PROBLEM SOLVING IN MANAGEMENT ACCOUNTING

English article on the results of my dissertation in Dutch.

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Introduction

'Once you have explained the problem, I do understand, but if I have to solve a problem like that at home, I don't know where to start'. This remark can often be heard in class. It indicates that it is not enough to explain a problem in accounting but that instructions have to be given how to tackle it.

This requires explicit instruction in cognitive strategies which may help the student to discover the beginning of a solution. This paper reports about the results of a study in management accounting from the perspective of cognitive psychology (Vernooij, 1993a).

Little educational research is done in the field of solving accounting problems. But much research is available from other disciplines such as mathematics (i.e. Polya, 1954; Anderson 1982, 1985; Schoenfeld, 1989) and physics (i.e. Mettes and Pilot, 1980; Larkin, 1983; Mettes, 1985; T. de Jong, 1986; Ferguson Hessler, 1989).

This literature suggests that there are four stages in solving a problem. These stages are: orientation on the problem situation, analysis of the problem structure, planning of the solution, and calculation of the answer.

Each stage contains the control of each step one has done in that stage. Schoenfeld (1989) suggests taking into account 'evaluation' as a fifth stage, showing the importance of considering both the process and the solution after the answer has been found. Veenman

(1993), and F. de Jong (1992) explored this metacognitive skill and found it makes an independent contribution to success in solving problems.

The art of problem solving requires more than just information about cognitive strategies. Accounting is built on different subdisciplines, like bookkeeping, cost accounting, commercial accounting and financial reporting. Each has its own habits and concepts. Their vocabularies are often not consistent with one another. To tackle a certain problem from different angles, requires a solid view on the differences between these subdisciplines.

In this paper, first, a description will be given of some conceptual models (Norman, 1983) which are subject of the instruction process in Dutch schools (Hoogheid and Fuchs, 1987; Slot, 1987). These models were detected with the Elaboration Theory of Reigeluth and Stein (1983). A transformation of the Dutch terminology is made to the English language. This was more then a translation: concepts cannot be translated literally as they are subject to local rules and conventions.

In order to give an indication about the differences that exist between the models used in different subdisciplines a short description is given of the way students build up a mental representation of these models. To investigate the scope of problems students have in solving accounting problems a research program was designed. A survey of 155 students in secondary education was undertaken and the results are given.

Characterizing conceptual models

A training in accounting requires students to develop problem solving skills. These skills are developed through the use of case studies. Many of those cases have the same structure: some data are provided and students are invited to compute one or more unknowns. The main issue in our research was the computation of 'operating income'. In Figure 1 an example is given to show the kind of problems involved.

A trading company has gathered the following information for June:

a. sales revenues	= $ 150,000
b. product costs of goods sold	= $ 80,000
c. purchasing costs	= $ 5,000
d. overhead costs	= $ 30,000

Required:
1. compute the gross margin in June;
2. compute the operating income in June.

Figure 1: example of a case study

In this problem the functional relationships between de data and the unknowns is missing. To solve it, students will have to remember some rules about how to relate the economic quantities to one another. They should start their orientation by ignoring the numbers and concentrating on the names of the variables. At his point insight is required into the prescriptions hidden in the names of the concepts.

These prescriptions can be presented in an *actions diagram* (Vernooij, 1990) of a specific problem. The teacher's goal is to have the students demonstrate their knowledge of the relationships between the data and the unknowns. The actions diagram for a specific problem must be derived from a more general conceptual model. The generally accepted accounting principles for financial accounting in Holland prescribe a combination of data as presented in Figure 2.

```
                                   operating income
                         ┌────────────────┴────────────────┐
                unidentified          -              overhead
                  variable                             costs
            ┌─────────────┴─────────────┐
        gross         -          purchasing
        margin                   costs
     ┌──────┴──────┐
  sales    -   product costs
revenues       of goods sold
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Figure 2: Actions diagram of the computation of the operating income in a trading company according to bookkeeping

To discover the functional relationships as described in Figure 2 students have several options. If the non-economic notions are excluded, students might try to remember a similar problem they have seen before and trace the required actions. (Notice that if they know the solution already the exercise is not a real problem anymore). If they don't know the solution they might try to take a look in the answerbook, if available, or await the teachers explanation.

Another possibility is to search for a description of the procedure behind the required computation. Such a procedure can be found as a conceptual model (Norman, Gentner and Stevens, 1976; Norman, 1983) in a textbook. The derivation of actions diagrams from general conceptual models is described by Norman, Gentner & Stevens (1976) as filling up certain quantities in a general model with a value or with a default value (which is usually 0).

Conceptual models give a description of the correct computation of important quantities in accounting. Mostly these procedures are presented as examples of particular instances, but they could be presented as stories explaining how entrepreneurs are selecting data required to solve problems.

Figure 3 shows how the actions diagram of Figure 2 is part of a conceptual model that can be referred to in solving this case study. Many of the quantities mentioned can be further described as computations of subordinate quantities.

