SUMMARY

SECONDARY EDUCATION AND THE ART OF PROBLEM SOLVING IN MANAGEMENT ACCOUNTING

The purpose of this study is to investigate the kind of difficulties pupils in secondary education encounter in problem solving in Management Accounting. The study consists of two parts. The first is about the 'knowledge base' required to solve accounting problems. The second concerns the mental representations pupils develop of the knowledge offered. The main focus was on conceptual and mental models as defined by Norman (1983). Conceptual models are accurate descriptions of objects or procedures. Mental models are interpretations of the conceptual models. As pupils' mental models cannot be measured directly, the conceptualizations of these mental models are described as 'mental representations'. In this study, an analysis is made of three different conceptual models to compute net profit over a given period which are presented one after the other in a certain Dutch textbook. Next the results are presented of an empirical research into the general and specific mental representations developed by some 155 pupils while computing net profit.

The *knowledge base* is described in terms of Cognitive Psychology. Anderson's distinction between declarative and procedural knowledge (1985) is taken as starting point and adapted in the same way as T. de Jong (1986) and Ferguson-Hessler (1989) did for problem solving in physics. This implies that strategic knowledge is recognized as a third type of knowledge. Declarative knowledge, procedural knowledge and strategic knowledge are required to proceed through the stages of problem solving. The stages recognized are:
- orientation on the problem situation,
- analysis of the problem structure,
- planning of the solution,
- calculation of the answer.

Declarative knowledge in Management Accounting consists of rules, concepts and formulas. One category of concept is 'quantity'. A quantity consists of a name, a value and a dimension indicating the units in which the quantity is measured. Quantities are related to one another and can be organized in conceptual models describing accounting procedures. Conceptual models can be represented in diagrams. Different types of companies and different situations result in different conceptual models. A further distinction can be made between approaches such as absorption costing, direct costing and micro-economics.
Horngren & Foster (1991) state that they prefer simple models for accounting purposes as long as management decisions are not influenced by more complex ones. This implies that there are general conceptual models which can be reduced to specific

variables from general conceptual models. Norman, Gentner & Stevens (1976) used the term 'default-value' as the means to neutralize a variable. In textbooks, these specific conceptual models are reflected in exercises and problems.

Procedural knowledge in Management Accounting concerns the computation of variables in a logical sequence. In each stage in the process of problem solving the pupil is required to master both general and accounting skills. *General skills* are for instance arithmetic and mathematical analyses. Most accounting problems, however, contain only data and an unknown variable without prescriptions as to how to relate the quantities to one another. This is part of *accounting skills*. And that is exactly what a problem solver should do: append the required prescriptions to the problem. These prescriptions must be derived from general conceptual models and selected on a basis of the data given. For different situations, like merchandising accounting and manufacturing accounting, different prescriptions should be added. A transformation model can be described for each situation. In Dutch textbooks, however, the same transformation model can be described in different concepts within varying subdisciplines of Management Accounting, for example bookkeeping and product cost calculation. There are also some differences between accounting principles applied in subdisciplines. For purposes of instruction, a consistent set of concepts and principles is preferable.

Strategic knowledge consists of cognitive strategies and metacognitive skills. It is the awareness of what steps are to be taken in problem solving. Economic notions can be helpful to find the answer, but so can instructional notions. Accounting problems have their own characteristics, like the data-adage: *all the required data are given and all the data given are required.* So pupils may combine the data in the most probable way, hoping to find the correct answer by chance.
As far as economic notions are concerned, two different kinds of problems can be distinguished: goal-seeking problems and what-if problems. Each requires its own strategy of problem solving. The two kinds of problems both depend upon notions related to the economic principle: (1) get the best results out of given means of production and (2) get a certain result with minimal use of means of production. *Goal-seeking problems* can be solved by relying on the strategy of goal-analysis to reconstruct step-by-step the diagram describing the conceptual model of the accounting procedure. *What-if problems* require instant reconstruction of the complete diagram as the 'goal' is already known and the unknown is hidden somewhere in the diagram.

