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Tracking Down the Knowledge Structure of Students

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1. INTRODUCTION

In this chapter the term "discipline" refers to accounting and economics, which each consist of subdisciplines. In these subdisciplines many terms are used that are either synonyms (different terms relating to the same concept) or homonyms (the same term is used for different concepts). This results in specific jargon for each subdiscipline. In this sense, each subdiscipline can be considered to have a dialect of its own.

A surprising number of basic terms are homonyms. They seem to be simple words, while in fact they are not. Take, for instance, the term "profit." At least two definitions are in common use. In newspapers the *accounting concept of profit* is used in reporting a company's performance, whereas students at school are taught about the *economic concept of profit* as the ultimate way of defining profit.

In the accounting concept of profit the payment of dividends to stockholders, as a payment for the capital used by the company, is not part of the company's costs. A company that does not make any profit at all is for that reason unattractive to stockholders. In the economic concept of profit, however, cost is defined on the basis of opportunity costing. From that perspective cost covers a reasonable financial compensation for all factors of

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production. Using the economic concept of profit, stockholders may be well-pleased if their company does not make any profit at all for many years, at least if there is no loss either.

Still, many students and even some teachers are not aware of the difference between these two concepts of profit, which result from different definitions of the term "cost." They therefore don't understand how companies can survive in the long run in situations of full competition without making any profit at all.

To switch from the accounting concept of profit to the economic concept of profit is like crossing a boundary between two domains. In the accounting domain the description on the basis of historic cost prevails, whereas in the economics domain the assumed description of optimal situations prevails. These different ways of reasoning in accounting and economics each have their own logic and they lead to many homonyms in the terminology, of which cost and profit are only two examples. Dictionaries are full of homonyms, because many words have different meanings in different situations, but in scientific works, each term is supposed to have just one meaning.

Once students cross the boundary from the accounting domain into the economics domain by learning about opportunity costing, it is difficult for them to return to the accounting domain when they are reading the daily newspaper. They run the risk of applying concepts from the economics domain in the understanding of the accounting domain, which easily leads to a misunderstanding of the situation. Students then build a wrong mental model (Norman, 1983) of the situation they are trying to understand.

As Layton (1991) points out, well-developed scientific concepts allow for cognitive actions (e.g. calculations). But if cognitive actions can take place in different subdisciplines, each having its own dialect, it is essential to be familiar with the dialects. To become expert, students must develop the ability to switch between dialects.

The language problem is mentioned by O'Rourke (1998) as well. He claims that economics is one of the most abstract and impractical of the business disciplines, yet proponents argue that it provides a crucial way of approaching business problems. Theoretical discourse has clarified some differences in use of terms between the various (sub)disciplines, but empirical research still needs to be done. How do students actually deal with new definitions of well-known terms? Do they consider it as switching between different definitions of the same word, as is normally the case with homonyms? Or do they consider it as switching between classification systems?

Research must focus on the way students deal with homonyms. As Chi (1992) points out, a *conceptual change* is required for a student to deal

correctly with two different notions behind the same term. A homonym covers two different concepts and the student must shift between these two concepts. To know, for instance, that a whale is not a fish but a mammal is not just a matter of redefining the term whale. It requires the understanding that a whole new system of definitions is needed to classify whales.

Vosniadou (1994) points out the misunderstandings that arise when students assimilate new terms without revising old ways of thinking. To add, for instance, the term profit to the customer concept of cost (as the price one pays for a product), some clarification is required about the way of defining both terms. Therefore, the phenomenon of conceptual change must be studied by teachers in order to understand the mistakes students make in solving problems.

The present article tries to gain insight into the mechanisms that cause students to misunderstand the knowledge offered to them. I reflect upon the way experts handle their terms, and I suggest a new way of teaching where explicit interest is shown in how students build a knowledge structure.