```
                                    operating income
                           ┌───────────────┴───────────────┐
                      unidentified         -          overhead
                        variable                        costs
                  ┌────────┴────────┐             ┌────────┴────────┐
           gross       -     purchasing     costs of    +     costs
          margin               costs     administration     of sales
    ┌────────┴────────┐      ┌──┴──┐       ┌──┴──┐
 ┌──┴──┐
  sales        -   product
revenues           costs of
                   goods sold
 ┌──┴──┐           ┌──┴──┐
```

Figure 3: Conceptual model of the computation of operating income in a trading company according to bookkeeping

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To solve a problem using economic insight students must try to discover the correct conceptual model behind a case study before they can transform this model into the specific actions diagram required to solve the particular problem. They must form a problem representation (Larkin, 1983) in economic terms.

Some features in this search can be mentioned. An exercise is mostly a fragment of a conceptual model or is a variation on that conceptual model enforcing some modification in order to find the correct actions diagram. But in cost-accounting another conceptual model might be used (see gross margin in Figure 4). This results in another gross margin ($ 65,000 instead of $ 70,000).

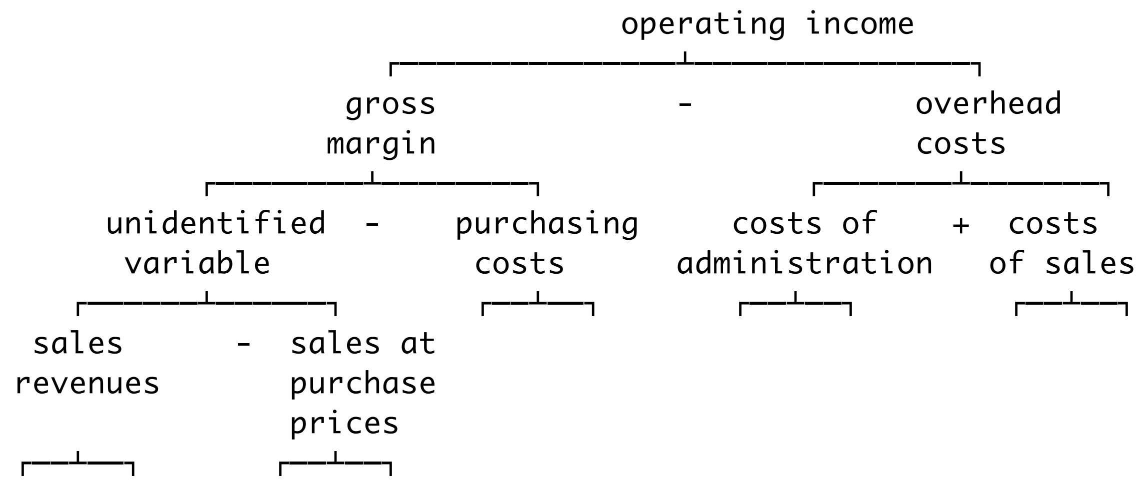

Figure 4: Conceptual model of the computation of operating income in a trading company according tot cost-accounting

The crux in accounting is that more and sometimes inconsistent prescriptions exist for computing the same variable. Horngren & Foster (1991, page 44) introduce three different ways to compute the 'product costs'. Thus the *product costs* of goods sold for the yearly income statement may well be of a different structure than the *product costs* in calculating the selling price (see Figure 5). Students must discover which prescriptions to use in which situation.

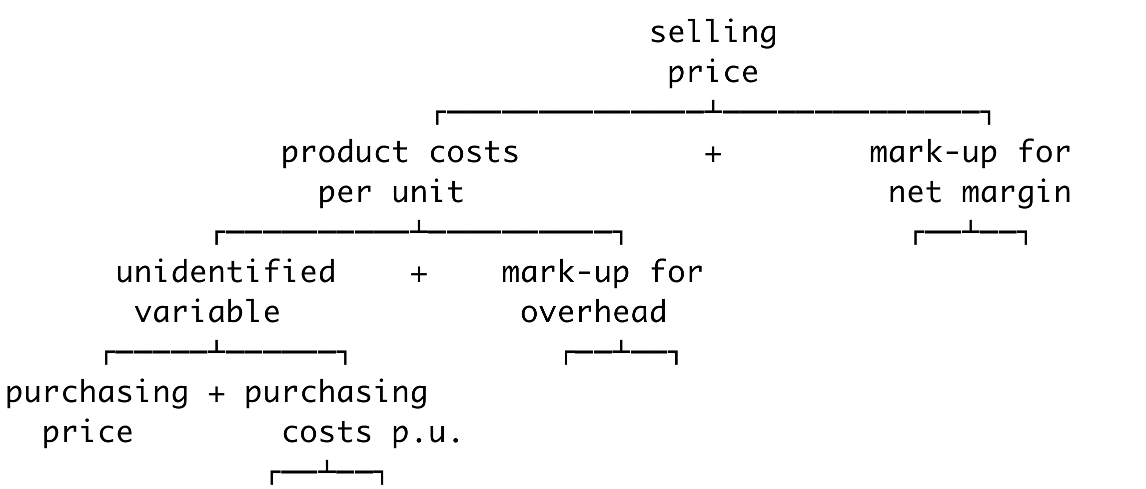

Figure 5: Conceptual model of computing the selling price in a trading company

The process of solving problems

In solving a problem in accounting the four stages mentioned must be worked out. The stage of *orientation* is aimed at recognizing the concepts used and at interpreting the type of company. The *analysis* of the problem structure embraces two steps. The first is the search for the conceptual model behind a certain problem.

The second is the transformation of this conceptual model into an actions diagram of the presented case study. Once the functional relationships are clear the *planning* of the solution is possible by selecting and ordering the steps required to compute the correct answer. Then the final *calculations* can be made.

The main point in this reasoning is the first step in the analysis. The students have to find the correct conceptual model behind a certain problem. But as a matter of fact they can only find their own mental representation of the conceptual model. If this mental representation is not correct, it is difficult to construct the correct actions diagram. Therefore, a teacher must pay attention to the mental processes students go through while studying examples of procedures.