Empirical evidence has been found of the *mental representations* pupils developed while using three conceptual models to compute a company's net profit. Representation means (Jorna, 1989): 'Something stands for something else'. Think-aloud protocols (Ericsson and Simon, 1984) give insight into the internal conflicts four pupils had to deal with while solving problems involving one of the three inconsistent conceptual models. Their monitoring process (Schoenfeld, 1989) got them into trouble as they tried to find some consistency between the problem solved and the prescriptions known from other conceptual models. It was found that these pupils tried to integrate inconsistent conceptual models, thus creating their own mental representation of the conceptual models offered. They created a mental representation

based on *catchwords* abstracting from essential features of the quantities under consideration. It is as if they were trying to categorize quantities with cognitive economy (Rosch, 1978) and easy predictability (Holland c.s., 1989) as forces behind their mental processes. A pilot study with 29 pupils, in which spreadsheets were used as a medium to enforce the pupils to analyze the problems offered gave results indicating the same dilemmas between conceptual models offered and mental representations developed.

A survey amongst 155 pupils of 6 different secondary schools showed that these pupils had the same problems in coping with the inconsistent conceptual models. A pretest-posttest control group design was used to compare two teaching methods, one presenting explicit conceptual models as an experimental way of teaching, the other presenting exhibits to demonstrate computations - as is usually done in the instruction of Management Accounting. The experimental group consisted of 75 pupils and the control group of 80 pupils.
The *Knowledge of Prescriptions* test resulted in significantly higher scores for the pupils of the experimental group. This was mainly due to the conservation of mental representations built up in chapters dealt with earlier. Fewer pupils of the experimental group redefined the prescriptions of the old concepts in accordance with the prescriptions of the new concepts.
The *Knowledge of Procedures* test consisted of two pretest-posttest experiments. The first experiment showed no significant difference between the experimental group and the control group. The second, however, did result in a significant difference in favor of the experimental group. The relevance, though, is limited, as hardly any pupils arrived at the right answers, as they did not know how to cope with the contradictory prescriptions related to the three conceptual models.

A more specific analysis resulted in two significant differences in favor of the experimental group. The first difference concerns the descriptions of the two main quantities 'product cost' and 'cost of goods sold'. The experimental group gave significantly fewer *identical descriptions* than the control group did. The second difference relates to the dimensions pupils used while answering the two tests. Here again the experimental group made significantly fewer *mistakes with dimensions* than the control group did. Still, the experimental group was not faultless, so more investigation and experimentation is required.
The dimension mistakes also showed up in an experiment cardsorting (Chi, Feltovich & Glaser, 1981). These cards showed prescriptions fitting in with varying conceptual models. The instruction was to sort out cards fitting in the same conceptual model. The results revealed one more feature about mental representations. Pupils declared cards to be synonymous regardless of characteristics intended to distinguish between situations and subdisciplines. They built models based on *catchwords*. These results indicate that mental processes do not develop as expected. Further research is required to investigate the processes pupils use to develop their mental representations of the conceptual models offered.

The results of this study have consequences for both the development of Management Accounting and the development of the instruction of management accounting.

Management Accounting is too much of a skill, sticking close to habits and to generally accepted accounting principles. The scientific approach should be elaborated. Too many habits and principles are inconsistent with one another. Accounting procedures are presented as a set of exhibits instead of as a limited number of general conceptual models linked to situations. These models could serve as frames of reference. The information about the situations could serve as signals to activate certain knowledge structures.
Simultaneously the *instruction in Management Accounting* should pay more attention both to the stages in problem solving and to consistent frames of reference. These frames enable pupils to develop mental representations corresponding to the conceptual models offered. Strategic knowledge gives a solution to a complaint often heard at school: "Once you have explained it, I understand the problem, but if I have to do it myself, I don't know where to start". Solving a cost-accounting problem means solving an incomplete case. It first requires the determination of the relations between data and unknown. These relations can be derived from general conceptual models. However, pupils can only deduce these relations from their own mental representations of the general conceptual models. Therefore, more attention is needed for the mental representations pupils develop while solving accounting problems.