The article starts with an investigation into the nature of misunderstandings. The approach is based upon cognitive psychology and can be of help in developing curricula by shifting attention away from the two usual perspectives in education, namely economic practice and economic theory, towards a third perspective: the knowledge structure students build in their minds.

To complete the article, a simple true-false test is presented which was used to investigate the ability of students to deal with economic terms like cost, payment, and expenditures. With this type of testing, not only can the knowledge structure of students be tracked down, but the test results can be put to use by discussing them afterwards with the students.

2. MISCONCEPTIONS

Many frequently used terms turn out to be homonyms. The same term has different meanings in different situations which are rooted in different subdisciplines of economics and accounting. If the relationship between a term and a subdiscipline is not sufficiently clear in a specific situation, homonyms can cause or reinforce misconceptions, leading to problems in students' understanding of economic processes or accounting procedures.

A misconception is a mini-theory which a person has in mind, but which is scientifically not true. A mini-theory contains a conclusion and an argument to support the conclusion. It can show up long after education should have molded the mini-theory in a different shape. Marton (1988) calls the study of misconceptions "phenomenography." Examples of mini-theories

are that the sun shows up in the daytime and the moon shows up at night, because in the daytime light comes from the sun and at night light comes from the moon and the stars. Or, that force is required to keep an object moving at the same speed, because you always have to push a trolley through a supermarket if you want to keep the trolley moving. Or, that cost is what you pay for an object, because the shop assistant names the selling price when a customer asks what a certain product costs.

In physics a lot of research has been done on misconceptions (Gilbert & Watts, 1983). Misconceptions are formally defined as: "The occurrence of utterances (about a class of physics situations) that are (a) deviant from current scientific theories, (b) consistent within groups of age, culture, etc., and (c) stable and hard to modify through education" (Taconis, 1995). Misconceptions can occur even before schooling starts (Marton, 1988) but they can also result from formal education as natural by-products of the process of knowledge acquisition (Driver, Guesne & Tiberghien, 1985). Examples are that the sea level rises when a floating iceberg melts, or that a current of electricity is comparable to a current of water.

In economics little research has been done on misconceptions. Yet there is every reason to do such research, as economics is much more a matter of context-bound cognition than is generally realized. Experts are usually able to decide upon a complex problem very rapidly because of their knowledge structure. Their thinking is triggered by small signals, and in specific situations experts deduce the meaning of the terms from the perspective of the situation involved (Chi, Slotta & De Leeuw, 1994). They have developed an understanding of different meanings related to different (sub)disciplines and they switch between them nearly unconsciously. This skill should be taught in the classroom.

The major issue is to acquire the skill of switching from one context-bound definition to another: *the ability to switch.* How to switch from the accounting concept of profit to the economic concept of profit? And how to switch back? Especially the step backwards is important, because once the switch is made from one concept to another, the student must be able to switch back and accept two different concepts for the same term, each from its own perspective. If he is not able to switch back, misconceptions distort the comprehension of new problems. In terms of cognitive psychology, the student builds in his mind a wrong initial representation of the situation involved (Anderson, 1985).

2.1 Some More Causes For Misconceptions

Besides the use of homonyms, it was found in a study on solving problems in accounting that misconceptions can result as a by-product of

education as well (Vernooij, 1995a, 1996). Students who followed a course in accounting and had finished a chapter on bookkeeping were asked to study a chapter on cost accounting. They had to solve problems about computing the cost price of products and the profit an entrepreneur could make with those products (Vernooij, 1995b). Some terms like cost of sales, gross profit and net profit, which students were familiar with from the perspective of bookkeeping, were used again in the chapter on cost accounting. But now they had a slightly different meaning. To track down the knowledge structure these students had developed, some of them were asked to solve some problems thinking aloud. These sessions were taped and transcribed. The transcriptions made clear where misconceptions arose when tackling the problems presented.