As mentioned before, Schoenfeld (1989) highlights the importance of paying attention to the *evaluation* of a problem. Once a case study is conceived of as a part of a conceptual model, elaboration of the acquired knowledge is necessary to master the economic model behind the specific case study. This elaboration can take place by presenting the same problem as part of a larger procedure or by stating the problem in terms of another subdiscipline.

Problems that confirm an established conceptual model can be termed fundamental problems. Another type of elaboration is possible by turning the problem upside down: one of the numbers given is taken as an unknown and the original unknown is presented as part of the data. This type of problem-stating is known as goal-seeking.

Fundamental problems can be solved by relying on the strategy of backward reasoning. The actions diagram hidden in the accounting procedure can be discovered by logical reasoning. A student can identify with the entrepreneur and wonder what data are required to compute the value of a certain economic quantity such as operating income in a certain period.

Goal-seeking problems are different as the goal is already known and the unknown is part of the original data. For instance, the entrepreneur may want to know how much the overhead costs should be, in order to attain a certain operating income. These problems require instant reconstruction of the complete actions diagram and for that reason require a quick recognition of the conceptual model suited to the problem (Vernooij en Minnaar, 1992).

Mental models

The most interesting question concerning educational research in accounting, is how students cope with inconsistent conceptual models. Do they consider them as separate entities which must be applied in different situations? Or do they try to build a consistent model in their minds? In the literature reports are found about research on the mental processes students go through.

Chi, Feltovich and Glaser (1981) investigated the differences between experts and novices in the way they perceived and categorized physics problems. Novices concentrate on superficial resemblances while experts classify them on similarities in problem solving methods. Glaser and Bassok (1989) studied the way experts develop their expertise by compiling useful procedures.

Larkin (1983) showed how differences in the problem-solving performance of experts and novices can be related to the use of different problem representations. Experts in physics are able to create a *physical* representation that contains imagined entities such as forces and moments, before they construct their mathematical equations.

Norman (1983) mentions the difference between two kinds of knowledge: the *conceptual models* offered to students in the instruction material and the *mental models* students actually develop in their minds. He points out that students might develop mental models that are quite different from what teachers expect.

Williams, Hollan & Stevens (1983) indeed describe some examples of mental models students developed while solving problems in physics. These mental models were quite different from the conceptual models offered to them. Holland, Holyoak, Nisbett and Thagard (1989) explored these processes of inference and found the students created a hierarchical mental structure.

Achtenhagen and John (eds) (1992) presented an approach where mental models are investigated and influenced by teaching. Peter Preiss (1992) described in his contribution a network structure which lies behind the list of content and goals of a curriculum. This network is a qualitative description of the concepts needed in business administration.

