation in instructional design itself. The conclusion is probably valid only when the information provided is complete and interaction in the group is strong. In groups with too few students it is suggested to strengthen the group with some good students after a short entrance test.
Observations turn out not to be a good instrument for our purposes. Turning knobs (each apparatus has about 20 rotational knobs or switches) probably requires "turning-aloud-protocols" in order to study this cognitive-motoric skills. Observations gave qualitative data with respect to the interaction of the students as a group.
Effect of the models has not been proved directly. The models help to design confronting tasks and tasks of a greater variety, to sequence the learning process on two levels, and, last but not least, to better understand the educational implications of the objectives of their own course.

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