One cause of misconceptions was students' assumption that authors always use a term in the way they have defined it. In the book under investigation, the author stresses in the chapter on bookkeeping that students should remember that gross profit equals sales in a period minus the cost of goods sold excluding the purchasing costs. However, the author, as a real expert in his subject, changes in the chapter on cost accounting to another meaning of gross profit, without making this switch clear to the readers. "As we have seen before", he states, "the margin for gross profit of a certain product consists of a percentage of the cost of goods sold including the purchasing costs." The two concepts of gross profit differed, however, in three respects: per period versus per product, real versus normative, and excluding versus including purchasing costs.

Another cause of misconceptions was the lack of ability to understand conceptual change. Some students stuck to the meaning of a term once it had been proven correct in an exam. In the "think aloud" sessions one student said explicitly: "I stick to the meaning we learned before, because that was approved in my bookkeeping test."

A third cause was found in the opposite behavior: some students were not able to switch back to the old knowledge structure once they had learned a new meaning of a homonym. They replaced the old meaning by the new one, instead of accepting two different knowledge structures at the same time. Such students rewrote the past by projecting newly learned meanings onto older terms. "At first we defined the term that way, but then we learned this new meaning, so from now on I use the term in this sense." In fact, these students refuse to accept the existence of homonyms.

Still, the most interesting cause of misconceptions found was the desire to create consistency where it did not exist. Some students recognized the different meanings in different situations and tried to solve the riddle by creating their own definitions. As a matter of fact, they created a knowledge structure based on *a dialect of their own*. They incorporated elements from

different subdisciplines and created something new in their minds. They created their own definitions and assumed they did really understand what was meant by the author of the book.

2.2 Cognitive Economy

Some students are really brilliant in creating a world of their own. They create a whole system of interrelated misconceptions to fit different (sub)disciplines at the same time. Or at least they think it fits different (sub)disciplines, whereas in reality it causes them problems wherever they go. As the result of the instruction process, they acquire only part of the knowledge structure the teacher intends. At the same time, they acquire a knowledge structure the teacher does not know about or even imagine.

For instance, once a student reduces the concept of gross profit in a period (measured in $ per month) and gross profit margin per product (measured in $ per product) to "gross profit" (measured in $), a new concept is born. The student does not distinguish anymore between two different concrete concepts but reduces his cognitive load to remembering just one concept that is more abstract. He assumes he will be able to work this one concept out into a particular form as soon as the situation requires him to do so.

In fact students try to reduce complicated knowledge structures to simple models in order to store the knowledge in their long-term memory. Rosch (1978) calls this "cognitive economy": the art of restructuring knowledge in a way that reduces the cognitive load required to remember the body of knowledge.

This process of concept building has been found in many students. It is supported by economists' habit of neglecting to make proper mention of the units in which terms are defined (Vernooij, 1993). Students behave the same way as is done in the Dutch encyclopaedia of business economics. The encyclopaedia defines two different concepts of cost. One is cost as a flow variable measured in (Dutch) guilders per period. The second is cost as a stock variable measured in guilders per product. But the encyclopaedia goes on to say that what these terms have in common is that they are both expressed in guilders, which implies that the general definition of cost is a variable expressed in guilders.

2.3 Different Concepts Behind the Term Cost

One fundamental term in economics is cost. People who have not studied economics or accounting think of cost as the selling price. As customers they often ask for the price of a product by saying "How much does it cost?"

Their perspective is the customer's view and they have the customer's notion of the word cost in mind. In fact, the word cost in this situation has two different meanings: price and expenditures. The unit in which cost is measured in the customer's view is the local currency.

In the customer's view, the words cost, price and expenditures are considered to be synonyms for the same concept. If somebody considers a word to be a synonym of another word, it means that he thinks this word could be substituted for the other word without changing the meaning of the sentence.