It gives a good indication of the complexity of cognitive structures, but it does not make an allowance for quantitative aspects. Dimensions like 'per period' or 'per product' are not stated explicitly. Differences between disciplines within accounting are not mentioned. This network requires a transformation from a qualitative level to a quantitative level before it can be used to solve problems in accounting.

In a pilot study (Vernooij, 1993b) it was found that many students try to integrate the different conceptual models offered to them. They expect consistency in the textbooks. If this consistency is absent, however, students tend to create it themselves. One solution found in computing the product costs per period was: *volume times product costs per unit*, thus subtracting purchasing costs and overhead costs twice.

Another solution was the redefining of the product costs per unit as: *purchase price plus purchasing costs per unit* (see Figure 6 and Figure 7). This approach results in correct answers on both the computation of operating income and the selling price, but it creates misconceptions about the computation of products cost of goods sold and product costs per unit.

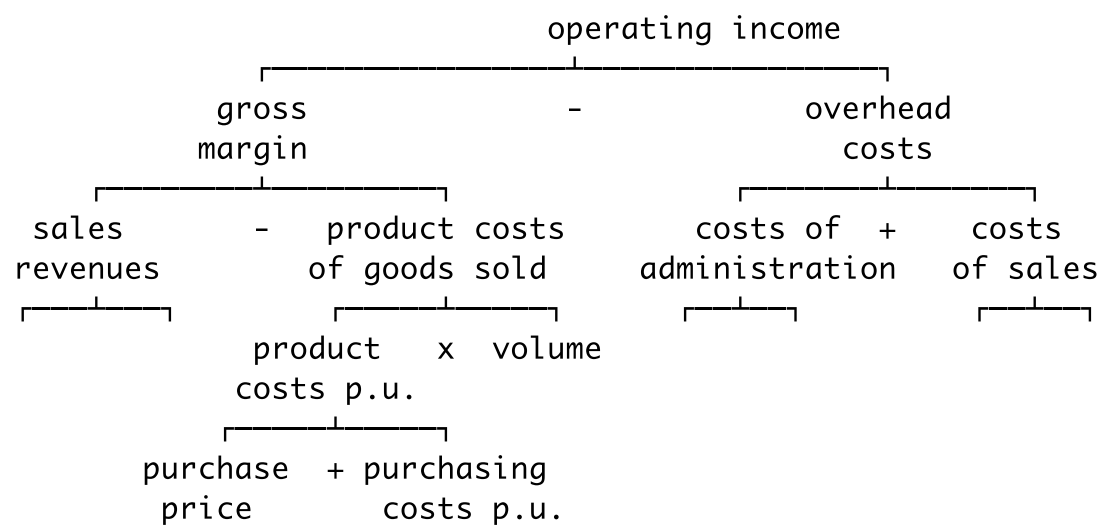

Figure 6: mental model of the computation of operating income in a trading company as an alternative model aimed at integrating the conceptual models

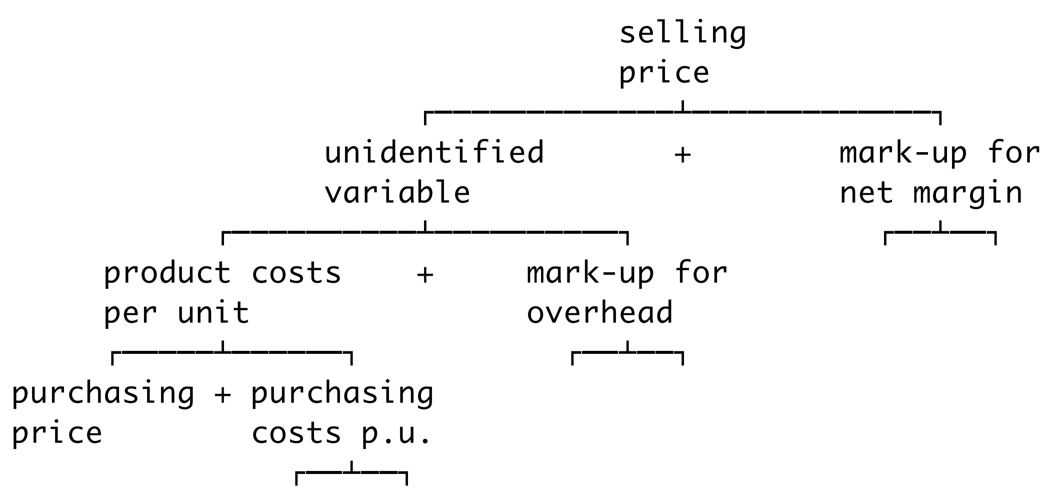

Figure 7: A mental model of computing the selling price in a trading company as an alternative model aimed at integrating the conceptual models

Design of a research program

To investigate the development of mental models once inconsistent conceptual models are offered, research was done at secondary schools (Vernooij, 1993a). The *population* consisted of 155 students in the 4th grade of secondary education from 6 different schools. The development of their knowledge was measured three times while a chapter was taught from a regular Dutch textbook (Hoogheid and Fuchs, 1987).

This book contained two topics: the computation of the selling price of a product in a trading company and the computation of the break-even point. This chapter contains two conceptual models to compute the operating income of a company, which are both inconsistent with a conceptual model taught in earlier chapters.

The *design* of the research program was the confrontation of the results of an experimental group with the results of a control group. The control group (80 students) was treated in the usual way with demonstrations of computations containing implicit conceptual models. The experimental group (75 students) was treated with actions diagrams making the conceptual models explicit.

Four different tests were developed and think-aloud protocols (Ericsson and Simon, 1984) were made. In this article the results of one test only are presented (Vernooij, 1993c). This test conceptualizes the mental models students developed while they were learning to solve the case studies.

The test consisted of two parts: the first part stated four questions (items a through d) about knowledge acquired earlier in the program (computing operating income according to the rules of bookkeeping) while the second part stated four questions (items e through h) about new knowledge acquired (computing the selling price of a product).

The same test was taken three times to the students: at the start of the program, after instruction in the cost per unit calculations and after instruction in the direct costing approach. One group of 21 students was invited to a retention test after two months which was repeated several days later.

Two independent judges were asked to mark the statements found with codes referring to available conceptual models: B for the bookkeeping model (see Figure 3), C for the cost per unit calculation (see Figures 4 and 5), D for the direct costing model and A for the alternative model (see Figures 6 and 7) and X for a missing answer or unidentifiable model.

Students who choose the right answer received two points if the answer was correct according to the conceptual model required and one point if it was recognizable but incomplete.

In analyzing the data one group of 25 students was found to produce errors at the first test other groups only performed in the second test. A thorough investigation led to the conclusion that these students received preliminary information on the new subject to be taught. The influence on the results of the first test made it necessary to exclude them from the results, presented in Tables 1 through 3.

Results

The results of the test are presented in Tables 1 through 3. The hypothesis was that the experimental group would perform better than the control group. In the first test (Table 1) no differences were found between the experimental group and the control group.

Table 1: Results on first test

	item a / d		item e / h		item a / h	
	mean	s.d.	mean	s.d.	mean	s.d.
experimental group (n = 75)	3.3	2.1	0.2	(too small)	3.5	2.1
control group (n = 55)	3.4	2.4	0.1	(too small)	3.5	2.4

results ANOVA items a t/m d (n = 130): $F(1,98) = 0.05; P \leq 0.823$

In the second test the experimental group performed better, but not because of a better score on the new knowledge (Table 2). As the results of Table 2 indicate the control group performed worse on the items about the knowledge acquired earlier. This resulted in a score that was significantly lower than the result of the experimental group. The same results were found at the third test (Table 3).

Table 2: Results on second test

	item a / d		item e / h		item a / h	
	mean	s.d.	mean	s.d.	mean	s.d.
experimental group (n = 75)	3.0	2.4	3.8	2.2	6.8	3.2
control group (n = 55)	1.3	1.4	3.6	2.0	4.9	2.4

results ANOVA items a t/m h (n = 130): $F(1,98) = 10.64; P \leq 0.002$

Table 3: Results on third test

	item a / d mean	s.d.	item e / h mean	s.d.	item a / h mean	s.d.
experimental group (n = 75)	3.7	2.7	3.0	2.5	6.6	4.2
control group (n = 55)	1.1	1.2	2.7	2.0	3.8	2.3

results ANOVA items a t/m h (n = 130): F (1,98) = 5.91; $P \leq 0.017$*
* significance level: $\alpha = 5\%$

Possible explanations for the differences found

To find an explanation for the results a close investigation was made of the choice of models by the students in computing the product costs of goods sold (Table 4). The investigation includes the group of 25 students excluded in Tables 1 through 3.

In the second test it was found, that 96 out of 155 students redefined the model B concept of 'product costs of goods sold' in a sense corresponding to model C. This was done by 75 % of the students from the control group and by 48% of the students of the experimental group.

In the third test the percentage of students of the control group was down to 55% but this was no indication they returned to the right model. Only 4% of the students of the control group produced a correct answer and this didn't change. Some turned towards the direct costing model, others developed a mental model too mixed up to categorize.

The students of the experimental group performed better in the third test. The choice for model C went down to 30% whereas the number of correct answers went up from 24% to 36%.