When students are introduced to accounting, they usually start with financial accounting. There they are confronted with the term profit, which is defined as the difference between revenues and cost. And as profit is a flow variable, which should be expressed in $ (or any other currency) per period, cost must be understood in the same way. Students are taught that cost reduces profit, and they understand that less cost leads to more profit. They also start to understand that not all expenditures are costs, as only the costs related to the products sold in a certain period can be subtracted from the revenues of the same period.

The development of this new meaning of cost requires a conceptual change (or shift) from cost as "expenditures" (measured in a currency) towards cost as "expenses" (measured in a currency per period). Because of this transformation cost is a quantity that has a negative influence on profit. Especially trading companies use this concept of cost.

A second round of conceptual change occurs as soon as a shift to management accounting is made. Then, the notion is introduced that cost is a valuable asset in the theory of costing. In management accounting, cost is a constituent part of the value of a product. As such, cost is measured in $ (or any other currency) per product. Product cost per unit is not the sum of expenses, but the sum of value added in the production process (Horngren & Foster, 1991). The more cost is required, the higher the price will be. That is to say, the industrial notion of cost implies that not the real cost is part of the production cost but the standard cost, that is the cost required under rational behavior.

Three broad domains of thought have been mentioned up till now: ordinary life, financial accounting and management accounting. Micro-economics can be added as another domain with its own notion of cost. Because of assumptions like *perfect foresight* and *opportunity costing*, a third round of conceptual change would be necessary if the microeconomic meaning of cost was introduced. In microeconomics the difference between real cost and standard cost has disappeared, because an entrepreneur has in advance all the information required to know what the results will be. Cost is reduced to standard cost and consists of the financial compensation for all

factors of production, including the capital that stockholders have put into the company.

Experts are able to distinguish between the four different meanings of cost, because they have developed four different concepts behind the term cost. They recognize the nature of the situation at hand, which makes it possible for them to decide upon the proper meaning of the homonym cost at that moment. But they recall as well problem schemata and procedures relevant to the situation involved. In cognitive psychology this phenomenon is called using scripts (or scenarios) (Schank & Abelson, 1977; Anderson, 1985).

The expertness of economists is based upon their ability to switch from one meaning of an economic term to another on the basis of characteristics of the situation. As soon as they notice a switch in situation they automatically switch to a different concept, mostly without being aware of that switch. This expert knowledge should be the central focus of instruction.

2.4 Becoming Expert

In summary, because economics and accounting are based upon a number of subdisciplines each using their own dialect, students must not only learn to handle synonyms (different terms for the same concept) and homonyms (the same term for different concepts) but must also learn different ways of classifying terms. To become expert, students must develop the ability to switch from one meaning of a term to another meaning by identifying the situation in which the term is used.

Besides, students develop mechanisms to store the knowledge in their long-term memory. They assume authors always use terms in the way they define them and they assume consistency even when it does not exist. Instead of accepting different meanings for the same term, students tend to choose between three ways of handling homonyms. They stick to old knowledge that was approved in a test, or they rewrite their old knowledge and stick to the new definition, or they create a world of their own, sometimes far beyond the expectations of the instructor.

A lot more research in economics and accounting is needed to describe the full implications of conceptual change. Such research is necessary to find out more about the way students build their personal knowledge structure. In the second part of this article a simple instrument is presented to investigate the knowledge structure students have already developed. But the test is not only useful for students. Teachers as well have done the test, leading to fierce discussions on the real meaning of fundamental terms like cost, expenditures, expenses and payments in the situations presented in the test.

3. TRACKING DOWN THE KNOWLEDGE STRUCTURE

One way of measuring the ability to switch between different meanings of homonyms is the true-false test (Bacdayan, 1998). One such test is presented in the appendix. This test was developed for tracking the knowledge structure of undergraduate students in accounting. Later on, it turned out to be of value as well for graduate students and even teachers. The test consists of six situations. Each situation is accompanied by six statements with the choice between 'correct' and 'incorrect'. Students are asked to make a choice for each of the six statements. In figure 1 one of the test items is presented.