Furthermore is was found, that 20 students developed in the second test a mental model according to the alternative model. This number went down to 14 in the third test. But this was no indication that more students gave the correct answer. The number of unidentified answers went up from 19 to 41.

Table 4: Registered codes on item a (product costs of goods sold)

	first test		second test		third test	
	EG	CG	EG	CG	EG	CG
model A	-	2	11	9	9	5
model B	*32*	*26*	*18*	*2*	*27*	*2*
model C	5	11	36	60	23	44
model D	-	-	-	6	1	3
rest	38	41	10	9	15	26

model A: alternative model
model B: bookkeeping model (correct for this item)
model C: costs per unit calculation
model D: direct costing model
EG: experimental group (n = 75); CG: control group (n = 80).

A close examination of the answers on the computation of the product costs per unit (Table 5) reveals an expected result at the first test. As the new definition for product costs had not yet been introduced (except for one of the classes) few students indicated an answer according to model C while quite a few tried to interpret the concept in terms of model B.

Table 5: Registered codes on item e (product costs per unit)

	first test		second test		third test	
	EG	CG	EG	CG	EG	CG
model A	2	2	10	3	19	9
model B	19	6	-	-	1	1
model C	*3*	*12*	*52*	*67*	*42*	*52*
model D	-	1	-	-	-	3
rest	51	59	13	10	13	18

model A: alternative model
model B: bookkeeping model
model C: costs per unit calculation (correct for this item)
model D: direct costing model
EG: experimental group (n = 75); CG: control group (n = 80).

After introducing model C most students answered accordingly, but quite a few developed already the alternative model. In the third test the growth of the alternative model is clear whereas the downfall in model C is evident.

As the results demonstrate, many students tend to integrate competing conceptual models into one overall structure. This was confirmed in the other tests of the research program (Vernooij, 1993a). Acquiring new knowledge coincides with the destruction of earlier acquired knowledge. In one group a fourth and fifth test was taken, some months after the research was finished. It was found that the deterioration of knowledge had continued (Table 6).

Table 6: Mental models of 21 students on item e with sustained testing

Choice of model:	*C*	A	Y
first test	*1*	1	19
second test (after introduction of model C)	*18*	0	3
third test	*12*	7	2
fourth test	*2*	11	8
fifth test	*1*	9	11

A: alternative model; *C: cost per unit calculation (correct)*; Y: other answers

Catchword models

In the research program information was gathered about the way students cope with the inconsistent conceptual models offered. The most remarkable result is the variety in mental models that students developed as a reaction on the conceptual models presented. Most students didn't accept the conceptual models as separate entities which must be used in different situations, but rather tried to integrate the models one way or another.

Some ways of integrating could be expected, like the attempts to create just one prescription of calculating the product costs of goods sold. As one student put it: "There are several definitions of 'product costs' so one has to make a choice." Consequently, he introduced the concept of 'product costs per unit' in the Financial Accounting model of computing operating income and ran into the problem of subtracting overhead costs twice.

Another way of integration is creating *catchword-models*. In these models, students abstract from essential economic dimensions like 'per period' or 'per product'. This result was already found in a pilot study (Vernooij, 1993d) where 29 students were asked to describe the computation of some quantities like 'product costs of goods sold' and 'product costs per unit'. Most students wrote down an *identical* description, making no difference at all between these two concepts or a *parallel* description, only making a difference in the quantity sold (Table 7).

Table 7: Comparison of descriptions of 'product costs of goods sold per period' and 'product costs per unit' in a separate test.

exper. group		control group		
2nd	3rd	2nd	3rd	
5	7	3	2	identical: p.c. per period = p.c. per unit
7	8	7	9	parallel: p.c. per period = volume x p.c. per unit
3	-	4	3	different descriptions
-	-	-	-	correct descriptions of both

The follow-up study under 155 students (Vernooij, 1993b) confirmed this mental process (Table 8). This leads to the conclusion that persistent mistakes might be caused by these inadequate cognitive structures. The use of an instruction strategy that makes the conceptual models explicit leads to a significant difference between the experimental group and the control group. However, students of the experimental group still made quite a number of mistakes.

Table 8: Number of identical descriptions of 'product costs of goods sold per period' and 'product costs per unit'.

		exper. group	control group	chi^2	p ≤
Round 1:	number:	58	48		
	identical:	10	12	0,55	0,46
Round 2:	number:	75	80		
	identical:	30	62	22,63	0,001*
Round 3:	number:	75	80		
	identical:	25	41	5,04	0,025*

* significant difference in favor of the experimental group.

Educational importance

In solving a case study in accounting, students must read a text and interpret this text with the mental models they have already in mind. If those models do not concur with the conceptual models required to solve the cases, systematic errors occur. Therefore teaching and learning must be made concurrent. First of all the conceptual models must be made consistent as much as possible. It they are inconsistent with one another, this difference must be taught explicitly and not hidden in computations only.

Secondly attention must be paid to the mental models students develop while solving problems. As long as students try to integrate two conceptual models that are inconsistent then the mistakes might shift backward and forward. Every correction on the base of one model shifts the error to the interpretation of the other model.

The students experience this shift as a dilemma and they try to eliminate this dilemma in different ways: by building their own intermediate model or by sustaining an error. As one student said: "If I have to believe what is written down here, the computation is right. But it is not at all in my book in this way." Still it was.

Teachers or teaching-learning arrangements, therefore, should not only correct errors in specific case studies, but should distinguish and correct the mental models leading towards persistent errors. This requires permanent attention for the integration of new knowledge with knowledge acquired earlier in the study process.

Not only should there be attention for the relations between quantities 'per unit' and 'per period' and between prospective and retrospective computations. Special attention is required for the differences between conceptual models of the many subdisciplines within accounting and economics. Nobody can start his teaching with the remark: "Forget everything you have learned up till now", because students can't.

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