First task: Choose "correct" or "incorrect" for each of the six statements about the following situation

A factory making wooden doors employs two men for $ 900 per month each. They are paid on the 25th of each month. At the end of the month this cost is entered on the income statement .

1. In this situation cost is synonymous with "payment."
   O correct
   O incorrect
2. In this situation cost has the meaning of "expenses."
   O correct
   O incorrect
3. In this situation cost has the same meaning as "asset."
   O correct
   O incorrect
4. In this situation cost is synonymous with "expenditures."
   O correct
   O incorrect
5. In this situation cost has the same meaning as "added value."
   O correct
   O incorrect
6. In this situation cost is synonymous with "reduction of profit."
   O correct
   O incorrect

Figure 1: A test of conceptual knowledge

Two of the six statements refer to cost as expenditures (measured in $ or any other currency as the unit), two refer to cost as expenses (both measured by the unit $ per period) and two refer to cost as assets (measured by the unit $ per product). In the situation presented in figure 1 there is a check whether students have gone through the conceptual change between everyday language (cost as expenditures) to financial accounting (cost as expenses).

Then there is a second situation as presented in figure 2. In this second situation there is a check on the change from financial accounting (cost as expenses) to management accounting (cost as assets). In a third situation the conceptual change to microeconomics could be measured.

Second task: Choose "correct" or "incorrect" for each of the six statements about the following situation.
A factory making wooden doors employs two men for $ 900 per month each. They are paid on the 25th of each month. In order to compute the right selling price per unit, the cost for labor is considered to be part of the product cost per unit.

1. In this situation cost is synonymous with "payment."
   O correct
   O incorrect
2. In this situation cost has the meaning of "expenses."
   O correct
   O incorrect
3. In this situation cost has the same meaning as "asset."
   O correct
   O incorrect
4. In this situation cost is synonymous with "expenditures."
   O correct
   O incorrect
5. In this situation cost has the same meaning as "added value."
   O correct
   O incorrect
6. In this situation cost is synonymous with "reduction of profit."
   O correct
   O incorrect

Figure 2. Testing a different meaning of cost

These tests are not only useful in giving the teacher an impression of the knowledge structure students have developed up to the moment of testing, they are valuable as well in setting off a discussion between students. To invite students to discuss their concepts, this test on conceptual knowledge can be used in different ways.

The easiest way to do this in class is to give all students a sheet with one situation and six statements and ask them to fill in the form. Then the results are counted in public. Usually students will have different choices on the same statements, and they must be able to justify their choice. Then a discussion can start.

A bit more complicated is an approach where two forms are distributed one after another with two different situations in which cost has two different meanings. Then the results are counted in public on these two

situations. The answers to all 12 statements can be summarized in a matrix as in figure 3.

	Situation 1		Situation 2	
	correct	incorrect	correct	incorrect
statement 1				
statement 2				
statement 3				
statement 4				
statement 5				
statement 6				

Figure 3. Matrix for assembling the results of a test of conceptual

First, the number of students must be counted who think statement 1 is correct. Then the number of students must be counted who disagree in order to be sure everybody has made a choice. Once the matrix is full, all choices are clear to everybody.

As soon as everybody has made a choice, students can be asked to justify their choice. This way the test becomes an important instrument for starting a discussion on the nature of the term "cost."

Some items usually have the remarkable result that half the population agrees and the other half disagrees. As a matter of fact, even among teachers in economics and accounting such evenly divided results have been found. In a workshop at the 5th Edineb Conference the two situations were presented. In the first situation only statements 2 and 6 are correct; in the second situation statements 3 and 5 are correct (see figure 4).

	Situation 1		Situation 2	
	correct	incorrect	correct	incorrect
statement 1	4	*2*	2	*4*
statement 2	*4*	2	2	*4*
statement 3	0	*6*	*2*	4
statement 4	4	*2*	3	*3*
statement 5	3	*3*	*6*	0
statement 6	*2*	4	0	*6*

The right answers are the italicized numbers in each row.

Figure 4. Results of the test of conceptual knowledge as given in a workshop at the 5th EDINEB conference in Cleveland, Ohio

The italicized numbers are the right answers. In situations 1 and 2 a lot of disagreement existed between the participants, resulting in fierce discussions. As a matter of fact the participants lined up in constantly changing groups, disputing each other's choices. Agreement only grew after

the units were introduced as criteria for identifying the true meaning of cost in the two given situations.

3.1 Scientific Relevance of the Test

To use a test consisting of true-false items, one must determine that the test is valid and reliable. A test is valid if it measures what it is intended to measure. This can be found out by determining whether all items contribute positively to the final result. A test is reliable if the results cannot be a coincidence. If the same test is done twice, the results should be roughly the same.

To check the validity and the reliability of the test, it was carried out twice in a program in which 100 students participated (Vernooij, 1993). Then it was checked in different ways. The technical results of these checks are mentioned in the appendix.

4. CONCLUSIONS

Conceptual change is closely related to the existence of different subdisciplines in economics and accounting. Each subdiscipline has its own dialect. If students work within a certain subdiscipline they can try to acquire the traditions and reasoning habits of that subdiscipline. Even then, conceptual change may be required if the discussion switches from one type of company (like industrial companies with mass production) to another type of company (like industrial companies with job-order production).

If problem-based learning (or any other kind of project-oriented approach) is introduced, then conceptual change must be part of the curriculum. Students must be introduced not only to the dialects of different subdisciplines but also to the art of switching between dialects. They must be able to absorb ideas from different books, periodicals and newspapers without building misconceptions. The process of assimilating and revising knowledge in order to build a fruitful knowledge structure must be made a conscious part of the educational process.

In collecting information on their own, students bring concepts from different domains together and have to cope with the different meanings of many homonyms. Somehow they must fit all the different meanings of homonyms and synonyms together. Each student develops his or her own knowledge structure while looking for answers to the problem under investigation. Instruments to identify misconceptions can be very valuable in steering that process. In this article one such instrument was presented, but

more instruments could be developed. Any teacher can make up more situations, related to the problems students are confronted with.

The real value of this kind of testing, however, is not so much the result itself, as the discussion it sparks between students. The test offered is a simple true-false test to get a discussion going. It offers both the students and the teacher the opportunity to find out whether all members of the group have the same understanding of basic concepts.

APPENDIX: THE SCIENTIFIC RELEVANCE OF THE TEST OF CONCEPTUAL KNOWLEDGE

To check the validity and reliability of the test on understanding the term cost, the test was carried out twice with the same students. Some 100 students from three different schools who had just finished the same chapter in the same textbook participated in the test. They were offered six situations each accompanied by the same six statements. The second round of the test was a week after the first one. Each of the six situations was considered to be one test-item to which a score could be assigned. Every correct answer to a statement gave one point and so the maximum score per situation was 6 points.

The validity of the test was checked by the item-rest correlation and the consistency test. The item-rest correlation can have a value between - 1.00 and +1.00. The results for the test-items varied between +0.32 and +0.61. So none of the items had to be discarded.

The second check on validity is the relationship between a high score on one item and a high score on other items (Cronbach's alpha). This statistical quantity can vary between 0.00 and 1.00. A value of more than 0.60 is acceptable for the statistical judgement that the test is valid. The alpha was 0.68 in the first round of the test and 0.75 in the second, so the test can be considered statistically valid.

The reliability can be measured by comparing the results of the two tests. To find out whether the students who scored high on the first test did as well on the second test, the correlation between the two tests was computed. This statistical quantity (the PMC) can vary between - 1.00 and +1.00. A correlation of +0.64 was found, which is an acceptable value.

The conclusion is that this test of six items each containing six statements can be considered valid for tracking the knowledge structure of students as far as the measured terms are concerned.

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